ABSTRACT

PRICE, STEVEN MITCHELL. How Perceived Cognitive Style, Metacognitive Monitoring, and Epistemic Cognition Indicate Problem Solving Confidence. (Under the direction of Timothy G. Hatcher).

The purpose of this exploratory study was to measure perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing as an indicator for problem solving confidence (Heppner, 1988). This study argues these cognitive indicators may be used as a diagnostic foundation for improving ill-structured problem solving capacity for adult professionals who develop software or use software systems to solve ill-structured problems.

A 95-item questionnaire was used to determine 1) the relationship between cognitive style and problem solving confidence, 2) the relationship between metacognitive monitoring and problem solving confidence, 3) the relationship between epistemic cognition and problem solving confidence, and 4) whether cognitive style, metacognitive monitoring, and epistemic cognition explain a significant amount of variance in problem solving confidence.

Multivariate analysis and backwards (stepwise) linear regression were conducted to establish the relationship between each of the study variables. The analysis determined that measured scores for the perceived assimilator (Kolb, 1984) cognitive style and metacognitive monitoring were moderately significant predictors of problem solving confidence as evidenced by a regression model that explained 20.5% of the expected variance.
How Perceived Cognitive Style, Metacognitive Monitoring, and Epistemic Cognition Indicate Problem Solving Confidence

by

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BIOGRAPHY

Steven Mitchell Price was born in Kansas City, Missouri yet has lived in several states through his lifetime eventually residing in North Carolina. He earned a bachelor of arts in Liberal Studies in 1981 and a bachelor of science in Chemistry in 1983 from California State University Fullerton. He also earned a bachelor of science in Industrial Engineering in 1985 from California State Polytechnic University Pomona before going on to graduate work. Mr. Price earned a Master of Business Administration in 1992 from Fairleigh Dickenson University and a Master of Public Administration from North Carolina State University in 2005.

He began in professional career in 1980 as an analytical chemist within the petroleum industry and continued in that field until discovering the allure of project management and organizational development. For over twenty five years Mr. Price has been a successful business analyst, program manager, and organizational development consultant working in both public and private settings. His career has taken him to the premier consulting practices and Fortune 500 companies serving within industries such as chemical, construction, pharmaceutical and biotechnology, manufacturing, software development, and training and development. In 2005 Mr. Price began his doctoral studies with the intent of integrating twenty five years of experience and a multidisciplinary education into a platform to advance his passion for organizational development research and practice.

Mr. Price is the son of Gerald and Ann Price and currently lives with his wife Sandra and their two daughters Kara and Megan in Wake Forest, North Carolina.
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CHAPTER ONE
INTRODUCTION

Contemporary society is an organizational society (Presthus, 1962) and a society of organizations (Drucker, 1993) that enjoins individual adult professionals as participants, clients and customers, and citizens (Warriner, 1984) in a world of problems and problem solving activities (Bennis, 1969). The economic, social, and political prominence of organizations has positioned individuals operating within organizational environments as the vanguard for identifying and solving complex problems. The notion of a complex problem is based upon ill-structured or everyday (Sinnott, 1989) problems that often have vaguely defined goals (Voss, 1988), posses multiple solution paths (Kitchner, 1983), and potentially have multiple, non-guaranteed solutions (Schraw, Dunkle, & Bendixen, 1995). Arguably solving complex problems has become a value-added critical competency (Jonassen, 1997) and necessity for professional practice (Bereiter & Scardamalia, 1993) in today’s organizations.

Increasingly adult professionals operating within organizational environments are exposed to a wider array of complex problems that require faster solutions, demand higher accuracy, and have a decreasing tolerance for failures (Jablokow, 2005). Several authors (Ackoff, 1974; Perrow, 1984; King, 1993; Mitroff, 1998; Jablokow, 2005) have suggested that awareness of problem complexity and ability to solve an ever-increasing array of highly-interconnected “systems” problems (i.e. capacity) pose considerable challenges for individuals and organizations that face a relentless need for innovation and performance improvement (Tornatzky & Fleischer, 1999).
Contemporary organizations have addressed this problem solving challenge by developing software and using software systems to enhance existing problem solving capacity and leverage technology innovation (Tornatzky & Fleischer, 1999). Although DeGrace and Stahl (1990) argue that software development is equivalent to solving complex problems, the difficulty experienced in these projects and organizational environments (Anton, 2003; Jongbae & Wilemon, 2003) suggests there is still a need to enhance individual problem solving capacity. This phenomenon provides the context for the present study and exploratory lens through which complex problem solving can be examined relative to enhancing the capacity to identify and solve ill-structured problems.

Problem solving capacity has been conceptualized within the cognitive literature as “how much” (e.g. short-term memory buffer) or “how well” (e.g. efficiency of information processed) which is analogous to the electronic counterpart of bandwidth which measures information exchange and processing per unit of time (Wegner & Townsend, 2000). The linkage between information processing and problem solving has been well established with Newell and Simon’s (1972) information processing theory which serves as the foundation for today’s problem solving research. Consequently this study argues there is a need to enhance individual problem solving capacity to identify and solve ill-structured problems in order to meet existing and emerging problem solving demands. The question becomes, “how can training and development professionals develop better problem solvers by enhancing their capacity to solve ill-structured (complex) problems (Frederiksen, 1984; Heppner, 1988; Mayer, 2002)?”
Developing better problem solvers has been a central focus of education (Dewey, 1933; Apps, 1973; Gagné, 1980) and professional development (Bridges & Hallinger, 1992; Moroco & Sullivan, 1999; Piskurich, Bechsci, & Hall, 1999). Although problem solving is inherently a social phenomenon (Ellis & Siegler, 1994), learning to solve ill-structured problems within organizations is exemplified by both unstructured (informal) workplace learning or through structured approaches such as professional development. However research indicates less than ten percent of organizational learning actually occurs in professional development venues (Baldwin & Ford, 1988; Broad & Newstrom, 1992; Tannenbaum, 1997) which suggests current approaches are contributing to the variability of the desired outcomes (Geissler, 1996).

The “traditional” hierarchical models of learning and instructional design assume problem solving is a linear process that builds upon a progressive assembly of concepts, rules, and principles to arrive at a solution (Jonassen, 1997). This is true for well-structured problems (e.g. math problems), but decidedly incorrect for ill-structured problems (e.g. software design) thereby not supporting or enhancing the advanced understanding required for ill-structured problems. As Jonassen (2000) suggested, different types of problems require different approaches to instructional design and program delivery.

One prominent problem-based approach used for professional development platforms has been problem-based learning (PBL) (Lohman, 2002) due to its intuitive appeal as the process of working towards the understanding and resolution of a problem (Barrows & Tamblyn, 1980). Although the curricular content is organized around problem scenarios rather than subjects or disciplines (Savin-Baden, 2000), problem-based approaches to
professional development have struggled to improve problem solving capacity (Albanese & Mitchell, 1993; Patton, 1994; Torres, Preskill, & Pointek, 1999). The research regarding the efficacy of problem-based approaches suggests assessment is the missing element (Gijbelsa, van de Watering, & Dochyc, 2005) that provides the “evidence of how and whether students organize, structure, and use information in context to solve complex problems” (Baxter & Glazer, 1998, p.40). Consequently the ability to assess problem solving strategy preferences and baseline capacity is an important diagnostic tool (Morrison, Ross, & Kemp, 2004) that can be used to improve problem-based professional development programs seeking to improve ill-structured problem solving capacity.

Although problem solving assessment instruments do exist (Heppner, 1988; O’Neil & Schacter, 1997), their psychometric properties and evaluative methods leave Human Resource Development (HRD) professionals with few cognitive options to assess problem solving skills in the workplace (Lohman, 2002). The assessment constraints identified from the problem solving literature reveals assessment in controlled environments with limited contexts, small sample sizes, and using qualitative research techniques such as protocol analysis (Ge & Land, 2004) focus on behavioral (i.e. observable) elements thus insufficient to gauge problem solving capacity. Conversely, the HRD assessment literature is decidedly directed toward process as a developmental approach (Patton, 1994) and transfer through formative approaches to refine existing programs or summative assessments for individual post-interventional assessments (Schriven, 1991).

Arguably the ability to assess baseline problem solving capacity requires a focus on the cognitive elements (Mayer, 2002) of ill-structured problem solving (Kitchener, 1983) to
alleviate assessment constraints (Lohman, 2002) and transcend formative and summative strategies (Schriven, 1991; Patton, 1994). An exploratory study (Gregory, 2004; Babbie, 2007) is proposed to investigate the value of cognitive variables, rather than behavioral (i.e. observable) variables as the diagnostic foundation for developing or enhancing ill-structured problem solving capacity for adult professionals who develop software and software systems to solve ill-structured problems.

When capacity is portrayed as how much do individual problem solvers understand about solving ill-structured problems and how well do they identify and solve ill-structured problems, then problem solving success becomes a combination of problem solving confidence (Heppner, 1988) and perceived self-efficacy (Bandura, 1982) to affirm the chosen course of action (Bandera, 1991). Consequently assessment of problem solving confidence gauges individual problem solver self-assurance (Heppner, 1988) when engaging ill-structured problems by focusing on the cognitive elements that undergird the problem solving process (Mayer, 2002). As Mayer (2002) argues, developing better problem solvers is dependent upon using cognitive theories of problem solving as the assessment diagnostic rather than behavioral characteristics to assess baseline problem solving preferences and overall capacity. Given Jonassen’s (1997, 2000) contention that the difference between well-structured and ill-structured problems require different solution approaches, then examining the cognitive variables that differentiate these two solution strategies requires further examination within the context of adult professionals who develop software or use software systems to solve ill-structured problems.
The notion of elements that differentiate the ultimate solution process between well-structured and ill-structured problems became apparent with Kitchener’s (1983) hierarchical model of cognitive processing for ill-structured problems. The model expanded the purely cognitive elements of problem solving (Bransford & Stein, 1983) by invoking epistemic cognition to explain solution justification thereby transcending problem solving as merely process (Kitchener, 1983). The model contends there are fundamental epistemic cognitive differences between well-structured and ill-structured problem solving, thereby suggesting evaluation of the cognitive influences of ill-structured problem solving may support a generalized assessment of problem solving capacity.

The next section develops the theoretical foundation for the present study by examining the cognitive elements described by Kitchener’s (1983) hierarchical model of cognitive processing. In this regard Kitchener’s (1983) hierarchical model of cognitive processing is examined relative to the perception of problem solving confidence (Heppner, 1988) for successful ill-structured problem solving.
Theoretical Foundation

The present study argued that cognitive elements, rather than behavior elements, were required to develop a diagnostic foundation for enhancing ill-structured problem solving capacity for adult professionals who develop software and software systems to solve ill-structured problems. The theoretical foundation for the present study is based upon the hypothetical relationship between Kitchener’s (1983) hierarchical model of cognitive processing for ill-structured problems and problem solving confidence (Heppner, 1988) as illustrated in Figure 1.

![Diagram of Kitchener’s Hierarchical Cognitive Processing Model](image)

*Figure 1. Theoretical Foundation for Ill-Structured Problem Solving Using Kitchener’s (1983) Hierarchical Cognitive Processing Model*
According to Kitchener’s (1983) model well-structured problems can be solved by using level 1 (cognitive engagement) and level 2 (metacognitive monitoring of level 1) skills. The interplay between processing information (cognitive engagement of level 1) and monitoring the chosen strategy and solution progress (cognitive monitoring of level 2) is characteristic of well-structured problems (Jonassen, 1997).

However when ill-structured problems are considered, a third level is exhibited when the problem solver develops epistemological doubt (Bendixen, 2002) because previously successful strategies and processes may no longer work as expected. Thus solving ill-structured problems requires epistemic cognition (level 3) that allows the problem solver to deal with uncertainty in knowing and weighing conflicting evidence claims for problem solving solutions (King & Kitchener, 2002).

Each of these cognitive elements of cognitive engagement, metacognitive monitoring, and epistemic cognition warrants closer examination to evaluate their interplay and to develop the psychometric parameters necessary for developing a diagnostic baseline for problem solving confidence. The next section reviews each cognitive element within the context of Kitchener’s (1983) model and relationship to problem solving confidence (Heppner, 1988).

The first level of Kitchener’s (1983) model involves cognitive engagement with ill-structured problems through general cognitive ability. Cognition or cognitive ability is a covert, un-measurable process that has been richly debated in cognitive psychology, connectionist modeling, and neurobiology to understand the higher functions of the human brain (Changeux & Dehaene, 1989).
Although cognition or cognitive ability cannot be directly measured, the job performance literature encapsulates many definitions of cognitive ability as individual capacity to process and comprehend information (Murphy, 1989; Waldman & Spangler, 1989). Cognitive ability has been used by multiple theorists to describe and measure individual instructional preferences, information processing style, and cognitive personality style (Curry, 1983). Thus a plausible measure of cognitive engagement required to operationalize Kitchener’s (1983) first level for solving ill-structured problems is cognitive style.

In elemental terms, cognitive style defines the bipolar dimension of processing information in integrated wholes or discrete parts which reinforces a dominant view that there are two qualitatively different types of thinking (Nickerson, Perkins, & Smith, 1985). The present study defines and operationalizes cognitive style as the preferred structural and process orientations that individuals exhibit as they gather, process, and evaluate information (Hayes & Allinson, 1998) to perceive, think, solve problems, learn, and relate to others (Witkin, Moore, Goodenough, & Cox, 1977). This definition was crafted for its alignment with Kitchener’s (1983) first level of cognitive engagement relative to solving ill-structured problems. Thus cognitive style and its associated psychometric measure are proposed to evaluate Kitchener’s (1983) level 1 factor.

The relationship between cognitive style and problem solving confidence is based upon Newell and Simon’s (1972) information processing theory which serves as the foundation for today’s problem solving research. Accordingly, cognitive ability, i.e. gathering and processing information, is a combination of long and short term memory
exchanges that operates within a self-framed problem space. Thus information gathering and processing forces individuals to make judgments about the sufficiency and adequacy of information available for problem solving (Browne & Pitts, 2004).

Although there are numerous learning (cognitive) style models (Coffield, Moseley, Hall, & Ecclestone 2004), the ultimate selection criteria of psychometric soundness, ease of administration, and the theoretical acceptability within adult education and professional development (Michelson,1996; Fenwick, 2000) supported Kolb’s (1984) experiential learning theory (ELT). The four “cognitive” styles (divergent, converger, assimilator, and accommodator) proposed by Kolb (1984) suggests that how experience is transformed and information processed may affect problem solving confidence through a perceptual dimension and a processing dimension. The next section expands upon cognitive style as information processing by examining how individuals metacognitively monitor information in use.

Metacognitive monitoring of cognitive engagement (i.e. level 1 skill) is the second level of Kitchener’s (1983) model. The metacognitive factor represents the interactions of knowledge, experiences, goals, and strategies that mediate cognition as a purely covert process with its overt counterparts of knowledge and regulation of the cognition process (Flavell, 1979). Although metacognition is an elusive construct with a variety of definitions, applications, and interpretations (Sigler & Tallent-Runnels, 2006) it is most broadly defined as awareness and control of one’s learning (Baker & Brown, 1984).

Metacognitive research is largely anchored to metacognitive knowledge and metacognitive control (Flavell, 1979; Baker & Brown, 1984; Brown, 1987; Jacobs & Paris,
Schraw and Dennision (1994) define metacognitive knowledge as awareness of cognition and knowledge of strategy selection and application which is segregated into declarative, procedural, and conditional knowledge (Brown, 1987; Jacobs & Paris, 1987; Schraw & Moshman, 1995). Conversely, metacognitive control is defined as “knowledge about planning, implementing, monitoring, and evaluating strategy use” (Schraw & Dennision, 1994, p.471). Metacognitive control provides the processing and use of regulatory strategies through planning, information management, monitoring, debugging, and evaluation to facilitate cognitive performance (Baker & Brown, 1984; Flavell, 1979; Schraw & Moshman, 1995).

The present study focuses on metacognitive control (i.e. monitoring) because it represents the mediating process between cognitive processing and problem solving engagement. This does not suggest metacognitive knowledge is unimportant but that strategy selection is subordinate to the explorative nature of metacognitive control. The rationale for focusing on metacognitive control is because those with superior structural knowledge and experience may be perceived as better problem solvers although they simply possess more knowledge and not necessarily more problem solving capacity.

The connection between metacognition and problem solving (Flavel, 1979; Kitchener, 1983; Brown, 1987) is well established as both knowledge and process (Paris, 2002) that facilitates problem solving by 1) identification and definition, 2) mental representation and relationships, 3) procedural planning, and 4) evaluation and reflection (Sternberg, 1986; Davidson, Deuser, & Sternberg, 1994; Metcalfe & Shimamura, 1994; Brand, Reimer, & Opwis, 2003). As Gourgey (1998) suggests, cognitive strategies enable
problem solvers to make progress and build knowledge but metacognitive strategies enable problem solvers to monitor and improve progress and develop an understanding of how to apply knowledge in new situations. This is consistent with the premise of Kitchener’s (1983) second level of the cognitive hierarchy for solving ill-structured problems. In this regard, metacognitive monitoring and its associated psychometric measures are proposed to evaluate Kitchener’s (1983) level 2 factor.

Given there are virtually no psychometrically valid instruments to measure or probe for metacognitive qualities (Buros Institute, 2008), the selection criteria for Schraw and Dennison’s (1994) Metacognitive Awareness Index (MAI) is based upon the numerous studies (Brand, Reimer, & Opwis, 2003) conducted using the MAI to gauge individual awareness and use of metacognition relative to reading comprehension and mathematics. The next section moves from information processing and monitoring toward challenging the veracity and content of the information itself through epistemological doubt.

The third level of Kitchener’s (1983) model suggests the uncertainty of weighing conflicting knowledge claims and the veracity of available information (King & Kitchener, 2002) produces epistemological doubt (Bendixen, 2002) when dealing with ill-structured problems. The doubt and uncertainty over strategy and process is ultimately reflected in the justification of the chosen solution. Although epistemology is often conceptualized within traditional philosophical inquiry as the search for true knowledge (Hoffer & Pintrich, 1997), in the cognitive realm epistemology becomes an individual focus (i.e. personal epistemology) that tests the veracity of information and knowledge, balanced by the justification of knowledge claims (Schommer, 1994).
Personal epistemology relates to the problems solving confidence through individual understanding of the nature of human knowledge and the ability to justify a specific course of action (Hofer, 2004). The present study focuses on personal epistemology (i.e. epistemic cognition) as the operationalization of Kitchener’s (1983) third level of ill-structured problems solving. In this regard epistemic cognition is encapsulated by how individuals come to know, the theories and beliefs they hold about knowing, and the manner in which these epistemological premises influence cognition and reasoning (Hofer & Pintrich, 1997).

The influence of how individuals come to know and the beliefs they hold about knowing is important for problem-solving because it requires individuals to “consider the veracity of ideas and multiple perspectives while evaluating problems or solutions” (Jonassen, 2000, p.70).

Instruments designed to measure epistemological traits have proven to be difficult to administer and interpret (Buros Institute, 2008). Although Schommer’s (1990) Epistemological Questionnaire was the first validated attempt to measure personal epistemology, Schommer (1990) was unable to yield all the theoretical dimensions with a 63 question instrument. Consequently Schraw, Dunkle, and Bendixen (1995) developed the Epistemic Beliefs Inventory (EBI) to correct the factor loadings predicted in Schommer’s (1990) EQ using only 32 questions. Thus the EBI was selected for the present study based upon the psychometric validation ascribed to multiple studies. In this regard, epistemic cognition and its associated psychometric measure are proposed to evaluate Kitchener’s (1983) level 3 factor. The next section moves from the cognitive elements described by

Problem solving confidence is an individual’s self-assurance and belief that their problem-solving abilities and coping effectiveness are synchronized (Heppner & Lee, 2002). Consequently problem solving performance is based upon the belief and tenacity for a particular course of action (Bandura, 1982) which ultimately results in self-appraisal of problem solving success (Heppner & Krasuskopf, 1987). The present study suggests problem solving confidence is a diagnostic factor for identifying and solving ill-structured problems. Empirical research suggests understanding effective and ineffective problem solving is instrumental for developing better problem solvers and making healthy life adjustments (Heppner, Witty, & Dixon, 2004).

The prevalent choice of assessing problem solving confidence is Heppner’s (1988) Problem Solving Inventory (PSI). The PSI assesses perceptions of one’s problem solving ability as well as behaviors and attitudes associated with problem solving style (Heppner, 1988; Heppner & Baker, 1997). The inventory does not assess actual problem-solving skills but rather the perception of problem-solving beliefs and style. This instrument has been validated in over 120 studies (Heppner, Witty, & Dixon, 2004) and continues to be used predominantly in counseling psychology. The model for the present study suggests that measures for problem solving confidence (Heppner, 1998) when related to Kitchener’s (1983) model of hierarchical cognitive processing for ill-structured problems provide the elements of a diagnostic framework to enhance individual problem solving capacity.
Problem Statement

The present exploratory study measured perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing as an indicator for problem solving confidence (Heppner, 1988). Given the limited cognitive assessment options identified within the problem solving (Ge & Land, 2004) and HRD literatures (Schriven, 1991; Russ-Eft & Preskill, 2001; Mayer, 2002) for HRD professionals in the workplace (Lohman, 2002), the problem addressed by the present study is how to develop a cognitively-based assessment diagnostic that addresses the behavioral limitations of previous research (Ge & Land, 2004). This study argues these cognitive indicators may be used as a diagnostic foundation for improving ill-structured problem solving capacity for adult professionals who develop software or use software systems to solve ill-structured problems.

Purpose of the Study

The purpose of the present study was to measured perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing as an indicator for problem solving confidence (Heppner, 1988). The study argues these cognitive indicators may be used as a diagnostic foundation for improving ill-structured problem solving capacity. The fundamental relationship suggests that problem solving confidence (PSC) is a function of cognitive style (LSI), metacognitive monitoring (MAI), and epistemic cognition which can be expressed as PSC = f (LSI+MAI+EBI).
The present study targets adult professionals who develop software and use software systems to solve ill-structured problems. The targeting rationale suggests these professionals have a vested interest in improving problem solving capacity as a value-added critical competency (Jonassen, 1997) and necessity for professional practice (Bereiter & Scardamalia, 1993) in today’s knowledge-intensive organizations.

Significance of the Problem

The significance of the problem addressed by the present study comes from the notion of problem solving as a “knowledge asset” that drives technology innovation. Technology innovation is the “introduction of knowledge-derived tools, artifacts, and devices (that help people) extend their environment” (Tornatzky & Fleischer, 1999, p.11). When contextualized within the process of solving ill-structured problems, software and the professionals who develop and use it introduces a critical aspect of problem solving as innovation.

The significance of developing better problem solvers comes from a long trajectory involving the post-industrial focus on technical-scientific expertise (Galbraith, 1967), development of a service economy that valued intellectual technology (Bell, 1969), and the emergence of knowledge work as the vehicle for value-added problem solving (Drucker 1986; Reich, 1993). This is particularly true for how software is designed and used in modern organizations to identify, formulate, solve, or prevent ill-structured problems. Arguably the ability to adapt and innovate depends upon the capacity to solve complex problems in organizational settings.
The significance of developing better problem solvers by understanding the cognitive factors that contributes to successful problem solving, hence advancing innovation, is evidence by Kitchener’s (1983) hierarchical model of cognitive processing. This study suggests the significance of understanding the covert elements (i.e. cognitive elements) is necessary to drive innovation by developing broader problem solving awareness. As such a diagnostic foundation for assessing individual problem solving confidence is proposed as the precursor for customized professional development programs that utilize problem-based learning strategies to enhance individual problem solving capacity.

Research Questions and Associated Hypotheses

The present exploratory study measured perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing as an indicator for problem solving confidence (Heppner, 1988).

The research questions emanate from how the independent variables (perceived cognitive style, metacognitive monitoring, and epistemic cognition) impact or influence the dependent variable, problem solving confidence and how differences between individual adult professionals who develop software and use software systems to solve ill-structured problems. The research questions and their associated hypotheses for the present study are described as follow.

Research Question 1 and Hypotheses \( H_1 \)

Is there a relationship between perceived cognitive style and problem solving confidence as reported by adult professionals who develop software and use software systems to solve ill-structured problems?
H1: Hypothesis number one suggests differences in perceived cognitive style (diverger, converger, assimilator, and accommodator) proposed by Kolb (1984) will have an influence on problem solving confidence.

*Research Question 2 and Hypothesis H2*

Is there a relationship between metacognitive monitoring and problem solving confidence as reported by adult professionals develop software and use software systems to solve ill-structured problems?

H2: Hypothesis number two suggests higher degrees of metacognitive monitoring (Schraw & Dennsion (1994) are indicative of higher problem solving confidence.

*Research Question 3 and Hypothesis H3*

Is there a relationship between epistemic cognition and problem solving confidence as reported by adult professionals who develop software and use software systems to solve ill-structured problems?

H3: Hypothesis number three suggests higher degrees of epistemic cognition (Schraw, Dunkle, & Bendixen, 1995) are indicative of higher problem solving confidence.

*Research Question 4 and Hypothesis H4*

Does perceived cognitive style, metacognitive monitoring, and epistemic cognition explain a significant amount of variance in problem solving confidence as reported by adult professionals develop software and use software systems to solve ill-structured problems?

H4: Hypothesis number four suggests the cumulative influence of the independent variables will explain a significant amount of variation relative to problem solving confidence.
Limitations of the Study

The results of the present exploratory study are limited to the variables which measure perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing as an indicator for problem solving confidence (Heppner, 1988). The results specifically focus upon ill-structured problem solving for adult professionals who develop software and use software systems to solve ill-structured problems irrespective of gender, education, or experience.

The limitations of the study are based upon its exploratory nature (Babbie, 2007) and the inherent limitations of both Kitchener’s (1983) hierarchical cognitive processing model (Schraw, Dunkle, & Bendixen, 1995) and the problem solving confidence construct (Heppner, 1988). The results of the present study also suggest self-report instruments may not accurately measure problem solving confidence because “learners have poor insight into their own behavior” (Prins, Veenman, & Elshout, 2006, p.375). In this regard, the key point of assessment effectiveness rests upon the assumption that individuals want to be assessed and are motivated to identify their problem solving skill gaps (Ryan, Brutus, Greguras, & Hakel, 2000). Thus the primary limitations of the present study rests with the argument that the selected cognitive indicators and the chosen data collection method may be used as a diagnostic foundation for improving ill-structured problem solving capacity for adult professionals who develop software or use software systems to solve ill-structured problems.
Assumptions

The assumptions for the present study include conducting problem solving research without actually solving a problem and the effects of organizational context can be minimized by focusing on cognitive rather than behavioral or environmental factors. The following sections expand upon the assumptions for the present study.

The first assumption suggests problem solving research must involve a problem to be solved rather than evaluating the factors that influence the problem solving task. Although task analysis is well-represented in problem solving research (Greeno, 1978; Kitchner, 1983; Voss; 1988; Jonassen, 1997) it is primarily derived from observing problem solvers in controlled settings using protocol analysis as the analytical framework. Given ill-structured problems have no single correct answer to judge performance (Jonassen, 2000) because their iterative and evolutionary process often ends with a solution that is a consensual and tentative agreement, the rational suggests directly solving the problem is inconsequential to understanding the dynamics of Kitchener’s (1983) cognitive processing hierarchy.

The second assumption seeks to minimize the effects of organizational context. Clearly the identification and solution of ill-structured problems is influenced by the context in which problem solving engagement occurs. The limitation is addressed by using Kitchener’s (1983) model to focus upon three cognitive variables that have corresponding psychometric instruments rather than attempt a larger multivariate analysis. This assumption draws from the failure of organizational effectiveness research (Cameron, 1981) to accurately portray the variables that comprise organizational context (Porras & Silvers, 1991) thereby within the present study context is assumed to be “neutral”.

20
Summary

This present study argues that the relentless need for innovation and performance improvement (Tornatzky & Fleischer, 1999) has created the need for greater ill-structured problem solving awareness and capacity. The population chosen for this study was comprised of adult professionals who develop software and use software systems to solve ill-structured problems because the notion of problem solving as a “knowledge asset” drives technology innovation consequently enhancing problem solving capacity is a value-added critical competency (Jonassen, 1997) needed for professional practice (Bereiter & Scardamalia, 1993) in today’s organizations.

The limited assessment options identified within the problem solving (Ge & Land, 2004) and HRD literatures (Schriven, 1991; Russ-Eft & Preskill, 2001; Mayer, 2002) suggests current strategies and psychometric instruments leave HRD professionals with few options to assess problem solving skills in the workplace (Lohman, 2002) thereby warranting closer examination of the cognitive elements required for problem solving (Mayer, 2002).

Correspondingly this exploratory study measured perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing as an indicator for problem solving confidence (Heppner, 1988). This study argues these cognitive indicators may be used as a diagnostic foundation for improving ill-structured problem solving capacity for adult professionals who develop software or use software systems to solve ill-structured problems.
CHAPTER TWO
LITERATURE REVIEW

Introduction

The present exploratory study examined the relationship between perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing as an indicator for problem solving confidence (Heppner, 1988). The study argued that cognitive, rather than behavior, elements were required to develop a diagnostic foundation for developing or enhancing ill-structured problem solving capacity for adult professionals who develop software and software systems to solve ill-structured problems.

This chapter establishes the study’s conceptual framework through graphic representation, outlines relevant study concepts, and reviews related literature and research to address the study research questions. The chapter is organized by 1) the conceptual framework for the study, 2) the nucleus of problem solving research 3) the problem solving lifecycle for ill-structured problems, 4) assessing problems solving capacity and confidence, 5) perceived cognitive style and problem solving confidence, 6) metacognitive monitoring and problem solving confidence, 7) epistemic cognition and problem solving confidence, and 8) chapter summary.

Conceptual Framework for the Study

The conceptual framework for the present study is based upon a fundamental relationship between the cognitive elements of ill-structured problem solving according to Kitchener’s (1983) model of hierarchical cognitive processing and the dependent variable of...
problem solving confidence (Heppner, 1988). The Osborn-Parnes Creative Problem Solving (CPS) (Osborne, 1963; Parnes, 1988) model was selected to facilitate the research discussion given its cognitive focus on divergent and convergent thinking and justification terminus. These qualities embody Kitchener’s (1983) model and Heppner’s (1988) confidence construct thereby providing a contextual framework for solving ill-structured problems as illustrated by Figure 2.

![Figure 2. Integrating Problem Solving with Kitchener’s Model, Osborn-Parnes Creative Problem Solving (CPS), and Heppner’s Problem Solving Confidence](image-url)

The remainder of this chapter discusses the foundational elements that provide the diagnostic foundation for improving ill-structured problem solving capacity for adult
professionals who develop software or use software systems to solve ill-structured problems. This chapter continues by examining the nucleus of problem solving research.

**The Nucleus of Problem Solving Research**

Jonassen (2000) argues that problem solving varies according to the problem type, problem representation, and individual differences between problem solvers whereby the solution strategy and problem solving process ultimately depend upon understanding the “structure” of the problem. Problem structure refers to how well the problem variables are defined and how well their relationships are established relative to each other (Partridge & Hussain, 1995). Consequently, the problem solving literature differentiates problems as either well-structured (Reitman, 1965; Neisser, 1976; Greeno, 1978), ill-structured (Reitman, 1965; Kitchner, 1983; Voss; 1988; Jonassen, 1997), and un-structured (Rittel & Webber, 1973).

Well-structured (tame) problems (Reitman, 1965; Simon, 1973; Neisser, 1976; Greeno, 1978) are “puzzles” (Neisser, 1976, Kitchner, 1983) or predictable because they are prescribed in advance, agreed to by all parties, and are unchanging within their solution timeframe (Radford, 1977). In general terms, well-structured problems consist of all elements of the problem, a known goal state, and all constraints are known. Well-structured problems can be solved in isolation of other problems, usually follow disciplinary lineages, and tend to be procedural and linear in which the ends, goals, and means of the problem are prescribed and apparent.

The next structural level involves the ill-structured or ‘everyday’ problem (Sinnot, 1989). Ill-structured problems have vaguely defined goals (Voss, 1988), posses multiple
solution paths (Kitchner, 1983), and do not have “known” solutions thereby making their solution strategies highly contextual and their stopping point judgmental (Reitman, 1965; Voss; 1988, Jonassen, 1997). These problems tend to be iterative and evolutionary wherein the problem formulation evolves from a problem statement that must be validated against a prescribed body of knowledge. Ill-structured problems can be prescribed in advance by a higher authority or mutually discovered, however their exploration often involves elements of consensus and conflict. Ill-structured problems tend to be explorative and non-linear in which the ends, goals, and means of the problem are specified.

The final structural level is called un-structured or ‘wicked’ (Rittel & Webber, 1973). Wicked problems have gradually emerged into academic prominence through the work of regional planners who encountered multiple, conflicting objectives and goals in their planning activities. Wicked problems also tend to be highly controversial and rarely remain static. These problems are complex and chaotic because there is no definitive problem formulation strategy or solution end point, thus a trial and error approach is indicative of the evasiveness of clear objectives and goals. Wicked problems are the most problematic because 1) you don’t understand the problem until you have developed a solution, 2) they are unique and novel, 3) they have no defined stopping point and no given alternative solution, and 4) their solution is a “one shot operation” that is likely controversial (Rittel & Webber, 1973). Wicked problems are, in large part, the overarching problems of society such as global warming.

Problem solving research has largely focused (Nickerson, 1994) on task analysis, mental constructs, or behavioral characteristics of problem-solving using well-structured,
domain-specific problems using the underpinnings of Newell and Simon’s (1972) information processing theory. The majority of the research was conducted in controlled environments with limited contexts, relying upon small sample sizes, and using qualitative research techniques such as protocol analysis (Ge & Land, 2004). The primary outcomes of this research has identified the differences between well-structured and ill-structured problem solving (Kitchner, 1983; Chi & Glaser, 1985; Voss & Post, 1988; Sinnott 1989) and the strategies employed between novice and expert problem solvers (Chi & Glaser, 1985). Table 1 illustrates the comparative framework that outlines key problem (structural) traits and the contextual differences discussed within the problem solving research.
### Table 1

*Summary of Problem Characteristics*

<table>
<thead>
<tr>
<th>Description and Objectives</th>
<th>Well-Structured (Tame)</th>
<th>Ill-Structured (Real World)</th>
<th>Un-Structured (Wicked)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics and Objectives</td>
<td>Procedural and linear; can be solved in isolation; the ends, goals, and means are prescriptive and apparent</td>
<td>Explorative and nonlinear; the ends, goals, and means are specified; the answer is consensual and controversial</td>
<td>Complex and chaotic; no definitive problem formulation; tend to be highly controversial and irreversible; often unique and novel</td>
</tr>
<tr>
<td>Disciplinary Involvement</td>
<td>Intra-disciplinary</td>
<td>Multi or inter disciplinary</td>
<td>Trans-disciplinary</td>
</tr>
<tr>
<td>Formulation and Solution Strategy</td>
<td>Analytical and algorithmic</td>
<td>Iterative and evolutionary</td>
<td>Trial and error without a formal strategy</td>
</tr>
<tr>
<td>Outcomes and Solution</td>
<td>Known with a fixed sequence (deterministic)</td>
<td>Known with a variable sequence (probabilistic)</td>
<td>Unknown with any sequence (emergent)</td>
</tr>
<tr>
<td>Example</td>
<td>Geometric math problem</td>
<td>Software design</td>
<td>National policy</td>
</tr>
</tbody>
</table>

The focus of this study is the ill-structured or *everyday* (Sinnott, 1989) problems that comprise the majority of problems encountered in innovative organizational settings. Correspondingly, this study excludes well-structured problems given their broad representation in the problem solving literature and un-structured (wicked) problems because...
they comprise the larger problems of society such as global warming that remain largely
controversial and insoluble (Rittel & Webber, 1973).

Although three types of problem structure are generally described in the literature,
there are several problem definitions (Checkland, 1981; Margetson, 1998) offered to match
the particular research interests. This study defines problems within the context of
Kitchener’s (1983) model as a felt need (Arlin, 1989; Dewey, 1991) to change the current
state (problem) to a future goal state (solution) (Mitroff, 1999; Jonassen, 2000) by choosing
an answer that is believed to be true and justifiable (Goldman, 1986).

One notable outcome of problem solving research indicates that the processes used
for well-structured problem solving are also fundamentally those used for ill-structured
problems (Simon, 1973), however different components are required to reach solutions
(Reitman, 1965; Kitchener, 1983). The notion of components or factors that differentiate the
ultimate solution process between well-structured and ill-structured problems became
apparent with Kitchener’s (1983) model of hierarchical cognitive processing for ill-structured
problems. The model contends well-structured problems leverage cognitive and
metacognitive abilities, however ill-structured problems invoke epistemic cognition because
there is epistemological doubt (Bendixen, 2002) regarding the course of action and
justification argument.

The realization that problem solving performance for ill-structured problems requires
developing consensual agreements that challenge the veracity of information and ideas until a
solution is reached that is believed to be true and justifiable. Consequently performance is
based upon the belief and tenacity for a particular course of action (Bandura, 1982) which
ultimately results in self-appraisal of problem solving success (Heppner & Krasuskopf, 1987). This study predicts problem solving confidence has the cognitive counterparts indicated by Kitchener’s (1983) model of hierarchical cognitive processing for ill-structured problems and is associated with problem-solving performance but not necessarily problem-solving effectiveness (Heppner, Witty, & Dixon, 2004). The next section describes a probable lifecycle for solving ill-structured problems. Although there are multiple problem solving models, the selection of the Osborn-Parnes Creative Problem Solving (CPS) (Osborne, 1963; Parnes, 1988) best exemplifies the design problems encounters by individual adult professionals who develop software and use software systems to solve ill-structured problems. The next section extends the problem solving research by discussing the unique nature of the ill-structured problem solving lifecycle.

The Problem Solving Lifecycle for Ill-Structured Problems

Problem solving research has evolved from solving well-structured, domain-specific problems (Reitman, 1965; Simon, 1973) all based on the underpinnings of Newell and Simon’s (1972) information processing theory despite the realization that real-world problems are ill-structured (Neisser, 1976). The research has disclosed the differences between well-structured and ill-structured problem solving (Kitchner, 1983; Chi & Glaser, 1985; Voss & Post, 1988; Sinnot 1989) and the strategies employed between novice and expert problem solvers (Chi & Glaser, 1985) although little research has been conducted outside of specific domains or using quantitative methods.

Although there are multiple problem-solving models proposed for well-structured problems (Bransford & Stein, 1983; Rowe, 1985) specific adaptations to ill-structured problems...
problems involves a) representing the problem space then initiating information search, b) generating solutions and selecting options, and c) developing a support justification for the solution selected (Sinnot, 1989; Voss and Post, 1988).

Ill-structured problems involve both divergent (producing a large number of ideas) and convergent (converging on best ideas) thinking to understand the problem and evaluate the solution strategy. There are two prominent forms of ill-structured problem exhibited within organizational settings. Design problems are characterized by divergent thinking to pursue multiple options through open inquiry (Couger, 1996). The goal of design problems is to explore future possibilities and preferences, to structure the problem, and to determine what choices are available. Conversely, choice problems require convergent thinking whose information search goal is to select one or more available options (Couger, 1996). The interaction of divergent and convergent thinking culminates in establishing the stopping point for information search and solution justification. As Browne and Pitts (2004) note, failures to gather adequate and appropriate information can have strong negative impacts on the eventual problem-solving effort. Thus “information gathering requires that the individual make a judgment regarding the sufficiency of the information obtained and then decide whether to acquire additional information” (Browne & Pitts, 2004, p.209).

The judgment of stopping point and assessment of solution viability is a critical component of the solution strategy. There are conflicting goals of effectiveness (acquiring accurate and appropriate information) and efficiency (not wasting time and money on information that is not needed). Thus the cost of accurate information becomes an issue with design problems because it may difficult to assess true costs and benefits given their value
may not be determined until “much later in the decision-making process, if at all” (Browne &. Pitts, 2004, p. 210).

Jonassen (2000) argues that generalized characterizations of problem-solving models are descriptively useful but they “tend to treat all problems the same in an effort to articulate a generalizable problem-solving procedure” (p.65). However, given the complex nature of ill-structured problem solving, the Osborn-Parnes Creative Problem Solving (CPS) (Osborne, 1963;Parnes, 1988) model can be used to illustrate the interplay between process and the cognitive elements described within this study because it is expressly developed from interaction between divergent and convergent thinking. The model occupies the central position in figure 1 and depicts six stages as 1) data input, 2) inferences, 3) evaluation, 4 solution finding, 5) justification, and 6) acceptance finding) to identify the problem and develop a solution strategy. Thus the CPS serves as the integration point to explain the connection between Kitchener’s (1983) cognitive elements and Heppner’s (1988) problem solving confidence construct. Each of these constructs are examined in subsequent sections.

According to Kitchener’s (1983) model, well-structured problems can be solved by using level 1 (cognitive engagement) and level 2 (metacognitive monitoring of level 1) skills. The notion of well-structured problems as linear and procedural, suggests the problem solver can rely upon predictable methodology and accepted rules to engage the problem. Accordingly, the cognitive and metacognitive load (i.e. level of effort) is relatively stable. Interestingly it is the metacognitive aspect that helps the problem solver recognize the problems and select an appropriate solution strategy. Metacognitive awareness allows the
problem solver to gauge the solution process and make corrections or modification as required until there is need to make a value interpretation.

When encountering ill-structured problems, a third level (epistemic cognition) to challenge the nature and limits of knowledge is required to augment levels 1 and 2 because one aspect of the problem solving process develops as epistemological doubt (Bendixen, 2002) thus prompting epistemological engagement. Therefore solving ill-structured problems requires epistemic cognition that allows the problem solver to deal with uncertainty in knowing and weighing conflicting evidence claims for problem solving (King & Kitchener, 2002). The next integration point in Figure 1 is Heppner’s (1988) problems solving confidence construct.

The psychological literature has successfully linked problem solving with problem-focused coping (Lazarus & Folkman, 1984). The relationship is encapsulated by the definition of problem solving as the interplay of cognitive, affective, and behavioral processes that individuals use to cope with problems encountered in daily living (D’Zurilla & Nezu 1982; Heppner & Krauskopf, 1987) which expands Anderson’s (1980) notion of problem solving as goal-directed cognitive operations. The linkage of coping as a ‘felt need’ for change from a stressor which can be alleviated by solving a problem that is creating the stress (i.e. problem-focused coping) is well-established in the healthcare, psychological, and counseling literature (Heppner & Baker 1997). As Heppner and Krasuskopf (1987) note, ultimately problem solving confidence comes from the notion of coping and adaptation and the resultant self-appraisal of problem solving success.
Problem solving performance for ill-structured problems relies upon developing consensual agreements that challenge the veracity of information and ideas until a solution is reached that is believed to be true and justifiable. Problem solving confidence is an individual’s self-assurance in a wide range of problem-solving activities and a belief and trust in one’s problem-solving abilities and coping effectiveness (Heppner & Lee, 2002). Consequently performance is based upon the belief and tenacity for a particular course of action (Bandura, 1982) which ultimately results in self-appraisal of problem solving success (Heppner & Krasuskopf, 1987).

Accordingly empirical research strongly suggests understanding effective and ineffective problem solving is instrumental for developing better problem solvers and making healthy life adjustments (Heppner, Witty, & Dixon, 2004). One key issue with assessing successful problem is selecting an assessment instrument (Heppner, 1988; O’Neil & Schacter, 1997) that operationalizes the notion of problem solving confidence within organizational settings (Lohman, 2002). The next section discusses the issues with assessing problem solving capacity and its impact on problem solving confidence.

Assessing Problem Solving Capacity and Confidence

There is a distinct need to understand problem solving capacity because individuals, organizations, and society are exposed to a wider array of problems that require faster solutions, demand higher accuracy, and have decreasing tolerance for failures (Jablokow, 2005). The notion of problem solving capacity rather than problem solving skills or ability connotes a higher degree of problem solving prowess that enables the problem solver to operate holistically across domains, perspectives, and boundaries.
According to Wegner and Townsend (2000) ‘capacity’ has been conceptualized within the cognitive literature as ‘how much’ (e.g. short-term memory buffer) or ‘how well’ (e.g. efficiency of information processed). These perspectives on capacity are analogous to the electronic counterpart of ‘bandwidth’ which measures information exchange and processing per unit of time. The bandwidth analogy, as a range of measurable performance, has a counterpart with assessing ones’ ability to identify, formulate, solve, or prevent problems. Given the individual variability exhibited when solving problems (Jonassen, 1997), assessment poses considerable challenges. The notion of bandwidth as a range of potential values has an individual counterpart with one’s ability to reason through, cope with, and adapt to perplexing situations using their knowledge and experience, i.e. the idea of how much and how well (Levenson, & Neuringer, 1971).

Problem solving capacity is the degree of individual prowess displayed when identifying, formulating, solving, or preventing problems. Consequently, the individual variability exhibited suggests problem solving capacity can be developed, augmented, used, or modified to increase problem solving awareness, improve problem solving strategies, and enhance problem solving performance. The issue of how to assess capacity in relation to the confidence displayed requires careful consideration to quantify the relationship.

Problem solving assessment has been operationalized as a combination of problem solving confidence, approach-avoidance style, and personal control as factors which has proven useful for “indicating how participants are likely to utilize resources or respond to training workshops” (Heppner, 1988, p.3). The present study contends that problem solving confidence is associated with problem-solving performance but not necessarily problem-solving effectiveness (Heppner, Witty, & Dixon, 2004). In this regard, problem solving
confidence is predicated upon the cognitive counterparts indicated by Kitchener’s (1983) model of hierarchical cognitive processing for ill-structured problems.

The prevalent choice of assessing problem solving confidence is Heppner’s (1988) Problem Solving Inventory (PSI). The PSI assesses perceptions of one’s problem solving ability as well as behaviors and attitudes associated with problem solving style (Heppner, 1988; Heppner & Baker, 1997). The inventory does not assess actual problem-solving skills but rather the perception of problem-solving beliefs and style. This instrument has been validated in over 120 studies (Heppner, Witty, & Dixon, 2004) and continues to be used predominantly in counseling psychology. The next section describes the first level of Kitchener’s (1983) hierarchical model through perceived cognitive style.

Perceived Cognitive Style and Problem Solving Confidence

Cognitive style is the preferred structural and process orientation that individuals exhibit as they gather, process, and evaluate information (Hayes & Allinson, 1998). The cognitive factor represents the first level of Kitchener’s (1983) model where the individual problem solver formulates the ill-structured problem solution strategy and processes as a cognitive operation. This section provides an overview of the relevant research in cognitive style and problem solving preferences as they apply to gathering and processing information. The research is examined to justify Kolb’s (1984) model of experiential learning and corresponding psychometric instrument to support Kitchener’s (1983) level 1 processing.

Within the cognitive style research literature there are several competing theories from which to choose for their effect and influence on problem solving strategies (Coffield, Moseley, Hall, & Ecclestone, 2004). Given the large number of theories, Riding and Cheema
(1991) have proposed that cognitive styles can be reduced to two dimensions as: 1) wholists and analytics and 2) verbalizers and visualizers. Within the wholist-analytic dimension, information is processed as an integrated whole or in discrete parts of a larger whole. The wholists are “big picture” thinkers who struggle with details and detail-oriented connections. Analytics grasp ideas and concepts in detail, however they have difficulty with integration. Conversely the verbaliser-imager dimension processes information in either words or pictures. Verbalizers perform best at verbal tasks, while imagers do better with descriptive, and imaginative tasks that have visual representation (Riding & Cheema, 1991). The notion of bipolar dimensions is consistent with the view that there are fundamentally two qualitatively different types of thinking (Nickerson, Perkins, & Smith, 1985).

Coffield, Moseley, Hall, and Ecclestone (2004) conducted a systematic study of seventy one learning style models to outline their merits and develop an improved research agenda. Based upon a selection criteria using citation volume, the presence of explicit theory, and theoretical acceptance, only thirteen models were deemed adequate for examination and use. Hall and Mosely (2005) extended the study by developing a taxonomy segregating learning styles into fixed traits, personality-based, and developmental characteristics. The combination of these two studies suggests the selected theory should match elements of the taxonomy and align with one of thirteen primary models. This criteria, the immense impact of experiential learning theory (Michelson, 1996; Fenwick, 2000), and instrument selection criteria requiring psychometric soundness, ease of administration, and the theoretical acceptability within adult education and professional development suggests Kolb’s (1984)
model of cognitive style is relevant and applicable for assessing the cognitive connection to problem solving confidence.

Kolb’s (1984) model of cognitive style is derived from experiential learning theory (ELT) that defines learning as “the process whereby knowledge is created through the transformation of experience. Therefore knowledge results from the combination of grasping and transforming experience” (Kolb, 1984, p. 41). ELT is based upon six fundamental premises which are encapsulated as learning is a holistic, cyclic process that requires the resolution of conflict to synergize existing and new knowledge to facilitate adaptation and congruence between the individual learning and environment (Kolb, 1984). The four “cognitive” styles (diverger, converger, assimilator, and accommodator) proposed by Kolb (1984) suggests that how experience is transformed and information processed may affect problem solving confidence through the perceptual dimension and a processing dimension. Figure 3 illustrates the relationship between assessing and transforming experience according to experiential learning theory.

![Figure 3. The Relationship Between Assessing and Transforming Experience in Experiential Learning Theory](image-url)
Experiential learning theory views learning from a perceptual dimension (concrete experience or abstract conceptualization) and through a processing dimension (active experimentation or reflective observation). According to the model, the cycle begins with concrete experience and progresses through reflective observation on the experience. Based upon the outcome, theory building or abstract conceptualization occurs. The final phase tests the theory through active experimentation to once again arrive at a new, transformed concrete experience. The model is predicated upon preferences and predispositions that individuals exhibit as they encounter different portions of the cognitive cycle. The theoretical argument suggests individuals have variable skills and abilities hence they favor (i.e. perceive they favor) one cognitive dimension over another.

Kolb’s (1984) model adheres to bipolar dimensions as active-reflective and abstract-concrete. The active-reflective dimension describes how experience influences information processing through direct participation to encourage active experimentation (AE) or through detached observation to favor reflective observation. Conversely the abstract-concrete dimension describes information processing as relating to tangible objects as concrete experience (CE) or embracing theoretical concepts as abstract conceptualization (AC). These dimensions are combined to determine the dominant ‘learning’ style. Accordingly the styles are classified as divergers, convergers, accommodators, and assimilators.

The corresponding instrument to measure Kolb’s (1984) learning styles is the Learning Style Inventory (LSI) (Kolb & Kolb, 2005). The LSI is based upon experiential learning theory and the corresponding learning styles that range from the active-reflective dimension to the abstract-concrete dimension. There are also linkages to the Myers-Briggs
Type Indicator (Myers-Briggs, 1962) that suggests the extroversion/introversion dimension corresponds to active-reflective dimension and that the feel/thinking dimension corresponds to the abstract-concrete dimensions (Kolb, 1984). The correlation to extroversion as an energy source from social settings and the internal reflection for sense-making of introverts is consistent with the active and reflective stances posited by ELT. Additional studies (Furnham, Jackson, & Miller, 1999) have correlated sensing (accommodating), feeling (diverging), thinking (converging), and intuitive (accommodating) dimension to their corresponding learning styles. How each of these learning styles relate to problem solving confidence in an important consideration for operationalizing Kitchener’s (1983) first level of cognitive processing. The following section discusses how each of the perceived cognitive (learning) styles impacts the problem solving process.

Divergers have concrete experience and reflective observation as their dominant learning abilities. Their predisposition toward ‘learning by doing’ and exploring possibilities and divergent thinking offers a culturally-sensitive, open-minded problem solver (Kolb, 1984, Kolb & Kolb, 2005). Divergers are introverted, big picture thinkers that process information reflectively according to their values and feasibility of options generated. As problem solvers, divergers are inductive and imaginative, preferring to generate ideas rather than engaging abstract thought and scenarios. They are particularly useful in the problem formulation stages of the problem solving process. Consequently the diverger problem solver justifies solution strategy and process by securing personal reassurances and building consensus for the selected direction and stopping point. Given their profiles, divergers are predicted to have a negative valance for problem solving confidence since they prefer
divergent (i.e. producing ideas and options) thinking and sense-making rather than analytical decisiveness.

Convergers have abstract conceptualization and active experimentation as their dominant learning abilities. Convergers are motivated to find practical use for innovative ideas and theories. Their predisposition toward technology and analytical skills places them as independent thinkers who prefer contemplative environments rather than collaborative exercises. Convergers are extroverted, task-oriented whose affinity for theories and ideas makes them avid readers and information gatherers. As problem solvers, convergers are extroverts whose intellectual draw to experimentation and demonstrating how things work as practical application makes convergers decisive problem solvers (Kolb 1984, Kolb & Kolb, 2005). The converger actively seeks answers thus they are very comfortable in the later stages of the problem solving cycle with evaluation and acceptance finding activities. Given their profiles, convergers are extroverted, decision makers with propensity for technical jobs in medicine and engineering thus the rational suggests their practicality provide more problem solving confidence. Thus their problem solving confidence valence is predicted to be positive.

Accommodators have concrete experience and active experimentation as their dominant learning abilities. Arguably, accommodators are ‘hands-on’ learners who prefer an action first approach to learning and problem solving (Kolb 1984, Kolb & Kolb, 2005). Accommodators display goal driven, action-oriented behavior that focuses on doing versus thinking thus they are deductive problem solvers who rely upon sensory input for their information gathering and often defer to experts rather than their own analytical skills. As
problem solvers, accommodators are extroverted, action taker that may have a tendency to disengage from highly complex problems if there is no tangible answer thus the rational suggests they have mixed problem solving confidence. The notion of maintaining progress toward a goal places them in the later part of the problem solving cycle as decision makers who prefer to evaluate ideas and suggestions thus arriving at an acceptable solution quickly in order to engage the next objective. Given their profiles, accommodators are predicted to have a variable (partially positive and negative) valance for problem solving confidence since they are action oriented, thereby preferring quick solutions rather than protracted analysis or information gathering.

Assimilators have abstract conceptualization and reflective observation as their dominant learning abilities. Assimilators are the thinkers within Kolb’s (1984) schema. They prefer logical conversations that provide congruence with their desire to understand and control the problem solving environment. The use of models and logical theories suggests assimilators prefer orderly information search and careful analysis rather than the messiness of collaborative efforts. They are ideally suited in the solution finding and evaluative portion of the problem solving cycle because their methodical approach seeks closure to problems through satisfying rules and making sense of the proposed solution. The assimilator is an introverted, complex thinker that has a tendency toward science and information jobs that require creative thinking thus the rational suggest they seek problem solving opportunities. Thus their problem solving confidence valence is predicted to be positive. Table 2 illustrates the cognitive styles. Scores on the LSI will be used to correlate perceived cognitive style to problem solving confidence. Each cognitive style (e.g. diverger) is calculated based upon the
LSI scoring criteria. Table 2 illustrates the interpretation of cognitive styles as they relate to information searching, problems solving process, and stopping point justification criteria.

Table 2

*Kolb’s Learning Style Characteristics*

<table>
<thead>
<tr>
<th>Learning Style</th>
<th>Traits</th>
<th>Information Search</th>
<th>Problem Process</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diverger</td>
<td>Multiple points of view; idea generators; cultural acuity; open minded</td>
<td>Introverted; gatherers through observation; filters by values and merits</td>
<td>Inductive; alternatives and value propositions; imaginative; difficulty with abstraction</td>
<td>Emotive; personal; seek feedback; feelings; consensus for value congruity</td>
</tr>
<tr>
<td>Converger</td>
<td>Practical application of theory and ideas</td>
<td>Extroverted; task oriented; focused search through perceptions</td>
<td>Deductive; experiment; options development; seeking cause and effect; single correct answer</td>
<td>Goal satisfaction; less socially oriented; logical connections</td>
</tr>
<tr>
<td>Accommodator</td>
<td>Hands on; gut feel</td>
<td>Extroverted; sensory input; defer to others for expertise</td>
<td>Deductive; goal oriented; application and practicality; trial and error</td>
<td>Team consensus</td>
</tr>
<tr>
<td>Assimilator</td>
<td>Ideas and abstract concepts; seek logical soundness</td>
<td>Introverted; logical ordering; reading; reflective</td>
<td>Inductive; diminished view of practicality; reliance on models</td>
<td>Rules and logic; explanation rather than solution</td>
</tr>
</tbody>
</table>
Kolb’s (1984) experiential learning theory and corresponding learning style inventory (Kolb & Kolb, 2005) operationalizes Kitchener’s (1983) level 1 cognitive influence for ill-structured problem solving. The next section moves from cognitive style as how information is processed and experience leveraged to solve ill-structured problems toward the regulation and monitoring of cognitive activity through metacognition.

**Metacognitive Monitoring and Problem Solving Confidence**

Metacognition is most broadly defined as awareness and control of one’s learning (Baker & Brown, 1984). The metacognitive factor represents the interactions of knowledge, experiences, goals, and strategies that mediate cognition as a purely covert process with its overt counterparts of knowledge and regulation of the cognition process (Flavell, 1979). This section provides an overview of the relevant research in metacognition and problem solving preferences as they apply to monitoring the cognitive operations of ill-structured problems solving. The research is examined to justify Schraw and Dennison’s (1994) notion of metacognitive awareness and corresponding psychometric instrument to support Kitchener’s (1983) level 2 processing.

Metacognitive research has several interpretations (Sigler & Tallent-Runnels, 2006) and research foci between strategy selection and knowledge, strategy use and self-appraisal, and cognitive monitoring (Chmiliar, 1997). Metacognition has been explained as knowledge, experiences, and strategies of metacognition (Flavell, 1979), the planning, monitoring, and regulating process (Brown, 1987), and self-appraisal and self-management (Paris & Winograd, 1990). Metacognitive research has evaluated individual differences (Baker, 1989; Brown & Campione, 1986), feeling of knowing (Cary & Reder, 2000), judgments of learning
(Koriat & Reichert, 2002), metacognitive ecology (Valot, 2002) and metacognitive awareness (Schraw & Dennision, 1994).

Metacognitive research, relative to ill-structured problem solving, has largely settled into metacognitive knowledge and metacognitive control (Schraw & Dennision, 1994). Research has shown that internally-generated metacognitive activities are more effective than their externally imposed counter part because “the point of metacognition is self-regulation, not regulation by others” (Gourgey, 1998, p.84). This suggests self-appraisal and self-management (Paris & Winograd, 1990) are the essence of the construct, thus increasing greater awareness through teaching, prompting, or scaffolding can improve metacognitive performance hence problem solving performance. Several authors have noted the need for more evidence to assess the impact of metacognition skills and knowledge on expert performance (Masui & DeCorte, 1998), influences on problem-solving activity (Lester, 1998), and specifically the role of metacognition on ill-structured problem-solving (Jonassen, 2000).

Previous metacognitive research has relied upon protocol analysis (Sternberg, 1986; Davidson, Deuser, & Sternberg, 1994; Metcalfe & Shimamura, 1994; Brand, Reimer, & Opwis, 2003). Given the reliance on direct observation to assess metacognitive knowledge and regulation is both costly and inefficient, self-reported measures were developed to assess metacognitive awareness (Schraw & Dennision, 1994) thus alleviating overt intervention. However “the assessment of metacognitive skills through self-reports is problematic because it appears that learners have poor insight into their own behavior” (Prins, Veenman, & Elshout, 2006, p.375). Everson and Tobias (1998) note that self-reported measures are more
efficiently administered than “think aloud” protocols, however their validity has been questioned thus contributing to the lack of research “conducted on the metacognitive processes related to learning in adults” (p.66).

There are virtually no psychometrically valid instruments to measure or probe for metacognitive qualities (Buros Institute, 2008). Thus the selection criteria for Schraw and Dennison’s (1994) Metacognitive Awareness Index (MAI) is based upon the numerous studies (Brand, Reimer, & Opwis, 2003) conducted using the MAI to gauge individual awareness and use of metacognition relative to reading comprehension and mathematics.

The MAI has two subscales. The present study used the monitoring subscale because metacognitive monitoring enables individuals to evaluate problem solving strategy and process in use (Schraw & Dennision, 1994) through the functions of planning (goal setting and allocating resources), information management sequencing and efficiently processing information, monitoring (assessment of strategy in use), debugging (correcting comprehension and performance), and evaluation (analysis of performance) (Baker & Brown, 1984; Flavell, 1979; Schraw & Moshman, 1995). Successful problem solving involves the ability to compare and evaluate problem solving strategies, whereby expert problem solvers possess a higher degree of “assessment awareness” (through domain knowledge). The ability to gauge which strategies and information are relevant and viable is essential for developing key learning strategies (Everson & Tobias, 1998).

The MAI monitoring subscale is based upon Schraw and Dennision’s (1994) original five dimensions through planning, information management, monitoring, debugging, and evaluation. How each of these dimensions relate to problems solving confidence is an
important consideration for operationalizing Kitchener’s (1983) second level of cognitive processing. The following section discusses how each of the dimensions impacts the problem solving process. Figure 4 illustrates the relationship between the metacognitive monitoring subscales and their influence on problem solving confidence.

Planning is a proactive exercise of setting goals allocating resources to attain each goal. When ill-structured problem solving is considered, “metacognition steers the problem-solving process and increases the effectiveness of goal-oriented behavior” (Brand, Reimer, & Opwis, 2003, p.252) thus there is a need to evaluate the effectiveness of metacognitive strategies during the problem solving process (Sigler & Tallent-Runnels, 2006).

Figure 4. The Metacognitive Monitoring Subscales and Their Relationship to Problem Solving Confidence.
Information management involves sequencing and efficiently processing information. Metacognition has implications for explaining knowledge transfer since metacognitive knowledge and regulation are instrumental in developing problem awareness and the subsequent attempts at modulating strategy in use (Brand, Reimer, & Opwis, 2003, p.252).

Monitoring requires the assessment of strategy in use. The relationship between metacognition and problem solving confidence is evidenced by ability appraisal versus metacognitive control to evaluating strategic options (Baker & Brown, 1984; Flavell, 1979; Schraw & Moshman, 1995) which suggests confident problem solvers use each in tandem to solve ill-structured problems. As Cary and Reder (2002) note “monitoring processes must exist, because strategy use has been shown to be influenced by the prior success of each strategy. The information gleaned from monitoring may be used later to facilitate selection of the best strategy when the person reencounters a problem of the same type” (p.64).

Debugging is making corrections to comprehension and performance through a series of questions based upon prior knowledge. As Sternberg (1998) suggests abilities are not necessarily fixed, but rather forms of developing expertise. Debugging is a higher-order metacognitive skill that presupposes prior knowledge through the use of principles, rules, and heuristics (Jonassen, 1997).

Evaluation involves the analysis of performance. The shift from problem solving as a concrete process to monitoring and evaluation is the shift from cognitive to metacognitive (Brand, Reimer, & Opwis, 2003). Consequently evaluation often focuses upon past performance in order to improve future prospects for success.
Scores on the MAI monitoring subscale will be used to correlate the degree of monitoring awareness that individual exhibit in these five dimensions against the corresponding numeric score. Higher scores indicate advanced monitoring capability and potentially a higher degree of problem solving confidence. Schraw (1998) argues that “individuals high on the metacognitive awareness dimension may use this knowledge to compensate for domain-specific knowledge” (p.117) however is cautious to suggest more research is required. Using metacognitive awareness as a surrogate for quantifiable measures such as test performance supports empirical evidence for metacognitive skill (Schraw & Dennsion, 1994). Table 3 illustrates the interpretation of the metacognitive monitoring levels as they relate to information search, problem solving process, and problem endpoint justification criteria.
<table>
<thead>
<tr>
<th>Metacognitive Monitoring</th>
<th>Traits</th>
<th>Information Search</th>
<th>Problem Process</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Complete balance between all knowledge with heavy emphasis on procedural and conditional knowledge</td>
<td>Broad scanning and soliciting environmental feedback; problem formulation guides the search process</td>
<td>Complete balance of control function with emphasis on planning and management; mature problem solver with problem solving confidence</td>
<td>Congruence with validating existing knowledge and extending knowledge base</td>
</tr>
<tr>
<td>Medium</td>
<td>Emerging balance in all knowledge with heavier procedural focus</td>
<td>Probing and seeking confirmatory information to bolster previous knowledge</td>
<td>Reasoned balance between management and control with emphasis on management and debugging; emerging traits to suggest problem solving growth trajectory</td>
<td>Recognition of established patterns and validation of existing knowledge</td>
</tr>
<tr>
<td>Low</td>
<td>Relies primarily upon declarative and procedural knowledge</td>
<td>Rules based search or limited browsing</td>
<td>Relies on information management; low confidence in problem solving</td>
<td>Satisfactory resolution of preliminary information search and residual feedback</td>
</tr>
</tbody>
</table>
The ability to assess the degree of metacognitive monitoring provides a valuable diagnostic relative to monitoring and controlling cognitive engagement with ill-structured problems. Schraw (1998) notes “cognitive skills tend to be encapsulated within domains or subject areas, whereas metacognitive skills span multiple domains even when those domains have little in common” (p.116). The notion of monitoring and controlling cognitive skills across domains is consistent with the multi and trans-disciplinary nature of ill-structured problem solving.

The next section extends the metacognitive influences on ill-structured problem solving into an epistemological influence. As Bendixen (2002) suggests, when epistemological doubt challenges metacognitive monitoring, another level is required to solve ill-structured problems (Kitchener, 1983).

Epistemic Cognition and Problem Solving Confidence

Personal epistemology (i.e. epistemic cognition) is what “individuals believe about the source, certainty, and organization of knowledge, as well as the control and speed of learning” (Schommer, 1994, p. 293). The epistemic cognition factor helps individuals evaluate the veracity of ideas and information relative to their justification of selected solutions (Jonassen, 2000) and as a measure of problem solving success (Heppner, 1988). This section provides an overview of the relevant research in epistemic cognition and problem solving preferences as they apply to evaluating the cognitive and metacognitive operations of ill-structured problem solving. The research is examined to justify Schraw, Dunkle, and Bendixen’s (1995) psychometric extension of Schommer’s (1994)
epistemological processing model and corresponding psychometric instrument to support Kitchener’s (1983) level 3 processing.

Epistemological research has developed alone three themes of inquiry as progressive phases, epistemological assumptions, and epistemological beliefs (Hofer & Pintrich, 1997). The contribution of each research foci provides the foundation upon which Kitchener’s (1983) model of hierarchical cognitive processing for ill-structured problems is substantiated.

The structural and developmental theme is dominated by Perry’s (1970) scheme of intellectual and ethical development. Although the developmental aspect of epistemology is a galvanizing foundation for subsequent epistemic formulations, the focus strays from the essence of how epistemic cognition influences problem solving. In this regard, the theme concentrates on epistemological growth rather than execution. Consequently this study is not concerned with epistemological development as the basis for assessing problem solving capacity. The next research focus on epistemological assumption more closely models the ill-structured problem solving behavior.

The focus on epistemological assumptions is evidenced by King and Kitchener’s (1994) reflective judgment model and Kuhn’s (1991) theories of argumentation. The impact of these works is substantial; however the earlier works of Kitchener (1983) in multiple level cognitive processing is the exemplar from this theme. The essence of Kitchener’s (1983) model delineates three “levels” required for solving ill-structured problems as 1) cognition, 2) metacognition, and 3) epistemic belief. In effect the model suggests well-defined problems can be solved using level 1 (cognitive engagement) and level 2 skills (metacognitive monitoring of level 1 activity) versus ill-structured problems which require levels 1 and 2, as
well as, level 3 (epistemic cognition to challenge the nature and limits of knowledge). Given the strength of Kitchener’s (1983) model (Schraw, Dunkle, & Bendixen, 1995), a suitable measure of epistemic cognition is required to test the influence of personal epistemology on ill-structured problem solving.

The final theme regarding epistemological beliefs is the integration point of Schommer’s (1990) work. According to this body of research, epistemological beliefs are a multidimensional construct that evolves with time and situational demands. The realization that epistemology operates like a ‘frequency distribution’ with vacillating gradations of absolute to relativistic modulations provides a new focus on epistemological development as a continuum rather than a distinct phase. The next sections discuss the influence of epistemic cognition on ill-structured problem solving.

As Kuhn and Weinstock (2002) note, “maturity and life experience, particularly educational experience, are often mentioned as the most likely contributors to the development of epistemological understanding” (p.138). The notion of developing in programmatic phases has been challenged by research that suggests life experience is not sufficient to prompt epistemological change (Kuhn & Weinstock, 2002) but rather contextual influences (Hammer & Elby, 2002) and more importantly epistemological doubt prompts conceptual change when current beliefs no longer work as they had in previous situations (Bendixen (2002). Accordingly, Schommer (1990) postulated that beliefs are more equivalent to a frequency distribution that vacillates between gradations of acceptance and uncertainty relative to epistemological beliefs.
Schommer’s (1990) work provided the multidimensional construct that suggested learners’ possess varying degrees of belief in knowledge as either certain, to be discovered, or evolving. Schommer’s (1990) research suggested there were at least five dimensions: “the structure, certainty, and source of knowledge, and the control and speed of knowledge acquisition (p.498)”. These original hypothesized dimensions included beliefs about the following: 1) the structure of knowledge (ranging from isolated bits and pieces to integrated concepts), 2) the stability of knowledge (ranging from unchanging to continually changing), 3) the source of knowledge (ranging from handed down by authority to derived from empirical evidence and reasoning), 4) the speed of learning (ranging from quick all-or-none to gradual), and 5) the ability to learn (ranging from fixed at birth to improvable over time and experience).

The Epistemological Questionnaire (EQ) (Schommer, 1990) was developed to test the construct and provide further evidence of epistemological modulation. Although the psychometric qualities of the EQ have been substantiated (Schommer, 1990; Kardash & Sinatra, 2003). Schommer (1990) was unable to yield the omniscient authority dimension with a 63 question instrument. Consequently Schraw, Dunkle, and Bendixen (1995) developed the Epistemic Beliefs Inventory (EBI) to correct the construct validity in Schommer’s (1990) EQ and using only 32 questions. Thus the EBI was selected for the present study based upon the psychometric validation ascribed to multiple studies (Schraw, Dunkle, & Bendixen, 1995). Figure 5 illustrates the relationship between the epistemic cognition subscales and their influence on problem solving confidence.
The EBI is based upon Schommer’s (1990) original five dimensions as structure, stability, and source of knowledge and the control and speed of knowledge acquisition. How each of these dimensions relates to problem solving confidence is an important consideration for operationalizing Kitchener’s (1983) third level of cognitive processing. The following sections discuss how each of the dimensions impacts the problems solving process.

The structure and organization of knowledge is envisioned as a continuum from knowledge being compartmentalized and simple to knowledge being highly integrated and “interwoven” as complex configurations. Individuals who believe knowledge is simple rely
upon simple problem schemata because they have strong recall (i.e. memorization) yet poor transfer skills. Conversely, strong believers in complex knowledge structures will demonstrate more complex information search behavior, yet their recall will be “slower because their search will be through a network instead of a list” (Schommer, 1998, p.133). Hammer and Elby (2002) discovered that expert and novice problem solvers did not necessarily display a unitary epistemology, but rather a complex array of contextually derived and situationally executed epistemologies when solving problems. Problem solvers with a sophisticated knowledge structure and organization demonstrate stronger problem formulation schemata and innovative thinking, thus their problem solving confidence is stronger than their epistemologically naïve counterpart.

The certainty of knowledge relates to the possibility of knowledge as being an absolute, fixed constant, or constantly evolving phenomena. The avoidance of ambiguity and deferral to deterministic thinking prevails with strong believers in simple and certain knowledge. Their problem response seeks the single answer that avoids grey areas and speculation. Conversely, when knowledge is believed to be complex and interconnected, multiple solution scenarios are entertained. Thus problem solvers with mature perspectives concerning knowledge stability, i.e. knowledge is complex and evolving, display innovative approaches to problem solving either through information search of solution strategy development. Consequently, sophisticated epistemological perspectives should correlate to greater problem solving confidence.

Knowledge has several sources over a range of being ‘handed down by an omniscient authority, to knowledge as ‘reasoned out through objective and subjective means’
The choice of problem solution strategies may in some cases remain un-attempted since the ‘experts’ are tackling the problem or as an exploratory stance that strives to reason through the issues and constraints.

The source of knowledge influences both individuals and individuals within collaborative environments to a large extent because information search and justification are based upon the reliability of the information source chosen. In general terms, a sophisticated problem solver will challenge the source of information if there are conflicting perspectives brought out during the problem solving process. Considering the veracity of knowledge source and available information (Joassen, 2000) suggest sophisticated epistemological judgment (King & Kitchener, 2002) will challenge available knowledge, information, and data to demonstrate a high degree of problem solving confidence.

Controlling knowledge acquisition is based upon the notion of ‘genetic hardwiring’ that our ability and performance with learning is predetermined, as opposed to, the ability to learn is based upon experience and exposure. The perception of mistakes and their implications is extremely relevant for belief in how knowledge is controlled. Strong believers in fixed learning ability interpret their mistakes “as a reflection of their inadequacy” thus disengaging from the problem attempt prematurely or simply failing to attempt multiple solution paths. Conversely, those who believe mistakes are opportunities to learn tend to persist in solution attempts and often develop an intense interest in studying further and remaining tenaciously engaged in the problem solution process. The confident problem solver is a continuous learner.
The speed of knowledge acquisition is envisioned as a distribution that runs the gamut from believing learning is ‘quick or not-at-all to learning is a gradual process’ (Schommer, 1990, p. 301). The notion of time investment becomes a critical factor when ‘quick learning’ is involved. Those with strong beliefs in the ‘easy way’ tend to operate in spurts with the preconception of time as fixed investment. The counterpart suggests the belief in gradual learning will yield to an exploratory phase to probe and understand the problem. Their time investment is gauged by progress toward the solution goal and is constantly modified and reevaluated during the solution process.

Scores on the EBI will be used to correlate the degree of epistemological maturity that individual exhibit in these five dimensions against the corresponding numeric score. Higher scores suggest advanced maturity and potentially higher degrees of problem solving confidence. Table 4 illustrates the interpretation of the epistemic cognition levels as they relate to information searching, problem solving process, and problem endpoint justification criteria.
**Table 4**

*Epistemic Cognition Characteristics*

<table>
<thead>
<tr>
<th>Epistemic Level</th>
<th>Traits</th>
<th>Information Search</th>
<th>Problem Process</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mature</td>
<td>Believes knowledge is a complex, ever-evolving process that can be learned gradually</td>
<td>Experimentation and networked information search; adaptable and questions assumptions; tenacious search</td>
<td>Complex schemata; broad transfer; systems orientation; entertains multiple solution scenarios; mistakes are learning opportunities</td>
<td>Single or multiple answers; experimentation and networked information search; adaptable and questions assumptions; tenacious search</td>
</tr>
<tr>
<td>Emergent</td>
<td>Believes knowledge has fixed and emerging elements that can be learned</td>
<td>Combination of recall and marginal experimentation</td>
<td>Intermediate schemata that can be enhanced with intervention</td>
<td>Single or multiple answers; entertains multiple solution scenarios; mistakes are learning opportunities</td>
</tr>
<tr>
<td>Naive</td>
<td>Believes knowledge is relatively fixed and constant and that learning is based on innate skills</td>
<td>Strong recall and memorization using a list; avoids ambiguity; defers to experts; limited search commitment</td>
<td>Simple schemata; poor transfer; deterministic; seeks single solution; mistakes reveal inadequacy</td>
<td>Single answer derived from clear schematic pathway; Simple schemata; poor transfer; deterministic; seeks single solution; mistakes reveal inadequacy</td>
</tr>
</tbody>
</table>
Schommer’s (1990) epistemological construct combined with Schraw Dunkel, and Bendixen’s (1995) Epistemological Beliefs Inventory offer a powerful combination to explain Kitchener’s (1983) level 3 processing for ill-structured problems. The theoretical correlation suggests higher scores on the EBI equate to a higher degree of epistemic cognition as derived from the dimensions. Thus individuals with greater personal epistemological maturity are predicted to be more confident problem solvers.

Summary

The relationship between perceived cognitive style, metacognitive awareness, and epistemic cognition as hypothesized indicators of problem solving confidence offers promise for assessing problem solving capacity within organizational settings and professional development programs. The literature review suggests the demand for improved problem solving capacity, the strength of the theoretical linkages proposed for this present study, and the lack of valid and applicable assessment instruments for HRD practitioners warrants closer examination.

The literature review for the present study covered by 1) the nucleus of problem solving research 2) the problem solving lifecycle for ill-structured problems, 3) assessing problems solving capacity and confidence, 4) perceived cognitive style and problem solving confidence, 5) metacognitive monitoring and problem solving confidence, and 6) epistemic cognition and problem solving confidence.

The nucleus of problem solving research disclosed a multi-year progression from extensive research on well-structured problems culminating in Newell and Simon’s (1972) landmark work in information processing. Subsequent efforts focused on the differences
between well-structured and ill-structured problems, their solution strategies, and the difference between novice and expert problem solvers. Collectively the research indicated gaps in problem solving assessment, especially using quantitative techniques, which prompted this study to evaluate the cognitive elements of ill-structured problem solving. This study argued that measures of perceived cognitive style, metacognitive monitoring, and epistemic cognition as outlined by Kitchener’s (1983) model provide the diagnostic foundation for assessing individual problem solving confidence.

Evaluating the problem solving lifecycle for ill-structured problems disclosed an intricate interplay between problem formulation and its subsequent justification process. Within the idealized schema of the Osborn-Parnes Creative Problem Solving (CPS) (Osborne, 1963; Parnes, 1988) model the stepwise evaluation of ill-structured problems as first a design problem, then a choice problem, illustrates the convergent and divergent thinking that surrounds these consensually-derived problems.

Assessing problem solving capacity and confidence disclosed two important considerations for ill-structured problem solving. The notion of problem solving capacity rather than problem solving skills or ability connotes a higher degree of problem solving prowess that enables the problem solver to operate holistically across domains, perspectives, and boundaries. In this regard, capacity was introduced as “bandwidth” (Wegner & Townsend, 2000). Conversely, problem solving confidence is an individual’s self-assurance and belief that their problem-solving abilities and coping effectiveness are synchronized (Heppner & Lee, 2002).
The organization of the literature review according to previous research and a discussion of solution strategies set the stage for Kitchener’s (1983) hierarchical model of ill-structured problem solving.

The first level of Kitchener’s (1983) model involves cognitive engagement with ill-structured problems through general cognitive ability. The cognitive literature reveals several competing theories from which to choose for their effect and influence on problem solving strategies (Coffield, Moseley, Hall, & Ecclestone, 2004). Ultimately Kolb’s (1984) experiential learning theory was selected for its overall merit relative to the present study. The next section expands upon cognitive style as information processing by examining how individuals monitor information in use.

The second level of Kitchener’s (1983) model involves metacognitive monitoring of one’s cognitive engagement (i.e. level 1 skills). The metacognitive factor represents the interactions of knowledge, experiences, goals, and strategies that mediate cognition as a purely covert process with its overt counterparts of knowledge and regulation of the cognition process (Flavell, 1979). The next section moves from information processing and monitoring toward challenging the veracity and content of the information itself through epistemological doubt.

The third level of Kitchener’s (1983) model suggests the uncertainty of weighing conflicting knowledge claims and the veracity of available information (King & Kitchener, 2002) produces epistemological doubt (Bendixen, 2002) when dealing with ill-structured problems. Given the problem definition and solution for ill-structured problems must be
justified, the notion of invoking epistemic cognition provides the final level of support for Kitchen’s (183) model.

The present study argued that cognitive, rather than behavioral, elements were required to develop a diagnostic foundation for developing or enhancing ill-structured problem solving capacity for adult professionals who develop software and use software systems to solve ill-structured problems. Examination of the literature reveals considerable research has been conducted relative to the elements described by this study and allows ample opportunity to expand upon the body of knowledge by using a quantitative focus directed toward how ill-structured problems are identified, formulated, solved, or prevented.
CHAPTER THREE

METHODS

The present study examined perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing as an indicator for problem solving confidence (Heppner, 1988). This was an exploratory study (Babbie, 2007) given the variables for problem solving capacity are evolving as a research construct. This study argues these cognitive indicators may be used as a diagnostic foundation for improving ill-structured problem solving capacity for adult professionals who develop software or use software systems to solve ill-structured problems.

This study is a non-experimental, cross-sectional, correlational research design. The non-experimental design does not allow the researcher to manipulate the independent variables (Kerlinger & Lee, 2000). The study utilized a 95-question survey instrument to measure problem solving confidence relative to 1) perceived cognitive style, 2) metacognitive monitoring, and 3) epistemic cognition. The study focused upon individual adult professionals who develop software and use software systems to solve ill-structured problems. This chapter provides an overview of the procedures used to test the study research questions and associated hypotheses as 1) study research design, 2) population and sample, 3) instrumentation, 4) data collection, 5) analysis of data, and 6) summary.

Research Design

The research design is ex post facto survey research that utilizes multiple assessment instruments to evaluate how the dependent variable, problem solving confidence relates to the independent variables of 1) perceived cognitive style, 2) metacognitive monitoring, and
3) epistemic cognition. The proposed research design and hypothesized relationships are illustrated in figure 6.

![Diagram](image)

*Figure 6. Research Model Illustrating Relationships Between Dependent and Independent Variables*

The three components of the research design include 1) perceived cognitive style, 2) metacognitive monitoring, and 3) epistemic cognition and their relationship to problem solving confidence.
solving confidence. There are four exploratory research questions proposed for the present study, accompanied by four research hypotheses that examine the relationship between problem solving confidence (Heppner, 1988) and Kitchener’s (1983) model of hierarchical cognitive processing for ill-structured problems. A summarization of the study variables is outlined in Table 5 followed by a discussion of measures and their validity and reliability.

Table 5

*Description, and Operationalization of Dependent and Independent Variables in the Study*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Operationalization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variable</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSC</td>
<td>Problem solving confidence measured as the cumulative score on the PSI (Heppner, 1988) problem solving confidence subscale</td>
<td>Lower scores indicate a higher degree of problem solving confidence</td>
</tr>
<tr>
<td><strong>Independent Variables and their Subscales</strong></td>
<td>Kolb’s Learning Style Inventory (Kolb &amp; Kolb, 2005)</td>
<td>Measured as scored preferences</td>
</tr>
<tr>
<td>DIV</td>
<td>Diverger cognitive style preference</td>
<td></td>
</tr>
<tr>
<td>CVG</td>
<td>Converger cognitive style preference</td>
<td></td>
</tr>
<tr>
<td>ASM</td>
<td>Assimilator cognitive style preference</td>
<td></td>
</tr>
<tr>
<td>ACM</td>
<td>Accommodator cognitive style preference</td>
<td></td>
</tr>
<tr>
<td>CE</td>
<td>Concrete experience dimension</td>
<td></td>
</tr>
<tr>
<td>AC</td>
<td>Abstract conceptualization dimension</td>
<td></td>
</tr>
<tr>
<td>AE</td>
<td>Active experimentation dimension</td>
<td></td>
</tr>
<tr>
<td>RO</td>
<td>Reflective observation</td>
<td></td>
</tr>
</tbody>
</table>
### Table 5 continued

<table>
<thead>
<tr>
<th><strong>MAI (Schraw &amp; Dennison, 1994)</strong></th>
<th>Measured as a total score where higher scores indicate a higher degree of metacognitive monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regulation of Cognition subscale</strong></td>
<td></td>
</tr>
<tr>
<td>MAI Total score on the MAI monitoring subscale</td>
<td></td>
</tr>
<tr>
<td>PL Planning subscale</td>
<td></td>
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<tr>
<td>IM Information Management subscale</td>
<td></td>
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<tr>
<td>MM Metacognitive Monitoring subscale</td>
<td></td>
</tr>
<tr>
<td>DS Debugging subscale</td>
<td></td>
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<tr>
<td>EV Evaluation subscale</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Epistemic Beliefs Inventory (EBI) (Schraw, Dunkle, &amp; Bendixen, 1995)</strong></th>
<th>Measured as a total score where higher scores indicate a higher degree of epistemological maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td>EBI Total score on the EBI instrument</td>
<td></td>
</tr>
<tr>
<td>SK Simple Knowledge subscale</td>
<td></td>
</tr>
<tr>
<td>CK Certain Knowledge subscale</td>
<td></td>
</tr>
<tr>
<td>IA Innate Inability subscale</td>
<td></td>
</tr>
<tr>
<td>OA Omniscient Authority subscale</td>
<td></td>
</tr>
<tr>
<td>QL Quick Learning subscale</td>
<td></td>
</tr>
</tbody>
</table>
Population and Sample

The target population for this study was adult professionals who develop software and use software systems to solve ill-structured problems. Software is often thought of a hidden technology because it operates silently in the background as the controlling mechanism for the world’s computers. However upon closer examination software is a technology innovation that combines knowledge-derived tools, artifacts, and devices (that help people) extend their environment (Tornatzky & Fleischer, 1999) by solving ill-structured problems. The focus on using software to identify, formulate, and solve ill-structured problems emanates from the prominence of knowledge work (Drucker 1986; Reich, 1993) and the stature of the $220 billion dollar software industry (U.S. Trade Outlook, 1998).

The accessible population was drawn from local companies within the Raleigh-Durham Metropolitan Statistical Data region. The area is appropriate given the national prominence of Research Triangle Park and nearby major technical universities. The demographic profile of the 95 adult participants who develop software and use software systems to solve ill-structured problems consisted of 63 (74.1%) males and 22 (25.9%) females. Of those participants, 67.1% (n=64) had Bachelor or Master level education. Of the 75 responded to the question about work experience, the largest category of participants had over 20 years experience (n=30, 40.0%).

The companies targeted for participation were chosen for their industry stature (e.g. Fortune 500), location and accessibility, and through personal contacts of employees. The companies varied by product (e.g. pharmaceuticals or software development) and by industry
size. The operative premise for their selection was based upon the complexity of the product and positioning required to be competitive in their respective industries.

The participants for this study were 95 adult professionals. The targeting rationale suggests adult professionals who develop software and use software systems to solve ill-structured problems have a vested interest in improving problem solving capacity. Participants were recruited to complete a problem solving survey as a sample of convenience which assumes randomization across a set population (Ferber, 1977) from local software development and technology-dependent companies and organizations that use software to solve ill-structured problems between June and October 2008. The next section discusses the four instruments used within the study to examine the relationship between problem solving confidence (Heppner, 1988) and Kitchener’s (1983) model of hierarchical cognitive processing for ill-structured problems.

Instrumentation

Participants completed an 95-question, Internet-based survey comprised of the 1) Learning Style Inventory (Kolb & Kolb, 2005), 2) metacognitive monitoring subscale from the Metacognitive Awareness Index (Schraw & Dennsion, 1994), 3) Epistemological Beliefs Inventory (Schraw, Dunkle, & Bendixen, 1995), and 4) the problem solving confidence subscale from the Problem Solving Inventory (Heppner, 1988. The following sections outline the psychometric characteristics and scoring strategy for each instrument included within the present study.
Measuring Perceived Cognitive Style

The Learning Styles Inventory (LSI) version 3.1 is a 12-item self-report instrument (see Appendix A) that measures different learning styles as derived from experiential learning theory (Kolb & Kolb, 2005). The group norms were developed from adults and college students which are sufficient proxies for the study population.

The LSI’s bipolar dimensions evaluate how individuals learn from a perceptual dimension (concrete experience or abstract conceptualization) and through a processing dimension (active experimentation or reflective observation). Concrete experience is an individual perception of accepting things as they are without any change and abstract conceptualization is an individual perception of evaluating concepts and ideas through iterative processing. Conversely, reflective observation relies upon challenging conclusions to validate their merit and active experimentation relies upon taking what has been concluded and trying to prove it works.

Principle component analysis has supported the two-factor structure hypothesized by Kolb (Kayes, 2005). Additional factor analysis using varimax rotation also supported the factor structures for both ipsative and normative scaling with 17 of 24 items loading as theorized in Kolb’s (1984) model yielding approximately 70% congruence between the LSI scales and model (Merritt & Marshall, 1984). The internal consistency of the LSI has a Cronbach’s alpha average of $\alpha = .80$ (Weirstra & DeJong, 2002; Kayes, 2005) and 8-week test-test reliabilities of $r = .90$ in all cases (Veres, Sims, & Locklear, 1991).

The LSI is a forced-choice instrument that requires respondents to rank nine-sets of four words into categorization of learning abilities as: Concrete Experience (CE), Reflective
Observation (RO), Abstract Conceptualization (AC), and Active Experimentation (AE). An item example is “When I learn ____ I like to deal with my feelings”. The participant ranks their concurrence with all the sentences in a grouping on a four point scale as 1 (least like you) to 4 (most like you).

The LSI is scored by adding coded responses to develop the four learning abilities (CE, RO, AC, AE) which are then converted into the bipolar dimensions of active-reflective calculated as (AE-RO) and abstract-concrete (AC-CE). These two dimensions are plotted on the Learning Style Type grid (Kolb, 1995) to indicate the four learning styles as 1) divergers (CE/RO), convergers (AC/AE), accommodators (CE/AE), and assimilators (AC/RO). The next section extends cognitive engagement into the realm of metacognitive monitoring.

**Measuring Metacognitive Monitoring**

Metacognitive monitoring was measured by using the 35 question subscale (see Appendix B) of the Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994). The overall MAI is a 52-item self-report instrument that measures metacognitive awareness along two scales: Knowledge of Cognition and Regulation of Cognition. The group norms for the MAI are based upon populations of working adults and college students.

There are significant correlations reported between the two scales ($r = .54$ and $r = .45$) (Schraw & Dennison, 1994). The original 100 item scale demonstrated high scale reliability with a Cronbach’s alpha at $\alpha = .95$. Factor analysis was used to test convergent and divergent validity. The average factor loadings were between .40 to .60.

The knowledge of cognition scale measures awareness of cognition and knowledge concerning strategy selection based upon individual strengths in declarative, procedural, and
conditional knowledge. This scale was not used for the present study because awareness or use of declarative, procedural, and conditional knowledge may imply superior structural knowledge and expertise rather than more problem solving capacity.

The Regulation of Cognition subscale measures knowledge about planning, implementing, monitoring, and evaluating strategy use as five subscales that assess 1) planning (7 items), 2) information management (10 items), 3) monitoring (7 items), 4) debugging (5 items) and, 5) evaluation (6 items). The subscale contains 35 items exemplified by “I ask others for help when I don’t understand something.” The MAI monitoring subscale is scored on a 5-point Likert scale from 1 (always false) to 5 (always true). Higher scores indicate a higher degree of metacognitive monitoring. Based upon the scoring ranges (35-175), the MAI designations are low monitoring (35-70), medium monitoring (71-105), and high monitoring (106-175). The metacognitive monitoring scores indicate the degree of evaluating probable problem solving progress and performance. In the next section, the degree of epistemological engagement completes the final phase of Kitchener’s (1983) model.
Measuring Epistemic Cognition

The Epistemic Beliefs Inventory (EBI) is a 32 item self-report instrument (Appendix C) designed by Schraw, Dunkle, and Bendixen (1995) to strengthen Schommer’s (1990) Epistemological Questionnaire (EQ) relative to the omniscient authority construct. The EBI as a measure of personal epistemology (i.e. epistemic cognition) offers viable psychometric alternative given the varimax rotation through factor analysis yielded eigenvalues greater than 1 thus explaining approximately 64% of the total sample variation. In addition, the original factors proposed by Schommer (1990) remained valid with Cronbach’s alpha coefficients ranging from $\alpha = .76$ to $\alpha = .86$ for the factors themselves.

The EBI measures individual epistemological belief along a five dimension scale. Three of these dimensions (structure, certainty, and source) relate to knowledge itself, and the remaining two (control and speed) to the acquisition of knowledge (Schommer, 1990). The instrument measures epistemological beliefs as 1) simple knowledge (8 items), 2) certain knowledge (8 items), 3) innate ability (7 items), 4) omniscient authority (5 items), and 5) quick learning (5 items). A typical item is “today’s facts are tomorrow’s fiction”. The EBI is scored as a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Higher scores indicate higher epistemic cognition (i.e. degree of epistemological maturity). Based upon the scoring ranges (32-160), the EBI designations are naive (32-64), emergent (65-112), and mature (113-160) epistemic cognition. The next section discusses the measurement of problem solving confidence.
Measuring Problem Solving Confidence

Problem solving confidence was measured by using the 11 question subscale (see Appendix D) of the Problem Solving Inventory (PSI form B) (Heppner, 1988). The PSI is a 35-item self-report instrument that measures individual problem solving styles along three scales as 1) problem solving confidence, 2) approach-avoidance style (degree of engagement), and 3) personal control (emotional/behavioral stability). The approach-avoidance style and personal control subscales were not used because motivational and affective elements of problem solving (Jonassen, 2002) are beyond the scope of this study. Validity was established for the entire PSI through factor analysis (Weirstra & DeJong, 2002; Kayes, 2005). The factor loadings on each of the three subscales were as follows, problem-solving confidence (.42 to .75), approach-avoidance style (.30 to .71), and personal control (.42 to .71). The three scales accounted for 70% of the explained variance. The reliability of the scales was demonstrated with a test-retest procedure and using Cronbach’s alpha to estimate internal consistency. The reliability for the factors problem-solving confidence ($r = .85, \alpha = .85$), approach-avoidance style ($r = .88, \alpha = .84$), and personal control ($r = .83, \alpha = .72$).

The Problem Solving Confidence subscale (Heppner, 1988) measures individual belief and trust in problem solving ability. The scale contains 11 items exemplified by “many problems I face are too complex for me to solve”. The PSI is scored on a 6-point Likert scale as 1 (strongly agree) to 6 (strongly disagree) to measure self-appraisal of problem solving ability whereby lower scores on the subscale indicate a positive self-appraisal of problem solving ability.
Data Collection

Participants for the present study were adult professionals who develop software and use software systems to solve ill-structured problems. Data collection for the present study used an Internet-based survey hosted and complied by Survey Monkey™ to accommodate the technical and administrative requirements for this study. The next sections outline the data collection process as 1) survey design and construction, 2) pilot testing, 3) survey recruitment strategy, and 4) survey administration.

Survey Design and Construction

Survey design and construction was based upon selecting the appropriate vehicle and setting to collect data. The choice for an Internet-based survey was based upon minimizing contextual effects associated with the study variables and actual problem solving (Tourangeau, 1999). In addition, electronic surveys that garner higher response rates tend to be completed in organizational settings (Schaefer & Dillman, 1998) and are more effective than mail surveys (Truell, Bartlett, & Alexander, 2002). Thus an Internet-based survey allowed greater access and penetration into the target audience. Although research on response rates vary, success continues to hinge upon tenacity and using incentives to engage potential respondents to participate such as appealing to the merits of their input for a study (Tourangeau, 2004).

As Tourangeau and Smith (1996) argue, context effects can be ‘managed’ over a short span with stable populations, hence the survey was structured for a quick response format with radio (single forced response) buttons. The survey does not ask respondents to actually solve an ill-structured problem consequently issues of organizational dynamics (e.g.
time constraints or procedural norms) are diminished if respondents answer questions in the ‘spirit’ of the research rather than their organizationally-sanctioned reaction.

The four instruments for this study were selected for ease of administration, psychometric soundness, and theoretical acceptability evidenced by use in practice and citation volume. Given the instruments were validated in multiple administrations and contexts (Kolb, 1984; Heppner, 1988; Schraw & Dennison, 1994; Schraw, Dunkle, & Bendixen, 1995) the total number of questions contained in each instrument had to be evaluated for psychometric consistency. The four combined instruments contained 131 questions, including five demographic questions that required pilot testing to focus the research and reduce question volume.

**Pilot Testing**

Pilot testing was conducted by an informal panel of five professional colleagues to establish content validity and to evaluate 1) question wording and clarity, 2) format and usability, 3) timing and ease of administration, and 4) completeness and coherence. The panel was chosen for their work experience with solving problems and using a variety of software applications. The panel size of five was selected based upon the ease of calculating consensus and availability (Fowler, 1995). The panel was asked to review and evaluate the original, paper version of the questionnaire composed of 131 questions which used intact versions of the 1) Learning Style Inventory (Kolb & Kolb, 2005), 2) Metacognitive Awareness Index (Schraw & Dennison, 1994), 3) Epistemological Beliefs Inventory (Schraw, Dunkle, & Bendixen, 1995), and 4) Problem Solving Inventory (Heppner, 1988).
Each panel member was interviewed individually to assess issues and concerns with the survey instrument and its research intent. After critical review by each individual panel member several administrative issues with question volume and survey layout were exposed. Subsequent analysis prompted more focus on the individual subscales and the constructs measured. The panel recommendations were used to develop final modifications for question volume and survey layout prior to developing an Internet-based version of the instrument.

The survey instrument was reduced to a total of 95 questions because the panel believed a threshold of 100 questions exceeded reasonable expectations for participants. Consequently the final survey was reduced to 95 questions by using only significant subscales and substituting Schommer’s (1990) EQ with the EBI. The final determination was made to directly support the research questions (Kitchener, 1983; Heppner, 1988).

In addition each section was delineated to allow participants to view their progress and provide a visual break in the question volume. The revised survey indicated the survey could be completed in a single session which was estimated from pilot testing to be approximately thirty minutes.

Survey Recruitment Strategy

Participants for this study were initially recruited through personal contacts within various software and technology organizations in the Research Triangle Park area of North Carolina. Once personal contacts were made, permission was sought to contact other members within the organization to participate in the survey by circulating an email request under the signature of the sponsor or Human Resources personnel. In many cases, the company size was small enough to simply make email contact or phone calls based upon a
previous working or social relationships. The recruitment procedure was operationalized by soliciting participants through initial telephone contacts to legitimize the research and gain permission for email contact. The use of ‘high-level’ contacts ensured stronger cooperation and reinforced the importance of conducting real-world research.

After initial contact an email transmittal message (Appendix E) was sent to these organizations to solicit individual participation on problem solving research. The organizations represented within this study ranged from software development to pharmaceuticals. The exact number of participants from each organization was not monitored in accordance with North Carolina State University IRB requirements.

This strategy ensured introductions and questions concerning human subjects’ protections were addressed preceded the pre-survey email. The email message explained the purpose of the research and provided an Internet-enabled URL to link directly to the Problem Solving Capacity Survey (Appendix G). Respondents were asked to click on an embedded URL within the body of the email. Upon launching the survey, simple directions were provided on the survey directing the User how to proceed through the survey. No password or special access privileges were required to access or complete the survey and it was assumed that all participants who accessed the URL completed the survey. The survey, by design, required the participant to finish in one session since each access time was considered a unique event.

After initial contact and allowing for adequate survey response time, a follow-up email was sent to the initial participant contacts. When respondents failed to respond to the follow-up email within five (5) business days, they were considered a ‘non-response’.
In order to minimize non-response bias, additional organizations and participants were solicited for participation through points of contacts with previous participants or through random inquiry to organizations of similar size and stature as originally targeted.

Although sample response rates continues to be a problem in sociological research (Tourangeau, 2004) through non-response (Bradburn, 1992; Groves & Couper, 1998), efforts were made to engage multiple organizations and individual adult professionals who use software and software systems to solve ill-structured problems. Given the inherent resistance to survey participation (Bradburn, 1992; Groves & Couper, 1998) and length of the survey instrument (95 questions), additional recruitment was required upon the original sampling strategy and organizational settings which subsequently resulted in a final response of 95 participants. During subsequent rounds of data collection participants were guided through the survey at promotional venues using paper administration of the survey. Additional participants were recruited with promotional techniques to participate in either the Internet-based survey instrument or in a paper version (which was subsequently keyed into the electronic venue). The promotional venues included home-based social events and blind recruiting at local restaurants. Each venue was designed to provide entertainment for the participants in a casual atmosphere while imploring them to participate in problem solving research. Although this method was not an optimal strategy, it nonetheless produced several qualified participants previously unknown to the researcher. The inclusion of new study participants, especially recruited later in the study, were also selected as a sample of convenience with specific attention to violating internal validity through instrumentation changes or selection bias (Babbie, 2007).
All response data was collected using Excel spreadsheets and subsequently entered into a file structure for Statistical Package for Social Sciences (SPSS) version 16 software to accommodate analysis.

Survey Administration

The survey was administered through Survey Monkey™ to accommodate participant preferences and schedules through an Internet-based format. Once participants engaged the survey URL they were given introductory instructions for each of the sections whereby data was collected through self-reported, forced choice answer options. The survey instrument is included within the Appendix G.

The survey instrument administration is divided into three key steps: 1) contacting the participants, 2) accessing the instrument, and 3) taking the survey. Participants were contacted by email for the first round of data collection. All aspects of the survey complied within the North Carolina State University Institutional Review Board guidelines for avoiding or protecting any confidential information (CI) such as personally identifiable information (names, addresses, cross references). This study did not collect any such information and all demographic variables exclude any information for collection related to specific departments, divisions, groups, project teams, or projects associated with ‘organizational identity’. The next section discusses the three analytical phases used for the present study to convert the survey data into an analytical profile that addresses the research questions.
Analysis of Data

Data for the present study was analyzed to determine the correlation between participants’ problem solving confidence and the predictor elements described in Kitchener’s (1983) model. The analysis entailed 1) reporting means, standard deviations, frequencies, and percents, 2) conducting multivariate analysis, and 3) performing stepwise multiple regression analysis.

The initial analysis generated mean scores, standard deviations, and Cronbach alphas for each of the instruments and their subscales. Additionally exploratory factor analysis was conducted to validate instrument constructs and reduce data. All factors loading at approximately 0.30 were selected given that they accounted for approximately 10% of the overlapping variance with the other items in the factor (Tabachnick & Fidell, 2001). Results from this analytical phase were used to establish the structure of the study data as a preparatory step for subsequent statistical analysis using multivariate techniques and linear regression.

The second analytical phase used multivariate analysis to assess the difference between the group means. The analyses were directed toward finding significant statistical correlations between the dependent variable (PSC) and hypothesized predictor (independent) variables and to reduce data for further analytical considerations.

The final analytical phase determined if the independent variables could be used to explain a significant amount of variance in problem solving confidence. In this analysis, data was assessed to check if any multicollinearity existed between the variables using the Pearson correlation coefficient since issues of multicollinearity increase the standard error of
the b coefficients thus falsely indicating significance of the regression coefficients (Allison, 1999). Data decisions to reduce multicollinear effects (Tabachnick & Fidell, 2001) were made as required. After the variables were selected, step-wise regression analysis was conducted to find optimal predictors for problem solving confidence. The present study is testing four research questions and their associated hypotheses thus the $R^2$ and $\beta$ were tested for significance in the simultaneous regression analyses to optimize the predicative capability of the regression equation.

Summary

The methods proposed for the present exploratory study were a non-experimental, cross-sectional correlational design utilizing a survey instrument to capture research data for subsequent multivariate analysis and linear regression. The Internet-based survey contained 95 questions which were distributed to 95 participants who develop software and use software systems to solve ill-structured problems. Participants used Likert scale responses to record their perceived cognitive style, metacognitive monitoring, epistemic cognition and problem solving confidence.

The present study addressed four research questions and four hypotheses relating to a study sample consisting of 95 participants. Data collected from study participants was analyzed using SPSS statistical software to 1) generate descriptive data 2) conduct multivariate analysis, and 3) perform stepwise multiple regression analysis. The multivariate analyses were used to detect significant relationships between the dependent variable (problem solving confidence) and independent variables (cognitive style, metacognitive
monitoring, and epistemic cognition). Once all significant relationships were identified and explained, multiple regression analysis was used to test the predictor variables.

The results of the present study established the relationship between Kitchener’s (1983) hierarchical model of cognitive processing for ill-structured problems and problems solving confidence (Heppner, 1988). This study extended the existing quantitative research on problem solving by demonstrating the correlation between cognitive factors and problem solving confidence. The results have significance for assessing problem solving capacity within organizational settings and professional development programs.
CHAPTER FOUR

RESULTS

Introduction

The present exploratory study examined perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing as an indicator for problem solving confidence (Heppner, 1988). This study argues these cognitive indicators may be used as a diagnostic foundation for improving ill-structured problem solving capacity for adult professionals who develop software or use software systems to solve ill-structured problems.

Data for the present study was collected through an Internet-based survey instrument. The study initially began with an email contact for potential survey participants to introduce the study and the survey instrument (Appendix F). When response rates diminished, additional measures were taken to recruit additional participants by using a combination of sponsored events to solicit additional responses and providing a paper version of the Internet survey (which required additional keying). Based upon all strategies, a total of 95 usable survey responses were received during the data collection period of June through October 2008.

The results of the present study are based upon measuring perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing and problem solving confidence (Heppner, 1988). The following sections describe the analytical process as generating descriptive statistics, conducting multivariate analysis, and performing multiple regression analysis. The chapter is
organized as 1) data preparation and descriptive analysis, 2) problem solving confidence 3) perceived cognitive style and problem solving confidence, 4) metacognitive monitoring and problem solving confidence, 5) epistemic cognition and problem solving confidence, 6) combining the independent variables through multiple regression, and 7) summary.

Data Preparation and Descriptive Analysis

The preliminary analytical phase evaluated the individual instruments for their statistical properties. The present study utilized instruments to measure 1) problem solving confidence, 2) perceived cognitive style, 3) metacognitive monitoring, and 4) epistemic cognition. The following sections outline the respective analysis used for each instrument within this study.

Problem Solving Confidence

Problem solving confidence was measured by using the 11 question subscale (see Appendix D) of the Problem Solving Inventory (PSI form B) (Heppner, 1988). The subscale is developed from a single construct, problem-solving confidence, which has two other constructs (approach-avoidance style and personal control) within the original 35-item self-report instrument. Construct validity was established for the entire PSI through confirmatory factor analysis (Costello & Osborne, 2005) as illustrated in Table 6.
Table 6

*Factor Solution for Principal Component Analysis and Item-Part correlation of Heppner’s PSI Using Varimax Rotation*

<table>
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<tr>
<th>Item</th>
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<th>Correlation (r)</th>
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**Problem Solving Confidence**

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**Approach Avoidance Style**

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**Personal Control**

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<tbody>
<tr>
<td>3</td>
<td>.44</td>
<td>.40</td>
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</table>

Note. Original research conducted by Heppner and Petersen (1982).

The three subscales problem-solving confidence (.42 to .75), approach-avoidance style (.30 to .71), and personal control (.42 to .71) produced factor loadings accounting for 70% or more of the expected differences.
Given the single construct for this scale, only reliability analysis was performed for the instrument. Table 7 provides a description of the participants problem solving confidence (PSC) level for the overall scale. The internal consistency of the scale was above the $\alpha = .70$ acceptable level (Garson, 2008) and is estimated with Cronbach’s alpha ($\alpha = .839$). The problem solving confidence score ranges could be from 6.0 to 66.0 where lower scores indicate higher problem solving confidence. The scores ranged from 17.00 to 40.00 with the average being 26.68 (SD= 4.44).

Table 7

**Participants Problem Solving Confidence Mean, Standard Deviation, and Scale Internal Consistency**

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>$\alpha$</th>
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<tbody>
<tr>
<td>Problem solving confidence (PSC)</td>
<td>26.68</td>
<td>4.44</td>
<td>.839</td>
</tr>
</tbody>
</table>

*Note.* Participants ($n = 95$), Maximum PSC = 66.0, Minimum PSC = 6.0. Scale for Problems Solving Confidence: 1-Strongly agree, 2-Moderately agree, 3-Slightly agree, 4-Slightly disagree, 5-Moderately disagree, and 6-Strongly disagree.

Table 8 provides the internal consistency for each problem solving confidence items of which all were above the $\alpha = .70$ acceptable level (Garson, 2008) and were estimated with an average Cronbach’s alpha ($\alpha = .839$).
### Table 8

**Internal Consistency of Problem Solving Confidence for Participants**

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Cronbach’s Alpha for Factors</th>
<th>Items in Factor</th>
<th>Corrected Item Total Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving Confidence</td>
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</tr>
<tr>
<td>PSC1</td>
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<td>.821</td>
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</tr>
<tr>
<td>PSC2</td>
<td>.505</td>
<td>.814</td>
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<td>PSC3</td>
<td>.382</td>
<td>.836</td>
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<td>PSC4</td>
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<td>PSC5</td>
<td>.539</td>
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<td>.794</td>
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<td>PSC9</td>
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<tr>
<td>PSC11</td>
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<td>.805</td>
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</tbody>
</table>

**Note.** Participants (n = 95), Scale for PSC: 1-strongly agree, 2-moderately agree, 3-slightly agree, 4-slightly disagree, 5-moderately disagree, and 6-strongly disagree.

**Perceived Cognitive Style**

The Learning Styles Inventory (LSI) version 3.1 was used to measure perceived cognitive style for the present study. The LSI is a 12-item self-report instrument (Appendix A) that measures different learning styles as derived from experiential learning theory (Kolb & Kolb, 2005).

Exploratory factor analysis was conducted to validate the scale constructs though a forced two-factor solution using a varimax rotation. One factor had 24 items with factor loading ranging from 0.349 to 0.741 for the perceptual dimension of concrete experience (CE) or abstract conceptualization (AC). A second factor also had 24 items with factor loading ranging from 0.334 to 0.716 for the processing dimension of active experimentation (AE) or reflective observation (RO). No loadings were below 0. 334. These factors were
consistent with LSI validity and reliability literature (Wierstra and de Jong 2002; Kayes, 2005) when principal component analysis with varimax rotation is used to extract 2 factors using the 4 primary LSI scales. The factor analytic results are illustrated in Table 9.
Table 9

*Two Factor Solution for Principal Component Analysis of Kolb’s LSI Using Varimax*

*Rotation*

<table>
<thead>
<tr>
<th>Items</th>
<th>Components</th>
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</tr>
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<tr>
<td>RO2</td>
<td>.319</td>
</tr>
<tr>
<td>AC2</td>
<td>.713</td>
</tr>
<tr>
<td>CE2</td>
<td>-.512</td>
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<tr>
<td>AE2</td>
<td>-.396</td>
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<tr>
<td>AC3</td>
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<tr>
<td>AE3</td>
<td>.003</td>
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<td>RO3</td>
<td>.352</td>
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<td>CE3</td>
<td>-.576</td>
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<tr>
<td>CE4</td>
<td>-.618</td>
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<tr>
<td>AE4</td>
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<tr>
<td>CE5</td>
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</tr>
<tr>
<td>RO5</td>
<td>.222</td>
</tr>
<tr>
<td>AC5</td>
<td>.473</td>
</tr>
<tr>
<td>AE5</td>
<td>-.299</td>
</tr>
<tr>
<td>RO6</td>
<td>.082</td>
</tr>
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Table 9 continued

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>AE6</td>
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<tr>
<td>CE6</td>
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<td>AC6</td>
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<td>.215</td>
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<td>.141</td>
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<td>-.623</td>
<td>-.181</td>
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<td>.011</td>
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<tr>
<td>AC9</td>
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<td>.478</td>
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<tr>
<td>RO10</td>
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<td>-.532</td>
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<tr>
<td>CE10</td>
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<td>-.201</td>
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<tr>
<td>AE10</td>
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<tr>
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<td>AC11</td>
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<td>.077</td>
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<tr>
<td>AC12</td>
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<td>.067</td>
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<tr>
<td>CE12</td>
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<td>-.035</td>
</tr>
<tr>
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<td>-.409</td>
</tr>
<tr>
<td>AE12</td>
<td>-.139</td>
<td>.354</td>
</tr>
</tbody>
</table>

*Note.* Components 1 and 2 explain 32.25% of variance in the total scale.

Analysis for internal consistency of each cognitive style dimension were conducted for survey responses to concrete experience (CE), abstract conceptualization (AC), abstract experimentation (AE), and reflective observation (RO). Table 10 provides the internal consistency for each cognitive style dimensions were all above the $\alpha = .70$ acceptable level (Garson, 2008) and were estimated with an average Cronbach’s alpha ($\alpha = .829$).
Table 10

*Internal Consistency of the Learning Style Inventory for Participants*

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Cronbach’s Alpha for Factors</th>
<th>Items in Factor</th>
<th>Corrected Item Total Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Experience</td>
<td>.879</td>
<td>CE1 .704</td>
<td>CE2 .530</td>
<td>CE3 .493</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CE4 .620</td>
<td>CE5 .310</td>
<td>CE6 .419</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CE7 .606</td>
<td>CE8 .496</td>
<td>CE9 .502</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CE10 .302</td>
<td>CE11 .369</td>
<td>CE12 .365</td>
</tr>
<tr>
<td></td>
<td>M = 24.91</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD = 7.235</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Abstract Conceptualization</td>
<td>.764</td>
<td>AC1 .666</td>
<td>AC2 .674</td>
<td>AC3 .467</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AC4 .674</td>
<td>AC5 .455</td>
<td>AC6 .451</td>
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<tr>
<td></td>
<td></td>
<td>AC7 .745</td>
<td>AC8 .633</td>
<td>AC9 .486</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AC10 .517</td>
<td>AC11 .658</td>
<td>AC12 .504</td>
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<tr>
<td></td>
<td>M = 34.29</td>
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</tr>
<tr>
<td></td>
<td>SD = 7.761</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Active Experimentation</td>
<td>.827</td>
<td>AE1 .611</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>AE4 .516</td>
<td>AE5 .412</td>
<td>AE6 .356</td>
</tr>
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<td></td>
<td></td>
<td>AE7 .529</td>
<td>AE8 .399</td>
<td>AE9 .467</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AE10 -.055</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>M = 33.11</td>
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<tr>
<td></td>
<td>SD = 6.155</td>
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</tbody>
</table>
**Table 10 continued**

<table>
<thead>
<tr>
<th></th>
<th>AE11</th>
<th>AE12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflective Observation</td>
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<td>.815</td>
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<tr>
<td>M = 28.40</td>
<td>RO1</td>
<td>.561</td>
</tr>
<tr>
<td>SD = 7.157</td>
<td>RO2</td>
<td>.531</td>
</tr>
<tr>
<td></td>
<td>RO3</td>
<td>.445</td>
</tr>
<tr>
<td></td>
<td>RO4</td>
<td>.632</td>
</tr>
<tr>
<td></td>
<td>RO5</td>
<td>.272</td>
</tr>
<tr>
<td></td>
<td>RO6</td>
<td>.525</td>
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<td></td>
<td>RO9</td>
<td>.560</td>
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<tr>
<td></td>
<td>RO10</td>
<td>.404</td>
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<tr>
<td></td>
<td>RO11</td>
<td>.689</td>
</tr>
<tr>
<td></td>
<td>RO12</td>
<td>.256</td>
</tr>
</tbody>
</table>

**Note.** Participants (n = 95), Scale for LSI: 1- Least like I learn, 2-The third best way I learn, 3-The second best way I learn, and 4-Most like the way I learn.

Once each of the learning style dimensions (CE, RO, AC, AE) are determined, they are converted into the bipolar dimension of active-reflective calculated as (AE-RO) and abstract-concrete (AC-CE). Figure 7 illustrates how the grids are aligned for the LSI. Each of the bipolar dimensions represents a point on the axis whereby the X-axis is represented by active-reflective (AE-RO) and the Y-axis represented by abstract-concrete (AC-CE). The values correspond to a quadrant which in turn indicates the four learning styles as divergers, convergers, accommodators, or assimilators. An example of the scoring technique is illustrated by a (AE-RO) score of +5 and a AC-CE score of +20 which falls in the converger quadrant.
Figure 7. The LSI Plotting Grid (Kolb, 1995)
Metacognitive Monitoring

Metacognitive monitoring was measured by using the 35 question subscale for metacognitive control (see Appendix B) of the Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994). A forced factor analysis with varimax rotation produced two factors as expected (Schraw & Dennison, 1994). One factor had 17 items with factor loading ranging from 0.31 to 0.70 for the knowledge of cognition dimension. The other factor had 35 items with factor loading ranging from 0.30 to 0.70 for the regulation of cognition dimension. Significant correlations were reported between the two scales (r = .54 and r = .45). The subscale used for this study was developed from a single construct, metacognitive monitoring, thus reliability analysis was performed for the specific instrument subscale.

Table 11 provides a description of the participants MAI level for the overall scale. The internal consistency of the scale was above the $\alpha = .70$ acceptable level (Garson, 2008) and is estimated with Cronbach’s alpha ($\alpha = .897$). The metacognitive monitoring score ranges from 35.0 - 175.0 where higher scores indicate a higher degree of metacognitive monitoring. The scores ranged from 85.00 to 165.00 with the average being 127.31 (SD = 14.97).
Table 11

Participants Metacognitive Monitoring Mean, Standard Deviation, and Scale Internal Consistency

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metacognitive monitoring (MAI)</td>
<td>127.31</td>
<td>14.97</td>
<td>.897</td>
</tr>
</tbody>
</table>

Note. Participants (n = 95), Maximum MAI = 175.0, Minimum MAI = 35.0. Scale for Metacognitive Monitoring (MAI): 1- Always false, 2-Somewhat false, 3-Neutral, 4-Somewhat true, 5-Always true.

Table 12 provides the internal consistency for each metacognitive monitoring items were all above the $\alpha = .70$ acceptable level (Garson, 2008) and were estimated with an average Cronbach’s alpha ($\alpha = .897$).

Table 12

Internal Consistency of Metacognitive Monitoring for Participants

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Cronbach’s Alpha for Factors</th>
<th>Items in Factor</th>
<th>Corrected Item Total Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAI</td>
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<tr>
<td>M = 127.81</td>
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<td>.883</td>
</tr>
<tr>
<td>SD = 14.401</td>
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<td>MM2</td>
<td>.534</td>
<td>.884</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PL1</td>
<td>.301</td>
<td>.887</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td>EV1</td>
<td>.278</td>
<td>.887</td>
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<td></td>
<td></td>
<td>PL3</td>
<td>.555</td>
<td>.882</td>
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<td></td>
<td></td>
<td>IM1</td>
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<td></td>
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<td></td>
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Table 12 continued

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<td>PL5</td>
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<tr>
<td>IM6</td>
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<td>.888</td>
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<td>DS2</td>
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<td>IM7</td>
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<td>.885</td>
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<tr>
<td>DS5</td>
<td>.372</td>
<td>.886</td>
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</table>

Epistemic Cognition

Epistemic cognition was measured by the Epistemic Beliefs Inventory (EBI) as a 32 item self-report instrument (Appendix C) designed by Schraw, Dunkle, and Bendixen (1995). The instrument was initially evaluated using used principal component analysis with varimax rotation to extract 5 factors (Schraw, Dunkle, & Bendixen, 1995 explaining approximately 64% of the total sample variation. In addition, the original factors proposed by Schommer (1990) remained valid with alpha coefficients ranging from $\alpha = .76$ to $\alpha = .86$ for the factors themselves.
Table 13 provides a description of the participants EBI level for the overall scale. The internal consistence of the scale was above the $\alpha = .70$ acceptable level (Garson, 2008) and is estimated with Cronbach’s alpha ($\alpha = .897$). The epistemic cognition score ranges from 32.0 - 160.0 where higher scores indicate a higher degree of epistemological maturity. The scores ranged from 73.00 to 130.00 with the average being 97.40 (SD= 10.32).

Table 13

Participants Epistemic Cognition Mean, Standard Deviation, and Scale Internal Consistency

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>$\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epistemic cognition (EBI)</td>
<td>97.40</td>
<td>10.32</td>
<td>.897</td>
</tr>
</tbody>
</table>

*Note.* Participants (n = 95), Maximum EBI = 160.0, Minimum EBI = 32.0. Scale for Epistemic cognition (EBI): 1- Always agree, 2- Somewhat agree, 3- Neutral, 4- Somewhat disagree, 5- Always disagree.

Although the five factors extracted as predicted (Schraw, Dunkle, & Bendixen, 1995), the scales were pushing the lower threshold for internal consistency with Chronbach alphas going below $\alpha = .60$ for the present study data. When the instrument was evaluated as a single scale, item-total extractions for CK2, OA3, SK1, QL2, and SK2 raised the Chronbach’s alpha ($\alpha = .728$) to the 0.70 acceptable level (Garson, 2008) as illustrated in Table 14.
Table 14

*Internal Consistency of the Epistemic Cognition for Participants*

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Cronbach’s Alpha for Factors</th>
<th>Items in Factor</th>
<th>Corrected Item Total Correlation</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
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<tr>
<td>EBI</td>
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</tr>
<tr>
<td>M = 92.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD = 9.245</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SK1</td>
<td>-.093</td>
<td></td>
<td>.600</td>
<td></td>
</tr>
<tr>
<td>CK1</td>
<td>.109</td>
<td></td>
<td>.579</td>
<td></td>
</tr>
<tr>
<td>QL1</td>
<td>.190</td>
<td></td>
<td>.570</td>
<td></td>
</tr>
<tr>
<td>OA1</td>
<td>.368</td>
<td></td>
<td>.551</td>
<td></td>
</tr>
<tr>
<td>IA1</td>
<td>.159</td>
<td></td>
<td>.573</td>
<td></td>
</tr>
<tr>
<td>CK2</td>
<td>-.243</td>
<td></td>
<td>.623</td>
<td></td>
</tr>
<tr>
<td>OA2</td>
<td>.209</td>
<td></td>
<td>.568</td>
<td></td>
</tr>
<tr>
<td>IA2</td>
<td>.098</td>
<td></td>
<td>.579</td>
<td></td>
</tr>
<tr>
<td>QL2</td>
<td>-.137</td>
<td></td>
<td>.604</td>
<td></td>
</tr>
<tr>
<td>SK2</td>
<td>-.025</td>
<td></td>
<td>.596</td>
<td></td>
</tr>
<tr>
<td>SK3</td>
<td>.065</td>
<td></td>
<td>.582</td>
<td></td>
</tr>
<tr>
<td>IA3</td>
<td>.355</td>
<td></td>
<td>.548</td>
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</tr>
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<td>SK4</td>
<td>.541</td>
<td></td>
<td>.527</td>
<td></td>
</tr>
<tr>
<td>CK3</td>
<td>.150</td>
<td></td>
<td>.574</td>
<td></td>
</tr>
<tr>
<td>IA4</td>
<td>.371</td>
<td></td>
<td>.548</td>
<td></td>
</tr>
<tr>
<td>QL3</td>
<td>.328</td>
<td></td>
<td>.555</td>
<td></td>
</tr>
<tr>
<td>IA5</td>
<td>.165</td>
<td></td>
<td>.572</td>
<td></td>
</tr>
<tr>
<td>SK5</td>
<td>.333</td>
<td></td>
<td>.560</td>
<td></td>
</tr>
<tr>
<td>CK4</td>
<td>.327</td>
<td></td>
<td>.556</td>
<td></td>
</tr>
<tr>
<td>OA3</td>
<td>-.226</td>
<td></td>
<td>.611</td>
<td></td>
</tr>
<tr>
<td>QL4</td>
<td>.219</td>
<td></td>
<td>.567</td>
<td></td>
</tr>
<tr>
<td>SK6</td>
<td>.152</td>
<td></td>
<td>.574</td>
<td></td>
</tr>
<tr>
<td>CK5</td>
<td>.156</td>
<td></td>
<td>.573</td>
<td></td>
</tr>
<tr>
<td>SK7</td>
<td>.166</td>
<td></td>
<td>.572</td>
<td></td>
</tr>
<tr>
<td>CK6</td>
<td>.388</td>
<td></td>
<td>.542</td>
<td></td>
</tr>
<tr>
<td>IA6</td>
<td>.257</td>
<td></td>
<td>.561</td>
<td></td>
</tr>
<tr>
<td>OA4</td>
<td>.251</td>
<td></td>
<td>.565</td>
<td></td>
</tr>
<tr>
<td>OA5</td>
<td>.145</td>
<td></td>
<td>.574</td>
<td></td>
</tr>
<tr>
<td>QL5</td>
<td>.372</td>
<td></td>
<td>.551</td>
<td></td>
</tr>
<tr>
<td>SK8</td>
<td>.125</td>
<td></td>
<td>.576</td>
<td></td>
</tr>
<tr>
<td>CK7</td>
<td>.106</td>
<td></td>
<td>.579</td>
<td></td>
</tr>
<tr>
<td>IA7</td>
<td>-.185</td>
<td></td>
<td>.605</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Participants (n = 95)
Education and Experience

Education and experience were measured by the Problem Solving Confidence survey. The descriptive statistics for these two demographic variables are indicated in Table 15.

Table 15

Participants Education and Experience Frequency and Percentage

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Education (EDU)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school/GED</td>
<td>6</td>
<td>6.3</td>
</tr>
<tr>
<td>Some college</td>
<td>12</td>
<td>12.6</td>
</tr>
<tr>
<td>2-year degree</td>
<td>7</td>
<td>7.4</td>
</tr>
<tr>
<td>4-year degree (BA/BS),</td>
<td>42</td>
<td>44.2</td>
</tr>
<tr>
<td>Master’s degree</td>
<td>13</td>
<td>13.7</td>
</tr>
<tr>
<td>Doctoral or professional degree</td>
<td>2</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Experience (EXP)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-5 years</td>
<td>7</td>
<td>7.4</td>
</tr>
<tr>
<td>6-10 years</td>
<td>13</td>
<td>13.7</td>
</tr>
<tr>
<td>11-15 years</td>
<td>11</td>
<td>11.6</td>
</tr>
<tr>
<td>16-20 years</td>
<td>16</td>
<td>16.8</td>
</tr>
<tr>
<td>20 or more years</td>
<td>38</td>
<td>40.0</td>
</tr>
</tbody>
</table>

*Note.* Participants (n = 95). Non-responses for education (EDU) = 13; non-responses for experience = 10.
The relationship between problem solving confidence (PSC) and cognitive styles as diverger (DVG), converger (CVG), assimilator (ASM), and accommodator (ACC) was measured using Pearson’s product moment correlation (r). Table 16 indicates there is no significant correlation between any of the cognitive styles and problem solving confidence at either the $p =0.05$ and $p = 0.01$ levels of significance.

Table 16

*Intercorrelations Among Cognitive Style and Problem Solving Confidence*

<table>
<thead>
<tr>
<th>Variable</th>
<th>PSC</th>
<th>DVG</th>
<th>CVG</th>
<th>ASM</th>
<th>ACC</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSC</td>
<td>1.00</td>
<td>-.006</td>
<td>-.036</td>
<td>.162</td>
<td>-.109</td>
</tr>
<tr>
<td>DVG</td>
<td>1.00</td>
<td></td>
<td>-.225*</td>
<td>-.376**</td>
<td>-.232*</td>
</tr>
<tr>
<td>CVG</td>
<td>1.00</td>
<td></td>
<td></td>
<td>-.431**</td>
<td>-.258*</td>
</tr>
<tr>
<td>ASM</td>
<td></td>
<td>1.00</td>
<td>-.417**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACC</td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

*Note.*** p<0.001 **p<0.01 * p<0.05*
Additional analysis was conducted using ANOVA to determine whether or not different levels of cognitive style were related to problem solving confidence. Results indicate no significant relationship as illustrated in Table 17.

Table 17

*ANOVA for Cognitive Style and Problem Solving Confidence*

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F-test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>47.238</td>
<td>3</td>
<td>15.746</td>
<td>0.813</td>
<td>0.490</td>
</tr>
<tr>
<td>Within Groups</td>
<td>1743.613</td>
<td>90</td>
<td>19.373</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1790.851</td>
<td>93</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Participant (n = 95)

The results of the ANOVA indicate there is no difference between the PSC score and the LSI cognitive style preference (p = .490).
Metacognitive Monitoring and Problem Solving Confidence

The relationship between problem solving confidence (PSC) and metacognitive monitoring (MAI) was measured using Pearson’s product moment correlation (r). The relationship between problem solving confidence and metacognitive monitoring indicates a weak (p = .01) negative correlation (r = -.340) which suggests larger values for metacognitive monitoring correspond to smaller values for problem solving confidence. The coefficient of determination ($r^2 = .117$) explains 11.7% of the variance in problem solving confidence due to metacognitive monitoring. This relationship is consistent with the scoring strategies indicating higher MAI score related to higher metacognitive monitoring and lower PSC score related to higher problem solving confidence.

Epistemic Cognition and Problem Solving Confidence

The relationship between problem solving confidence (PSC) and epistemic cognition (EBI) was measured using Pearson’s product moment correlation (r). The relationship between problem solving confidence and epistemic cognition ($r = -.046$) indicates no significant correlation between epistemic cognition and problem solving confidence at either the $p = 0.05$ and $p = 0.01$ levels of significance.

Combining the Independent Variables through Multiple Regression

In order to detect multicollinearity among the independent variables, Pearson correlation coefficients were computed for the whole sample. Table 18 presents the correlations between all of the major variables for solving ill-structured problems. Since each of the variables is measuring a distinct aspect of problem solving confidence only those variables deemed adequate predictors were entered into the regression model. Backwards
(stepwise) regression builds a regression equation using the best variables to optimize the correlation coefficient ($R^2$) and minimize the standard error of the estimate ($S_e$). The process enters all of the independent variables into the equation then deletes those variables that help produce more optimal results. $R^2$ measures the total variation of Y (the dependent variable of problem solving confidence) relative to the X (independent variables). Higher values indicate more variation is explained by the overall equation. Correspondingly $S_e$ measures the variation in the regression line whereby smaller values indicates a higher degree of fit. Table 18 indicates the variables MAI ($r^2 = .117$) and ASM ($r^2 = .026$) are suitable for inclusion in the regression model.
Table 18

*Intercorrelations Among the Independent Variables in Problem Solving Confidence*

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSC</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EBI</td>
<td>-.046</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASM</td>
<td>.162</td>
<td>.174</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACC</td>
<td>-.109</td>
<td>-.158</td>
<td>-.431**</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DVG</td>
<td>-.006</td>
<td>.040</td>
<td>-.376**</td>
<td>-.232*</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVG</td>
<td>-.036</td>
<td>-.084</td>
<td>-.417**</td>
<td>-.258*</td>
<td>-.225*</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXP</td>
<td>-.092</td>
<td>-.155</td>
<td>.134</td>
<td>-.043</td>
<td>-.040</td>
<td>-.115</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDU</td>
<td>-.128</td>
<td>.036</td>
<td>.206</td>
<td>-.009</td>
<td>-.297**</td>
<td>-.019</td>
<td>.221*</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>MAI</td>
<td>-.340**</td>
<td>.178</td>
<td>.029</td>
<td>.028</td>
<td>-.179</td>
<td>.087</td>
<td>.146</td>
<td>.039</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Note: *** p<0.001 **p<0.01 * p<0.05. Participants (n = 95)

The selection of two variables for inclusion into the regression equation guided the subsequent analysis to examine the data to ensure linearity, normality, and the variance of the error terms. Based upon the analysis only Total MAI ($\beta = -.115$, $p = 0.000$) and ASM ($\beta = 1.686$, $p = .058$), emerged as significant predictors of problem solving confidence as illustrated in Table 19.
### Table 19

**Results for a Three Iteration Backward Stepwise Regression Model**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>316.386</td>
<td>2</td>
<td>158.193</td>
<td>10.172</td>
<td>.000</td>
</tr>
<tr>
<td>Residual</td>
<td>1228.589</td>
<td>79</td>
<td>15.552</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1544.976</td>
<td>81</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable in Equation</th>
<th>(Constant = 40.685)</th>
<th>R²</th>
<th>Unadjusted β</th>
<th>Standardized β</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAI</td>
<td>0.157</td>
<td>-.115</td>
<td>-.413</td>
<td></td>
</tr>
<tr>
<td>ASM</td>
<td>0.048</td>
<td>1.686</td>
<td>-.193</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable not in Equation</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXP</td>
<td>-.856</td>
<td>.394</td>
</tr>
<tr>
<td>DVG</td>
<td>-.132</td>
<td>.895</td>
</tr>
<tr>
<td>ACC</td>
<td>-.058</td>
<td>.954</td>
</tr>
<tr>
<td>CVG</td>
<td>.643</td>
<td>.522</td>
</tr>
<tr>
<td>EBI</td>
<td>-1.096</td>
<td>.276</td>
</tr>
<tr>
<td>EDU</td>
<td>-1.554</td>
<td>.124</td>
</tr>
</tbody>
</table>
The use of backward (stepwise) regression to reduce the error term associated with inclusion of non-significant predictors in the regression model yielded a model that explained 20.5% of the variance. After three iterations of the regression equation, the final model yielded the equation: \[ \text{PSC} = 40.685 - (.115)(\text{Total MAI}) + (1.686)(\text{ASM}) \]

Multiple regression illustrates the relationship between the dependent and independent variables to predict the strength of the relationship. The regression equation (model) calculated for this study indicates \( \text{PSC} = 40.685 - (.115)(\text{Total MAI}) + (1.686)(\text{ASM}) \). Given the equation represents a linear relationship that can be graphed on an X-Y axis, each of the factors implies information about the relationship. The dependent variable, problem solving confidence (PSC) is related to total MAI score (MAI) and the assimilator cognitive style (ASM). The equation indicates a constant of 40.685 (which is the Y intercept) can be plotted relative to a negative (-.115) total MAI and a positive (1.686) ASM. The negative MAI (-0.115) suggests that large values for metacognitive monitoring, which indicate strong metacognitive monitoring skills, are associated with small values for problem solving confidence is also indicative of stronger problem solving confidence. Likewise the influence of ASM (1.686) suggests a moderate relationship to problem solving confidence.
Summary

The analysis of the present study was conducted using an Internet-based survey instrument to capture results for 95 survey participants during June and October 2008 for adult professionals who develop software and use software systems to solve ill-structured problems. The analysis was divided into three analytical protocols as 1) generating descriptive statistics, 2) conducting multivariate analysis, and 3) performing backwards (stepwise) multiple regression analysis.

Data was produced from an Internet-based survey that organized participant responses in Microsoft Excel which was subsequently analyzed using SPSS statistical software (version 16). Four research hypotheses were tested using multivariate techniques and stepwise multiple regression. The $R^2$ and $\beta$ were tested for statistical significance using multiple regression.

The results of multivariate analysis and backward (stepwise) linear regression indicate the variables for, DVG (diverger cognitive style), ACC (accommodator cognitive style), CVG (converger cognitive style), and EBI (total EBI score), were not significant predictors of problems solving confidence. Their removal from the regression equation produced a subsequent equation that explained 20.5% of the variance between the independent and dependent variables chosen for the study when the variables MAI (MAI total score) and ASM (assimilator cognitive style) were included.
CHAPTER FIVE
SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Introduction

The present exploratory study examined perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing as an indicator for problem solving confidence (Heppner, 1988). This study argues these cognitive indicators may be used as a diagnostic foundation for improving ill-structured problem solving capacity for adult professionals who develop software or use software systems to solve ill-structured problems.

The results of the present study indicate several of the original variables hypothesized to be predictors of problem solving confidence were statistically insignificant thereby eliminated from the final regression model. The present study was designed to answer the following research questions.

1. Is there a relationship between perceived cognitive style and problem solving confidence as reported by adult professionals who develop software and use software systems to solve ill-structured problems?

2. Is there a relationship between metacognitive monitoring and problem solving confidence as reported by adult professionals who develop software and use software systems to solve ill-structured problems?

3. Is there a relationship between epistemic cognition and problem solving confidence as reported by adult professionals who develop software and use software systems to solve ill-structured problems?
4. Does perceived cognitive style, metacognitive monitoring, and epistemic cognition explain a significant amount of variance in problem solving confidence as reported by adult professionals who develop software and use software systems to solve ill-structured problems?

This chapter provides 1) conclusions and analytical discussion for each of the research questions, 2) overall conclusions for the present study, 3) implications for the study, 4) recommendations for future research and practice, and 5) closing remarks about the study.

Summary of Findings

The present study addressed four research questions and four associated hypotheses in a three-phased analytical approach to examine the relationship between problem solving confidence (Heppner, 1988) and perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) model of hierarchical cognitive processing. The following sections summarize the findings for the present study and provide a discussion of the research outcomes as follows.

Research Question 1

Is there a relationship between perceived cognitive style and problem solving confidence as reported by adult professionals who develop software and use software systems to solve ill-structured problems?

Conclusions for Perceived Cognitive Style and Problem Solving Confidence

The Kolb Learning Style Inventory (Kolb & Kolb, 2005) was used to measure perceived cognitive style as diverger, converger, assimilator, and accommodator for the study sample. The hypothetical relationships predicted divergers would have low problem solving
confidence due to their introversion and inductive reasoning, accommodators would have low to moderate problem solving confidence due to their extraverted and deductive reasoning, and convergers and assimilators would have high problems solving confidence due to their practical posture and ability to seek logical soundness respectively. Problem solving confidence was measured by the problem solving confidence subscale of Heppner’s (1988) Problem Solving Inventory.

The relationship between problem solving confidence (PSC) and cognitive styles as diverger (DVG), converger (CVG), assimilator (ASM), and accommodator (ACC) was measured using Pearson’s product moment correlation (r). The findings indicate there is no significant correlation between any of the cognitive styles and problem solving confidence at either the p =0.05 and p = 0.01 levels of significance. Only the assimilator (ASM) cognitive style had any appreciable influence (r = .162) for inclusion in the regression model which yielded acceptable results ($\beta = 1.686$, $p = .058$). Consequently the accommodator (ACC), diverger (DVG), and converger (CVG) cognitive styles were not significant indicators of problem solving confidence. Thus the research question as to whether a relationship exists between cognitive style and problem solving confidence is only partially answered by the study results. Given the weak results, the research question did not provide sufficient focus for three of the four cognitive styles to correlate preferred information processing (cognitive style) and problem solving confidence.

Discussion of Perceived Cognitive Style and Problem Solving Confidence

The relationship between problem solving confidence and cognitive style appeared to have intuitive and empirical appeal relative to individual problems solving. There are three
possible explanations for the observed results based upon the definition of cognitive style as
the preferred structural and process orientations that individuals exhibit as they gather,
process, and evaluate information (Hayes & Allinson, 1998). The three explanations for the
observed results between cognitive style and problem solving confidence include 1) 
information processing as a sensory preference rather than predictor of problem solving
confidence, 2) the limitations of self-reported cognitive style relative to the clarity and
sufficiency of information available to solve an ill-structured problem, and 3) the personality
and preferences espoused by ELT may indicate process inclinations rather than degree of
confidence.

Information processing is a combination of long and short term memory exchanges
that operates within a self-framed problem space (Newell & Simon, 1972). Information
gathering and processing forces individuals to make judgments about the sufficiency and
adequacy of information available for problem solving (Browne & Pitts, 2004) and has been
instrumental to describe models of cognition (Simon, 1979). However when sensory
preference for verbalizers or visualizers (Riding & Cheema, 1991) is considered, the notion
of sensory preference for words or pictures to gather and process information changes the
dynamic. The LSI is measuring perceptual (concrete experience or abstract
conceptualization) and processing (active experimentation or reflective observation)
dimensions which are not significantly correlating to problem solving confidence because no
specific information was being processed at the time of the survey for participants to solve an
ill-structured problem.

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The LSI did not directly link the nature and content of information available to solve an ill-structured problem. Thus participants may have assumed complete and comprehensive information was available when they recorded their level of problem solving confidence. As with the perceptual dimension, the absence of a “real” problem situation presupposes adequate and sufficient information is available to solve the problem thus not affecting confidence or promoting doubt (Bendixen, 2002).

Finally the personality preferences espoused by the LSI may have implied preferences for information search and integration rather than confidence in problem solving. The notion of introversion and extroversion or feeling and thinking has marginal value when assessing problem solving confidence through an electronic venue (Kolb & Kolb, 2005).

Although the LSI has proven to be a validated and reliable indicator of learning style preference measurement (Kolb & Kolb, 2005) divergers, convergers, and accommodators do not correlate within the sample as predicted. The correlation of assimilators to problem solving confidence may be linked to participant’s preference for logic and desire to understand and control the problem solving environment. The use of models and logical theories suggests assimilators prefer orderly information search and careful analysis rather than the messiness of collaborative efforts. They are ideally suited in the solution finding and evaluative portion of the problem solving cycle because their methodical approach seeks closure to problems through satisfying rules and making sense of the proposed solution (Kolb & Kolb, 2005).
Research Question 2

Is there a relationship between metacognitive monitoring and problem solving confidence as reported by adult professionals who develop software and use software systems to solve ill-structured problems?

Conclusions for Metacognitive Monitoring and Problem Solving Confidence

The Metacognitive Awareness Inventory (Schraw & Dennison, 1994) subscale for metacognitive monitoring was used to measure the degree of metacognitive monitoring exhibited by the study sample. The regulation of cognition subscale measures five subscales as 1) planning, 2) information management, 3) monitoring, 4) debugging, and 5) evaluation. The hypothetical relationships predicted higher scores of the MAI will indicate higher degrees of problem solving confidence. Problem solving confidence was measured by the problem solving confidence subscale of Heppner’s (1988) Problem Solving Inventory.

The relationship between problem solving confidence (PSC) and metacognitive monitoring (MAI) as planning (PL), information management (IM), monitoring (MM), debugging (DS), and evaluation (EV) was measured using Pearson’s product moment correlation (r). The subscale was evaluated as a single construct whereby the findings indicate there is a significant correlation between MAI and PSC at the $p = 0.01$ level of significance. The MAI had any appreciable influence ($r = -0.340$) for inclusion in the regression model which yielded acceptable results ($\beta = -0.115, p = .000$). Thus the research question as to whether a relationship exists between metacognitive monitoring and problem solving confidence is answered by the study results as a negative relationship.
Discussion of Metacognitive Monitoring and Problem Solving Confidence

The relationship between problem solving confidence and metacognitive monitoring indicates a negative correlation ($r = -.340$) for the variables. This suggests that large values for metacognitive monitoring, which indicate strong metacognitive monitoring skills, are associated with small values for problem solving confidence which is also indicative of stronger problem solving confidence.

The overall notion of metacognitive “control” as one’s “knowledge about planning, implementing, monitoring, and evaluating strategy use” (Schraw & Dennision, 1994, p.471) suggests not all aspects of metacognitive strategy are apparent when actual problem solving is not performed by study participants. The influence of the metacognitive monitoring instrument comes from the five subscales of 1) planning, 2) information management, 3) monitoring, 4) debugging and, 5) evaluation that comprise its construct and described as follows.

Planning (i.e. goal setting and allocating resources) indicates that large values relative to MAI score for metacognitive planning are associated with small values for problem solving confidence. This directly correlates to higher problem solving confidence. Planning helps guide the problem solving process by increasing goal-oriented behavior (Brand, Reimer, & Opwis, 2003). Thus the coordination process, expressed through planning, helps the problem solver to evaluate strategy effectiveness (Sigler & Tallent-Runnels, 2006). Likewise information management involves sequencing and efficiently processing information (Newell & Simon, 1972). The explanation for correlation suggests the ability to
gauge which strategies and information are relevant and essential for developing key learning strategies (Everson & Tobias, 1998) but may not impact problem solving confidence.

Monitoring requires the assessment of strategy in use. The relationship between monitoring and problem solving confidence is evidenced by ability appraisal versus metacognitive control to evaluate strategic options (Baker & Brown, 1984; Flavell, 1979; Schraw & Moshman, 1995) which suggests confident problem solvers use each in tandem to solve ill-structured problems. The weaker relationship may be attributed to the fact no actual monitoring (i.e. because no problem was actually being solved) was taking place, but rather queried. As Cary and Reder (2002) note “monitoring processes must exist, because strategy use has been shown to be influenced by the prior success of each strategy. The information gleaned from monitoring may be used later to facilitate selection of the best strategy when the person reencounters a problem of the same type” (p.64).

Debugging is about making corrections to comprehension and performance through a series of questions based upon prior knowledge. Debugging is a higher-order metacognitive skill that presupposes prior knowledge through the use of principles, rules, and heuristics (Jonassen, 2000). As with monitoring, debugging is highly contextual to solving an actual problem. Given the survey is querying monitoring ability rather than measuring or verifying monitoring activity, the contextual and situation importance of debugging is may not be accurately represented in the MAI subscale.

Evaluation involves the analysis of performance. The shift from problem solving as a concrete process to monitoring and evaluation is the shift from cognitive to metacognitive (Brand, Reimer, & Opwis, 2003). Consequently evaluation often focuses upon past
performance in order to improve future prospects for success. Given the overall correlation of MAI to problem solving confidence (PSC), evaluation appears to be active in validating self-efficacy (Bandera, 1982).

The assembly of each of these dimensions as the overarching control or monitoring of cognition validates Kitchener’s (1983) second level of cognitive processing for solving ill-structured problems. The strength of the overall MAI suggests a strong correlation between all of the metacognitive dimensions and problem solving confidence.

**Research Question 3**

Is there a relationship between epistemic cognition and problem solving confidence as reported by adult professionals who develop software and use software systems to solve ill-structured problems?

**Conclusions for Epistemic Cognition and Problem Solving Confidence**

The Epistemological Beliefs Index (Schraw, Dunkle, & Bendixen, 1995) was used to measure the degree of epistemological maturity and its relationship to problem solving confidence. The EBI measures individual epistemological belief along a five dimension scale. Three of these dimensions (structure, certainty, and source) relate to knowledge itself, and the remaining two (control and speed) to the acquisition of knowledge (Schommer, 1990). The instrument measures epistemological beliefs as 1) simple knowledge, 2) certain knowledge, 3) innate ability, 4) omniscient authority, and 5) quick learning. The hypothetical relationships predicted higher scores of the EBI indicate higher degree of problem solving confidence. Problem solving confidence was measured by the problem solving confidence subscale of Heppner’s (1988) Problem Solving Inventory.
The relationship between problem solving confidence (PSC) and epistemic cognition (EBI) as simple knowledge (SK), certain knowledge (CK), innate ability (IA), omniscient authority (OA), and quick learning (QL) was measured using Pearson’s product moment correlation (r). The findings indicate there is no significant correlation between any of the epistemological subscale and problem solving confidence at either the $p = 0.05$ and $p = 0.01$ levels of significance. The EBI was measured as a single construct. Thus the research question as to whether a relationship exists between epistemic cognition and problem solving confidence is not answered by the study results. Given the weak results, the research question did not provide sufficient focus to correlate epistemic cognition (personal epistemology) and problem solving confidence.

Discussion of Epistemic Cognition and Problem Solving Confidence

Kitchener’s (1983) third level of cognitive processing is exhibited when the problem solver develops epistemological doubt (Bendixen, 2002) because previously successful strategies and processes no longer work as expected. Thus solving ill-structured problems requires epistemic cognition (level 3 of Kitchener’s hierarchical model) that allows the problem solver to deal with uncertainty in knowing and weighing conflicting evidence claims for problem solving (King & Kitchener, 2002). The rationale for including epistemic cognition in the present study is largely the empirical notion of solution justification. In effect, ill-structured problems often have vaguely defined goals (Voss, 1988), posses multiple solution paths (Kitchner, 1983), and potentially have multiple, non-guaranteed solutions (Schraw, Dunkle, & Bendixen, 1995).
The exclusion of epistemic cognition given the lack of statistical significance may be due to the EBI instrument itself. The overall notion of epistemic cognition (epistemic cognition) as what “individuals believe about the source, certainty, and organization of knowledge, as well as the control and speed of learning” (Schommer, 1994, p. 293) to evaluate the veracity of ideas and information relative to their justification of selected solutions (Jonassen, 2000) suggests not all aspects of epistemic cognition may be measured in a self-report format that does not include actual problem solving. This contention does not diminish the contribution of epistemic cognition to solving ill-structured problems, but rather draws into question how best to measure the dimension of the construct relative to solving ill-structured problems. The five dimensions of 1) simple knowledge, 2) certain knowledge, 3) innate ability, 4) omniscient authority, and 5) quick learning are briefly discussed to validate their influence on ill-structured problem solving (Heppner, 1988; Schommer, 1994).

The structure and organization of knowledge may be envisioned as a continuum from knowledge being compartmentalized and simple to knowledge being highly integrated and “interwoven” as complex configurations. Analysis suggests the structure of knowledge does not impact problem solving confidence (Newell & Simon, 1972). Although it was hypothesized that individuals who believe knowledge is simple often rely upon simple problem schemata (i.e. memorization), measuring this dimension appears to be problematic. The theoretical linkage to strong structural knowledge via expertise in problem solving bolsters the importance of the dimension, yet provides little guidance to effectively measure its impact on problem solving confidence (Chi & Glazer, 1985).
The certainty of knowledge relates to the possibility of knowledge as being an absolute, fixed constant, or constantly evolving phenomena. The avoidance of ambiguity and deferral to deterministic thinking prevails with strong believers in simple and certain knowledge. Their problem response seeks the single answer that avoids grey areas and speculation. Consequently the weak association between a stable perception of knowledge and problem solving confidence indicates a possible issue of measurement. Again, the notion of expertise lends credence to the perception of knowledge as evolving, however the ability to measure one’s perception of this dimensions is problematic according to the study analysis (Schommer, 1990).

Innate ability (i.e. controlling knowledge acquisition) is based upon the notion of “genetic hardwiring” that our ability and performance with learning is predetermined, as opposed to, the ability to learn is based upon experience and exposure (Kolb 1984). The perception of mistakes and their implications is extremely relevant for belief in how knowledge is controlled. Strong believers in fixed learning ability interpret their mistakes as a reflection of their inadequacy thus disengaging from the problem attempt prematurely or simply failing to attempt multiple solution paths. Conversely, those who believe mistakes are opportunities to learn tend to persist in solution attempts and often develop an intense interest in studying further and remaining tenaciously engaged in the problem solution process (Schommer, 1990; Jonassen, 1997).

Knowledge has several sources over a range of being “handed down by an omniscient authority to knowledge as reasoned out through objective and subjective means” (Schommer, 1998, p.301). Omniscient authority showed no statistical significance for this study.
Schommer (1990) also had difficulty getting the omniscient authority construct to load in factor analysis. The source of knowledge influences both individuals and individuals within collaborative environments to a large extent because information search and justification are based upon the reliability of the information source chosen. In general terms, a sophisticated problem solver will challenge the source of information if there are conflicting perspectives brought out during the problem solving process.

The notion of time investment becomes a critical factor when ‘quick learning’ is involved. Those with strong beliefs in the ‘easy way’ tend to operate in spurts with the preconception of time as fixed investment (Schommer, 1990). The counterpart suggests the belief in gradual learning will yield to an exploratory phase to probe and understand the problem. Their time investment is gauged by progress toward the solution goal and is constantly modified and revaluated during the solution process (Newell & Simon, 1972). Thus the notion of engagement becomes an important determinant for individuals search for information, working through multiple problem iterations, and eventually justifying a solution (Apter, Mallows, & Williams, 1998).

Research Question 4

Does perceived cognitive style, metacognitive monitoring, and epistemic cognition explain a significant amount of variance in problem solving confidence as reported by adult professionals who develop software and use software systems to solve ill-structured problems?
Conclusions for Independent Variables and Problem Solving Confidence

The combination of all statistically significant variables that demonstrate a relationship with problem solving confidence were placed in a regression equation to conduct a step-wise regression analysis. Based upon analysis of multicollinearity, MAI ($r^2 = .141$), and ASM ($r^2 = .026$) were suitable for inclusion in the regression model. The final regression model placed the variables as MAI ($\beta = -0.115, p = 0.000$) and ASM ($\beta = 1.686, p = .058$) as significant indicators of problem solving confidence. After three iterations of the regression equation, the final model yielded the equation: \[ PSC = 40.685 - (.115)(MAI) + (1.686)(ASM) \] which explained 20.5% of the variance.

Thus the research question as to whether a relationship exists between each of the independent variables and problem solving confidence is partially answered by the study results. Given the complex interrelationships of the independent variables the regression model produced a statistically significant relationship between the variable MAI and ASM with problem solving confidence (PSC). The final regression model explained 20.5% of the variation in the hypothesized relationship which correlates to a large effect size for the population studied (Kotrlik, & Williams, 2003).

Conclusions

The present exploratory study measured perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing as an indicator for problem solving confidence (Heppner, 1988). This study argues these cognitive indicators may be used as a diagnostic foundation for improving ill-structured problem solving capacity for adult professionals who develop software or use
software systems to solve ill-structured problems. The present study addressed four research questions and four associated hypotheses in a three-phased analytical approach.

The first research question examined the relationship between problem solving confidence (PSC) and cognitive styles as diverger (DVG), converger (CVG), assimilator (ASM) and accommodator (ACC). Based upon the analysis, there is no significant correlation between any of the cognitive styles and problem solving confidence at either the $p = 0.05$ or $p = 0.01$ levels of significance. Only the assimilator (ASM) cognitive style had any appreciable influence ($r = .162$) for inclusion in the regression model which yielded acceptable results ($\beta = 1.686, p = .058$). Consequently the accommodator (ACC), diverger (DVG), and converger (CVG) cognitive styles were not significant indicators of problem solving confidence. The failure to correlate problem solving confidence with cognitive style indicates the LSI measures cognitive preferences, which depict process inclinations, rather than degree of problem solving confidence.

The second research question examined the relationship between problem solving confidence (PSC) and metacognitive monitoring (MAI). The analysis indicates the relationship between problem solving confidence and metacognitive monitoring is a weak ($p = .01$) negative correlation ($r = -.376$) which suggests larger values for metacognitive monitoring correspond to smaller values for problem solving confidence. The conclusions suggest measuring the monitoring function may require improvement in a self-report format as opposed to actual problem solving.

The third research question examined the relationship between problem solving confidence (PSC) and epistemic cognition (EBI). Based upon the analysis, the findings
indicate there is no significant correlation at either the $p = 0.05$ and $p = 0.01$ levels of significance. The failure to correlate at significant levels suggests not all aspects of epistemic cognition may not be measured in a self-report format as opposed to actual problem solving.

The final research question, which integrated all of the independent variables into a indicator of problem solving confidence concluded that the independent variables of MAI ($r = -0.340$) and ASM ($r = 0.162$) were statistically significant relative to problem solving confidence. Their inclusion into a step-wise regression analysis that underwent three iterations suggests these independent variables account for 20.5% of the variance in the regression model.

The analytical results for this study suggests Kitchener’s (1983) model of hierarchical cognitive processing has guarded merit for explaining the problem solving confidence that adult professionals who develop software and use software systems to solve ill-structured problems demonstrate in organizational settings. Lykken (1968) makes the case that within the areas of clinical psychology and personality research most of the conclusions specify no more than the direction of a correlation, difference, or treatment effect. The threshold of 20% explanation of the total variance (Lykken, 1968; Hair, Anderson, Tatham, & Black, 1998) is not inconsistent with sociological research outcomes (Babbie, 2007; Garson, 2008). Thus explaining 20.5% of the variance in the regression model is consistent with existing research.
Implications for the Study

The present exploratory study measured perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing as an indicator for problem solving confidence (Heppner, 1988). The study concluded the level of problem solving confidence (PSC) is indicated 20.5% of the time with the following equation: 

\[ PSC = 40.685 – (.115)(MAI) + (1.686)(ASM). \]

Arguably there are several implications for instructional design when baseline assessment of problem solving confidence and cognitive profiles are available. This section discusses three prominent implications derived from the empirical value of the research and the ability to assess baseline problem solving capacity. The implications for the present study include 1) developing an improved understanding of problem complexity, 2) minimizing the reliance on domain dominance and expertise to solve ill-structured problems, and 3) improving the focus of PBL for professional development platforms. The next three sections are discussed relative the research outcomes as follows.

*Developing an Improved Understanding of Problem Complexity*

Nickerson (1994) notes that problem solving research has primarily focused on task analysis, mental constructs, and behavioral characteristics. Although these foci have produced considerable insight into how problems are classified and solved, the inattention to why problem solvers think about problems as they do remains elusive. Research concerning ill-structured problem solving has focused on approach by developing models and assembling empirical evidence to predict the strategy and solution path rather than investigating the cognitive, metacognitive, and epistemic factors in sufficient detail to
evaluate problem solving capacity. The implications of the present study to develop an
improved understanding of problem complexity comes from the realization that problems
vary according to problem type, problem representation and complexity, and individual

The present study disclosed three problem types as well-structured (tame) problems
(Reitman, 1965; Neisser, 1976; Greeno, 1978), ill-structured or ‘everyday’ problems
(Kitchner, 1983; Voss, 1988; Sinnot, 1989), and un-structured or ‘wicked’ (Rittel & Webber,
1973). The study illustrated well-structured problems are “puzzles” (Neisser, 1976, Kitchner,
1983) that can be solved by applying rules because they tend to be procedural and linear in
which the ends, goals, and means are prescribed and apparent. At the next level, ill-structured
problems tend to be iterative and evolutionary wherein the problem formulation evolves from
elements of consensus and conflict as with justification of the answer. Lastly, un-structured
or wicked problems are complex and chaotic because there is no definitive problem
formulation strategy or solution end point, thus a trial and error approach is indicative of the
evasiveness of clear objectives and goals which is exemplified by public policy problems.

Each of these problem types operates interdependently as a cluster, network, or set of
interrelated problems and contextual conditions (Margetson, 1998). The term “problem
situation” (Checkland, 1981) conveys the essence of problem configuration by suggesting
problems encountered are actually multiple, interacting problems that transcend traditional
disciplinary boundaries. Thus we are not confronted with separate problems but with
complex systems of strongly interacting problems (Ackoff, 1974). Understanding problem
complexity is a paramount concern because misrepresenting problem complexity or applying
linear and deterministic thinking regardless of the problem outcome is in effect finding the “right” solution to the “wrong” problem (Mitroff, 1998). When highly-interactive, complex problems are misclassified or overly-simplified the outcome can be problematic.

Perrow’s (1984) argument that risk assessment in complex, high-technology environments, which is based upon problem classification, presupposes deterministic (known outcomes and fixed sequences) and stochastic (known outcomes and know probabilities) problem scenarios despite the recognition that highly complex technical problems exhibit non-linear, often chaotic behaviors indicative of uncertain and emergent (unknown outcomes and moot issues) problems. King (1989) amplifies the point that solving the wrong problem, or more aptly problem type, is a prescription for disaster within high-technology environments such as nuclear power and biotechnology. Consequently individuals entrusted with identifying, solving, or preventing ill-structured problems in organizational environments have a vested interest in understanding problem complexity.

Arguably, the correlation between the cognitive factors espoused by Kitchener (1983) and problem solving confidence (Heppner, 1988) offers promise for extending problem solving research beyond procedural considerations. In this regard a focus on developing an assessment baseline provides the foundation for developing customized curriculum and scaffolding that can be used for problem-based professional development programs. The present study amplified the importance of not only recognizing problem types, but the complexity associated with different solution strategies. Given there is virtually no research in the role of metacognition on ill-structured problem-solving (Jonassen, 2000) and “the degree to which metacognition influences problem-solving activity has not been resolved”
(Lester, 1998, p.666), this study demonstrated the importance of individual cognitive elements and their influence on problem solving confidence as a foundation for enhancing problem solving capacity. The next section examines the potential for minimizing the reliance on expertise to identify and solve ill-structured problems within organizational settings by developing and enhancing problem solving capacity for a larger contingent of the adult professionals who develop software and use software systems to solve ill-structured problems.

*Minimizing the Reliance of Domain Dominance and Expertise to Solve Ill-Structured Problems*

The second implication of this study is exposing the limitations of domain dominance and expertise as exclusive indicators of problem solving capacity. In this regard, subject matter expertise becomes the operative focus for the discussion. In this regard “expertise is proficiency taken to its highest level and understanding” (Glaser, 1988, p.63).

One of the primary contentions of this study was to demonstrate that cognitive variables (cognitive style, metacognitive monitoring, and epistemic cognition), rather than a sole reliance on levels of education (EDU) and years of experience (EXP), were viable indicators of problem solving confidence (i.e. capacity).

A substantial argument can be made that ‘expert’ problem solvers are certainly domain dominant (e.g. subject matter expertise), but can they transfer this expertise to other domains and across problem types? In this regard, the over-reliance on the epistemology and methodology inherent in a particular discipline (domain) has not proven to transfer to all problem situations (Russ-Eft & Preskill, 2001). The problem with domain dominance
suggests those with superior structural knowledge and experience may be perceived as better problem solvers, when in fact, they simply possess more knowledge and not necessarily more problem solving capacity. As Ackoff (1974) suggests, problems classified according to domain specificity are ultimately resolved according to methods inherent in that domain despite the need for multi or trans-disciplinary approaches and expertise.

The focus on the procedural aspects of problem solving reinforces the notion of domain dominance, despite the fact that different problems require different solution strategies (Jonassen, 2000). The notion of domain dominance has constrained rather than enhanced problem solving capacity because the approaches used in business, engineering, law, medicine, the social sciences, and the physical sciences are distinct and integral to the pedagogy of the domain.

The research conducted to examine the differences between novice and expert problem solvers (Chi, Feltovich, & Glazer, 1981) disclosed a complex array of cognitive and metacognitive factors that differentiate these two levels of problem solving. As Voss (Voss et al., 1983) and colleagues note, “experts and novices typically differ in a number of ways in addition to their acknowledged differences in expertise” (p. 173). The crux of the research disclosed three characteristics observed in expert problem solving that continue to dominate the research as the preparatory phase of problem solving (i.e. visualization or framing), the problem solving strategy selection, regulation, and monitoring, and the possession of exceptional domain knowledge. The key factor that differentiates expert problem solving appears to be the preparatory stage whereby experts tend to dwell longer on problem characteristics and making cognitive connections prior to attempting solution strategies.
Brand-Gruwel, Wopereis, and Vermetten (2005) conducted research to determine the difference between expert and novice problem solving by observing how the participants conduct information searches and decompose real-world problems. In effect the experts in both cases have better defined problem-solving skills and tend to spend more time framing the problem and developing viable options. As the researchers note “experts spend more time on the main skill, define problem, and more often activate their prior knowledge, elaborate on the content, and regulate their process (p.487).” The implications of this research on technology innovation is the information searching framework used by the model and results that suggest experts follow a specific pathway during the problem-solving process.

Research by Stylianou and Silver (2004) indicated “experts were able to recognize meaningful patterns in the diagrams they constructed and to determine the utility of a diagram (p.379) because their diagram represented ‘rich pictures’ (Checkland, 1981). Conversely novices, who also use diagrammatic representations, seem to realize elements declarative knowledge, but lacked the procedural knowledge to leverage the diagram to its full effect (Stylianou & Silver, 2004). Thus for experts, “constructing visual representation was only the starting point from which to launch a very specific higher level analysis” (p.381). Their research clearly supports the contention that experts construct visual representations more frequently to conceptualize the problems and develop the constraints and solution strategy and that they have a vast amount of domain knowledge that is highly structured and organized in memory (Stylianou & Silver, 2004).

The interpretation of the results for this study suggest experts initially enter a qualitative phase in which the problem is ‘visualized and framed’ prior to manipulating
information and rules. In effect the expert problem solver activates a knowledge-derived schema that guides categorization of the problem and the search for relevant information. Thus experts activate more advanced problem schemata, which begins with preliminary probing and categorization, followed by execution of procedural (knowledge about “how” to do things) and declarative (knowledge about ‘things’) knowledge. In effect the research disclosed that “experts’ schemata contain a great deal of procedural knowledge, with explicit conditions for applicability” (Chi, Feltovich, & Glazer, 1981, p.151) whereas novices’ schemata contained sufficient declarative knowledge but lacked ‘abstracted solution methods.

Some other approaches that have investigated nuance of the dominant themes are adaptive expertise and the use of metaphors. The notion of adaptive expertise is also a prominent consideration because there remains an issue whether or not experts can transfer their expertise across domain, or more specifically to novel problems (Barnett & Koslowski, 2004). Another distinction of expert problem solvers is their use of metaphor. In this regard, experts use metaphors less often, in favor of more efficient methods. However, both experts and novices use metaphors to correct mistakes, yet experts use metaphors to create broader goals (Chin, 2001). Lemaire and Siegler (1995) have proposed a four-layered account of expertise from a strategies perspective: Experts have better strategies, tend to use strategies that are better overall more often, are better able to select the circumstances to which a strategy best applies, and are better able to execute a given strategy.

The reliance on domain dominance and expertise to solve ill-structured problems comes from the post-industrial focus on technical-scientific expertise (Galbraith, 1967),
development of a service economy that valued intellectual technology (Bell, 1969), and the emergence of knowledge work as the vehicle for value-added problem solving (Drucker 1986; Reich, 1993). In contemporary society, the terms ‘thought leader’, ‘guru’, and ‘subject matter expert’ have all been used conspicuously in the problem solving arena. Each of these phrases implies a certain level of skill or knowledge attainment and most certainly a consensual agreement from those seeking advice and counsel. The present study suggests developing or enhancing problems solving capacity is not necessarily dependent upon domain dominance but rather understanding the complexity of problem types and understanding the cognitive factors that undergird the problem solving process. The next section provides insight for improving problem-based learning (PBL) when used as a professional development platform.

**Improving the Focus of PBL for Professional Development Platforms**

Problem Based Learning (PBL) is the learning which results from the process of working towards the understanding and resolution of a problem (Barrows & Tamblyn, 1980). PBL also strives to leverage professionally relevant material, encourage holistic thinking and reflective practice, and develop decision-making skills (Drinan, 1998). The appeal of PBL as an educational approach and curriculum development model justifies its popularity as a professional development framework (Bridges & Hallinger, 1992; Moroco & Sullivan, 1999). Although research indicates problem-based approaches to professional development vary in their ability to promote higher-level cognitive skills (Geissler, 1996) some research indicates less than ten percent of the organizational learning actually occurs within these venues (Tannenbaum, 1997). This study argues these cognitive indicators may be used as a
diagnostic foundation for improving ill-structured problem solving capacity for adult professionals who develop software or use software systems to solve ill-structured problems. In effect the cognitive diagnostics can be used to augment instructional design and improve professional development venues that cater to improving problem solving capacity.

The structure of PBL in professional development venues is to present real world problems to small groups while facilitating discovery and cycling through the problem solving process (MacKinnon, 1999). Although PBL offers a robust framework for use in professional development programs, two primary challenges emerge from its academic heritage in higher education as a curriculum development strategy (Engle, 1998) and through outcomes assessment criteria (Savin-Badin, 2000). This study sought to provide support for each of these concerns by developing the assessment framework to guide program development as well as the assessment variables.

The traditional hierarchical models of learning and instructional design assume problem-solving is a linear process that builds upon a progressive assembly of concepts, rules, and principles to arrive at a solution (Jonassen, 1997). When one considers the complexity of ill-structured problems, the notion of linearity and rule-based process is insufficient to develop the problem solving skills required for today’s technology-driven arena. The key differentiating factors that separate PBL from traditional, didactic methods is organizing the curricula around problems rather than disciplines (Savin-Baden, 2000). The focus on problems, rather than discipline, is a fundamental shift towards broadening the approach to problem-solving.
The present study proposed the cognitive elements for solving ill-structured problems provide the diagnostic foundation for improving ill-structured problem solving capacity for adult professionals who develop software or use software systems to solve ill-structured problems. Although research indicates problem-based approaches to professional development vary in their ability to promote higher-level cognitive skills (Geissler, 1996), many proposed strategies and programs remained anchored to well-structured problem-solving techniques thereby reducing the potential for a wider range of enhanced problem-solving skills. This study suggested the problem is not the educational process, but rather instructional development shortcomings that impact the educational process (Jonassen, 2000). Consequently, realizing the structural and cognitive dimensions of ill-structured problems helps to develop an understanding of the problem-solving process and help develop the capacity to identify, formulate and prevent or solve ill-structured problems.

One of the key questions often asked about PBL remains, “is it effective”? The notion of effectiveness is relative to how PBL is assessed in either academic or professional development settings. In academic settings, PBL assessment can be problematic due to the tendency toward student stratifications (Savin-Baden, 2004b), reinforcing individual and institutional hegemonic practices (Herron & Major, 1998), attaining pre-determined levels of expertise (Margetson, 1998), and failure to recognize the differing characteristics of adult learners (Drinan, 1998). The corresponding professional development issues include assessing the required techniques and performance criteria (Stoneall, 1992), validating improved decision-making (Patton, 1994), and verifying improved understanding of critical organizational issues (Torres, Preskill, & Pointek, 1999). Invariably, “the effectiveness of
PBL depends on student characteristics and classroom culture as well as the problem tasks. Proponents of PBL believe that when students develop methods for constructing their own procedures, they are integrating their conceptual knowledge with their procedural skill” (Roh, 2003, p.1). The effectiveness argument was addressed by this study by suggesting the cognitive elements play a critical role in problem solving confidence. In particular, the ability to enhance problem solving capacity may not necessarily require developing expertise, but realizing cognitive strengths and weaknesses.

The argument against discipline-based problem-solving, especially within the context of organizational problems, has been encapsulated by Ackoff’s (1974) observation that the problems encountered are actually multiple, interacting problems that transcend traditional disciplinary boundaries. The entrenchment of problem-solving based upon discipline-specific knowledge bases and investigative approaches challenges broader, holistic approaches to problem-solving. As Savin-Baden (2000) notes, “transcending discipline boundaries may be difficult to manage if students see knowledge as essentially propositional rather than connected to their learner or pedagogical identity” (p.101).

The present study emphasized the role of PBL as a professional development platform due to the intuitive appeal of focusing on problem solving in organizational settings. Savery and Duffy (1994) note the constructivist framework develops an understanding of environmental interaction through which cognitive conflict stimulates learning thereby allowing knowledge to evolve through evaluation of the viability of individual understanding. Thus the constructivist framework shifts from content coverage to problem engagement, lecturing to coaching, and passive learning to active engagement (Tan, 2004).
this regard using the cognitive assessment suggested by this study to develop problem solving capacity baselines are useful for developing customized curriculum and assessing overall progress toward improved ill-structured problem solving capacity and confidence. The next section moves from the potential implications of the present study toward expanding the research agenda and enhancing the opportunities available to practitioners.

Recommendations for Future Research and Practice

The previous section outlined three significant implications of the present study. The improved understanding of problem complexity, minimizing reliance on experts to solve ill-structure problems, and enhancing the effectiveness of PBL for professional development platforms sets the stage for improving HRD practice especially given the value of the research outcomes to assess baseline problem solving capacity. Correspondingly there are three recommendations this study posits for future research and practice. First this research must be extended to include the contextual effects of organizational problem solving thereby combining the cognitive with the contextual. This emphasis is required to examine other problem solving variables, such as affective factors, in dynamic and evolutionary environments. Second the practice of HRD must strive to enhance critical thinking and reflective practice as a reasoned approach to ill-structured problems solving and create the balance between managing and leading innovation. Finally, probing demographic differences will help develop a better understanding how gender, education, and experience contribute to problem solving confidence. The next sections address these concerns through 1) evaluating the context of organizational problem solving, 2) advancing critical thinking and reflective practice, and 3) probing demographic differences to evaluate problem solving confidence.
Evaluating the Context of Organizational Problems Solving

Eliminating organizational content from the present study to focus on a select grouping of variables was a major study assumption. The rationale was developed from the failure of organizational effectiveness research (Cameron, 1981) to accurately portray the variables that comprise organizational context (Porras & Silvers, 1991). Arguably the sheer number of variables and constructs forced aspects of this study to treat the impact of contextual effects a neutral. Organizational context is an important factor for solving complex problems, however most organizational variable studies choose organizations that have a restricted range of variation on the dependent variable which is often expressed as the “organizational goal” (Perrow, 1977).

The present study recognizes the importance of organizational context however the impossibility of selecting and measuring which contextual variables influence problem solving confidence and how that influence is exhibited requires limiting the variables under consideration. The organizational effectiveness literature (Pennings & Goodman, 1977; Cameron, 1981) has attempted to model multi-variable configurations seeking a unifying theory of performance indicators and predicting organizational outcomes. However Campbell (1976) notes, “organizational effectiveness as a construct has no direct operational definition” (p.30) and consequently no universally accepted means of measurement have been devised. Thus organizational effectiveness research, which has remained relatively dormant since the 1980’s, fully realized the difficulty assessing organizational context.

The artificial constraint created by minimizing the influence of organizational context may impact the transferability of future research in the area of problem solving capacity and
innovation for adult professionals developing software and using software systems to solve ill-structured problems. A discussion of organizational context relative to its impact upon problem solving is presented to frame future research. This section examines how network dynamics, organizational change, and technology innovation have become three of the most prominent organizational context issues that impact ill-structured problem solving (Ackoff, 1974; Drucker, 1993; Mitroff, 1998).

Organizational problems can emanate from either internal or external sources. Invariably they are contextual, have diverse characteristics, and possess varying degrees of complexity. Organizational problems rarely exist in isolation. Understanding the contextual importance of organizational problems is a prerequisite for developing the ability to frame problems, identify constraints, and perceive the relationships and interconnections. Clearly the influence of network dynamics complicates ill-structured problem solving by virtue of the number, complexity, and duration of the relationships within organizational settings.

Today’s organizations use networks to focus on performance relative to external conditions which can be both real and anticipated. Both technological and social networks have created a distributed, decentralized, collaborative, and adaptive world that no longer operates according to linear, mechanistic paradigms (Kelly, 1994). Networks are a combination of technology, social paradigms, and interrelatedness that blend individuals, organizations, cultures, and societies into a complex web of interaction.

The complexity of social networks is the greatest challenge to solving organizational problems because the interconnections and interdependencies impede individual action. In mapping inter-organizational environments Auster (1990) notes the number of functions
(size), linkages (density), and kinds of linkages (diversity) impacts internal and external reachability within the network and affects stability. The interactions within networks are exemplified by Bieman’s (1992) five characteristics of interaction. The type of interaction (vertical/horizontal/competitive/complimentary) and its purpose (task performance or task stimulation) undergo various configurational changes depending on the intensity, duration, and formality characteristics of the interaction. Invariably network complexity impacts the ability to decide and act. Bronner (1986) suggests the number and types of elements, relationships, and contexts, and the definitiveness of goals, alternatives, and information impact how decisions are made and problems solved depending on experience and time frame for action. Thus this study could have been modified to examine how problems in social networks (i.e. teams) are affected by the consensual nature of solving ill-structured solutions. Arguably the differences between individual and group problem solving confidence may impact the “perception” of problem solving capacity or exacerbate the effectiveness of existing capacity when constrained by group dynamics. The next section examines the influence of organizational change and ill-structured problem solving.

Solving problems represents change. The change is the migration from one condition state, i.e. the problem to another, more desirable condition state, i.e. the solution. There are several models for organizational change within the literature, however few encapsulate the essence of organizational dynamics as well as the Porras and Silvers (1991) change model. The model is based upon organizational interventions and targeted behavioral changes to produce the desired outcome. This is consistent with Cervero and Wilson’s (2006) notion of learning as a social intervention to produce behavioral change through educational outcomes.
The Porras and Silvers (1991) model begins with intervention strategies for either organizational transformation or development. The intervention is selected based upon either being strategic or operational. The organizational variables targeted include structure, technology, cultural and communicative, and work settings. The gradations of change or problem-solving that are attempted are intended to produce degrees of behavioral change and ultimately individual and organizational change. Although no single model can accurately depict the full range of organizational issues. Clearly the acceleration of change and the rise of networks have constrained individual action by condensing reaction time and amplifying change stress through an omnipresent connection to a larger web of organizational and societal existence. Accordingly, effectiveness depends on adaptable and flexible individual action under conditions that enable, trigger, permit, or precipitate change depending on the synchronization between change driver and organizational reality.

The notion of organizational change as problem solving stems from the felt need to move from one condition state to another, more desirable condition state. The migration between states is both a learning process and problem solving process. The results of this study indicate cognitive factors play an important role for ill-structured problem solving, however the experience with change was also demonstrated to be an indicator of problem solving confidence. Thus change and problem solving are correlated philosophically, with potential for a psychometric counterpart. The next section examines problem solving as innovation to discuss the implications of developing more problem solving capacity in support of innovation.
Innovation is a broad construct that is characterized by the newness of ideas (Amabile, 1996; Tornatzky & Fleischer, 1990) that promote a performance enhancing and value-creating change (Drucker, 1993) in products, processes, or services (Luecke & Katz, 2003) within a network (Cabral, 1998). Innovation is also a complex process “that involves human systems at many different levels and through many different contexts” (Tornatzky & Fleischer, 1990, p. 46) and possesses a certain degree of uncertainty (Klein & Rosenberg, 1986).

Understandably the multitude of perspectives through which innovation has been conceptualized, researched, and discussed possess some interesting challenges for examination and exploration. Realizing not only the semantic challenge, but the number of avenues that can be used to examine innovation, Tornatzky and Fleischer (1990) developed a unifying approach by evaluating technology innovation. According to their definition, technology innovation is the “introduction of knowledge-derived tools, artifacts, and devices (that help people) extend their environment” (p.11). They go on to suggest technology is “at its heart a cognitive construct” (Tornatzky & Fleischer, 1990, p.13).

The characterization of technology innovation as knowledge applied to physical objects is what Goodman (1986) suggests as changing an object from one state to another. The notion of state changes is also exemplified through Newell and Simon’s (1972) theory of human problem solving as a transition from given states of the problem to be solved to the states directly attainable from them. The juxtaposition of knowledge or more specifically cognition and state changes, offers a comparative framework for the processes of technology innovation and problem-solving. Although there is an intuitive connection between
innovation as creativity and solving problems creatively, the larger purpose for comparison lies in problem-solving as a strategy to “overcome obstacles and meet goals” (Ellis & Siegler, 1994) which is a major element of technology innovation. According to Jablokow (2005) a better understanding of cognitive diversity within and approaches to problem-solving will enhance the innovation process and provide improvements for innovation management.

This contention is reflected in Perkins (2004) breakthrough thinking, Reid and Brentani’s (2004) “fuzzy” front end, and Tushman, Anderson, and O’Reilly’s (1997) managing strategic innovation. Each perspective implies a conscious approach to improving the operative capacity of individuals and organizations to innovate. Although Jablokow’s focus was on the catalytic nature of science to precipitate the problem-solving process, a larger venue is required to address how problem-solving may serve as the precursor for technology innovation. More broadly, the question becomes can better problem-solving skills, or a better awareness of the how problems are structured and solved to enhance the innovation process?

The challenges inherent in technology innovation can be used as an exploratory framework to demonstrate equivalency between the innovation process and problem-solving. Some of the challenges cited within the technology and innovation literature streams suggest levels of analysis (Klein, Danereau, & Hall, 1994), degree of innovative change (Tornatzky & Fleischer, 1990), measuring innovation (Bamberger, 1991), implementation (Klien & Sorra, 1996), developing innovative cultures (Kanter, 1988), and management of innovation (Tushman, Anderson, & O’Reilly, 1997) are relevant considerations.
The challenges identified represent one perspective and are not intended to be an exhaustive exploration of all major issues or research paths currently entertained by scholars and practitioners. Among this broad array of challenges, managing innovation, or more aptly, enhancing the technology innovation process as suggested by Jablokow (2005) offers the most promising venue to explore the comparative nature of technology innovation and problem-solving. The next section advances critical thinking and reflective practice as potential outcomes of the research presented in this study.

Advancing Critical Thinking and Reflective Practice

A key recommendation for improving HRD practice relative to enhancing problem solving capacity is to advance critical thinking and reflective practice beyond an esoteric dialog. Although the present study focused upon the cognitive elements of ill-structured problem solving, the “art” of thinking (DeBono, 1994) was only indirectly applied. Interestingly, one of the operative goals of PBL is to promote critical thinking (Barrows, 1986; Duch, 1995). This suggests that authentic (Glasgow, 1997) and professionally relevant problems (Drinan, 1995) promote the search for meaning and facilitate discriminate thinking.

The terms critical thinking and problem-solving are often used synonymously with regard to problem discovery and the ensuing solution strategy (Brookfield, 1987; Garrison, 1991). However critical thinking, especially in the context of understanding trans-disciplinary interactions, requires some degree of separation from the process of problem solving. Scriven and Paul (2004) define critical thinking as “the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or
evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action” (p.1).

Critical thinking is not a definable body of knowledge that can be directly transferred or a curriculum that can be bounded. Critical thinking, especially in practice, is similar to Mezirow’s (1991) content, process, and premise reflexive states. Cranton and King (2003) encapsulate content reflection as the “examination of the content or description of a problem” (p.34) and process reflection as an evaluative mechanism that “involves checking on the problem-solving strategies we are using” (p.35). Each reflexive state is based upon our assumptions about “self (narrative), the cultural systems in which we live (systemic), our workplace (organizational), our ethical decision making (moral-ethical), or feelings and dispositions (therapeutic)” (Merriam, 2004, p.62).

Thus critical thinking allows us to both analyze and synthesize the problem situation, its parameters and constraints, and the available data and information used in solution strategy. Our experience plays a critical role; not only as the baseline from which we operate, but also as the lens through which we our problem perceptions are generated. As Savin-Badin (2000) notes, “the concept of ‘turning experience into learning’ is often spoken of in these days or reflective practice and experiential learning” (p.116).

The terms reflection, reflexivity, and reflective practice are distinctive permutations of a common theme. Each offers a slightly different perspective, but each is required to develop an appreciation of problem-solving complexity. Mezirow (1991) contends “reflection enables us to correct distortions in our beliefs and errors in problem solving (and) critical reflection involves a critique of the presuppositions on which our beliefs have been
built” (p.1). In a complimentary fashion Weick (1999) contends reflexivity provides “tools to help people make sense of an unknowable, unpredictable world (p.803).

Relative to reflective practice, Schön (1983) argues there is a crisis of confidence in professional knowledge and that the limits of this knowledge should provide an avenue, through reflective practice, to understand our roles and what are actions disclose to us and others. Our ability to think and reflect critically sets the stage for understanding the larger world of problems. This issue became germane in a post-industrial society that was organized around professional competence and expertise. Schön (1983) argued that an epistemology rooted in reflection-in-action clarified the limits of professional knowledge and provided an avenue for defining a contemplative role for professionals within society. The assessment suggests professionals must strive to reflect upon what they do and know, how they conduct practice, and what practice discloses to us and others.

The notion of critical thinking and reflective practice as logical outgrowths of problem solving capacity suggests a better understanding of the cognitive dimensions of ill-structured problem solving reinforces how we examine the assumptions that govern business decisions and take informed actions (Brookfield, 2000). Thus introducing the cognitive elements as measured responses in conjunction with the art of thinking critically and reflectively provides an unique balance required for improving problem solving capacity today and in the future.
Probing Demographic Differences to Evaluate Problem Solving Confidence

The present study excluded evaluation of demographic variables although there is considerable empirical evidence that gender, level of education, and years of work experience contribute to problem solving capacity and prowess (Jonassen, 2000). Kolb and Kolb (2005) noted that normative groups indicated males were more ‘abstract’ than females on the AC-CE scale but was cautious to suggest that overall, gender differences require more research. Schraw and Dennison (1994) did not evaluate gender but found that older students have more metacognitive awareness. Neither researcher made any definitive conclusions regarding years of work experience. The most striking evidence of demographic differences comes from the epistemic cognition research. In this regard, Women’s Ways of Knowing (Belenky, et. al., 1986) describes distinct differences in female epistemological development.

The focus on cognitive, metacognitive, and epistemic cognition attempted to minimize evaluation of external factors (e.g. organizational context) and provide insight into developing a diagnostic foundation. Additional research regarding gender, education, and experience warrants closer examination if these traits can be isolated relative to problem solving confidence. Clearly the interaction of these demographics contributes to problem solving confidence but which traits dominate and dictate the degree of confidence? Careful research design and perhaps modification of the instruments used in this study offer promise for broadening the research agenda.
Closing Comments

The research questions, research design, and research outcomes of the present study provide valuable insight into the nature of solving ill-structured problems. The conclusion of any research project offers ample opportunity to reflect and contemplate the significance of the research and its probable impact for future research and practice. The notion of problem solving capacity, i.e. the ability and desire to engage ill-structured problems, is a journey of discovery and justification. The cognitive factors and confidence in their execution is one aspect of a larger body of inquiry. Clearly the world of problems exists in a systems context.

This study argued that perceived cognitive style, metacognitive monitoring, and epistemic cognition according to Kitchener’s (1983) hierarchal model of cognitive processing were indicators for problem solving confidence (Heppner, 1988). Although the study results offered moderate support for this contention, the larger issue of understanding problem complexity and the systems nature of problem situations belies the importance of the research and its implications for future research and practice. This author hopes the present study sparks further interest in problem solving research and prompts the next generation to examine problems in a new light.
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Appendix A

*Kolb’s Learning Style Inventory*

Below are 12 sentences with a choice of endings. Rank the endings for each sentence according to how you think each one fits with how you would go about learning something. Try to recall recent situations where you had to learn something new. Then, using the spaces provided, rank a ‘4’ for the sentence ending that describes how you learn *best*, down to a ‘1’ for the sentence ending that seems least like the way you learn. Be sure to rank the endings for each sentence. Please do not use the same ranking twice in any one sentence.

1. When I learn ( ) I like to deal with my feelings ( ) I like to think about ideas ( ) I like to be doing things ( ) I like to watch and listen

2. I learn best when ( ) I listen and watch carefully ( ) I rely on logical thinking ( ) I trust my hunches and feelings ( ) I work hard to get things done

3. When I am learning ( ) I tend to reason things out ( ) I am responsible about things ( ) I am quiet and reserved ( ) I have strong feelings and reactions

4. I learn by ( ) feeling ( ) doing ( ) watching ( ) thinking

5. When I learn ( ) I am open to new experiences ( ) I look at all sides of issues ( ) I like to analyze things, break them apart down into their parts ( ) I like to try things out

6. When I am learning ( ) I am an observing person ( ) I am an active person ( ) I am an intuitive person ( ) I am a logical person

7. I learn best from ( ) observation ( ) personal relationships ( ) rational theories ( ) a change to try out and practice
8. When I learn ( ) I like to see results from my work ( ) I like ideas and theories ( ) I take
   my time before acting ( ) I feel personally involved in things

9. I learn best when ( ) I rely on my observations ( ) I rely on my feelings ( ) I can try
   things out myself ( ) I rely on my ideas

10. When I am learning ( ) I am a reserved person; ( ) I am an accepting person ( ) I am a
    responsible person ( ) I am a rational person

11. When I learn ( ) I get involved ( ) I like to observe ( ) I evaluate things ( ) I like to be
    active

12. I learn best when ( ) I analyze ideas ( ) I am receptive and open-minded ( ) I am
    careful ( ) I am practical
Appendix B

*Metacognitive Awareness Index Monitoring Subscale*

Please respond to the questions below by indicating how true or false each statement is about you. Please respond by selecting the degree of that most accurately applies to you as follows: 1) always false, 2) somewhat false, 3) neutral, 4) somewhat true, and 5) always true

1. I ask myself periodically if I am meeting my goals.
2. I consider several alternatives to a problem before I answer.
3. I pace myself while learning in order to have enough time.
4. I think about what I really need to learn before I begin a task.
5. I know how well I did once I finish a test.
6. I set specific goals before I begin a task.
7. I slow down when I encounter important information.
8. I ask myself if I have considered all options when solving a problem.
9. I consciously focus my attention on important information.
10. I ask myself if there was an easier way to do things after I finish a task.
11. I periodically review to help me understand important relationships.
12. I ask myself questions about the material before I begin.
13. I think of several ways to solve a problem and choose the best one.
15. I ask others for help when I don't understand something.
16. I find myself analyzing the usefulness of strategies while I study.
17. I focus on the meaning and significance of new information.
18. I create my own examples to make information more meaningful.
19. I find myself pausing regularly to check my comprehension.
20. I ask myself how well I accomplished my goals once I'm finished.
21. I draw pictures or diagrams to help me understand while learning.
22. I ask myself if I have considered all options after I solve a problem.
23. I try to translate new information into my own words.
24. I change strategies when I fail to understand.
25. I use the organizational structure of the text to help me learn.
26. I read instructions carefully before I begin a task.
27. I ask myself if what I'm reading is related to what I already know.
28. I re-evaluate my assumptions when I get confused.
29. I organize my time to best accomplish my goals.
30. I try to break studying down into smaller steps.
31. I focus on overall meaning rather than specifics.
32. I ask myself questions about how well I am doing while I am learning something new.
33. I ask myself if I learned as much as I could have once I finish a task.
34. I stop and go back over new information that is not clear.
35. I stop and reread when I get confused.
Appendix C

The Epistemological Beliefs Inventory

There are no right or wrong answers for the following questions. I want to know what you really believe. For each statement below, select the degree to which you agree or disagree with the statement as follows: 1) Always agree, 2) somewhat agree, 3) neutral, 4) somewhat disagree, and 5) always disagree.

1. It bothers me when instructors don’t tell students the answers to complicated problems
2. Truth means different things to different people
3. Students who learn things quickly are the most successful
4. People should always obey the law
5. Some people will never be smart no matter how hard they work
6. Absolute moral truth does not exist
7. Parents should teach their children all there is to know about life
8. Really smart students don’t have to work as hard to do all that well
9. A person who tries too hard to understand a problem will just end up being confused
10. Too many theories just complicate things
11. The best ideas are often the most simple
12. People can’t do too much about how smart they are
13. Instructors should focus on the facts instead of theories
14. I like teachers who present several competing theories and let their students decide which is best
15. How well you do in school depends on how smart you are
16. If you don’t learn something quickly, you won’t ever learn it
17. Some people just have a knack for learning and others don’t
18. Things are simpler than most professors claim they are
19. If two people are arguing about something, at least one of them must be wrong
20. Children should be allowed to question their parents authority
21. If you haven’t understood a chapter the first time through, going back over it won’t help
22. Science is easy to understand because it contains so many facts
23. The moral rules I live by apply to everyone
24. The more you know about a topic, the more there is to know
25. What is true today will be true tomorrow
26. Smart people are born that way
27. When someone in authority tells me what to do, I usually do it
28. People who question authority are trouble makers
29. Working on a problem with no quick solution is a waste of time
30. You can understand something for years and still not really understand it
31. Sometimes there are no right answers to life’s big problems
32. Some people are born with special gifts and talents
Problem Solving Index Problem Solving Confidence Subscale

People respond to personal problems in different ways. The statements on this inventory list deal with how people react to personal difficulties and problems in daily life. Please respond to the items as honestly as possible so as to most accurately portray how you handle personal problems, NOT how you think you should solve them. Please read each statement and respond by selecting the answer based upon your agreement or disagreement with the statement. Please respond as follows: 1) strongly agree, 2) moderately agree, 3) slightly agree, 4) slightly disagree, 5) moderately disagree, and 6) strongly disagree

1. I am usually able to think of creative and effective alternates to my problems.
2. I have the ability to solve most problems even though initially no solution is immediately apparent.
3. Many of the problems I face are too complex for me to solve.
4. When solving a problem, I make decisions that I am happy with later.
5. When I make plans to solve a problem, I am almost certain that I can make them work.
6. Given enough time and effort, I believe I can solve most problems that confront me.
7. When faced with a novel situation, I have confidence that I can handle the problems that arise.
8. I trust my ability to solve new and difficult problems.
9. After making a decision, the actual outcomes is usually very similar to what I had anticipated.
10. When confronted with a problem, I am unaware of whether I can handle the situation.

11. When I become aware of a problem, one of the first things I do is try to find out exactly what the problem is.
Appendix E

Demographics

Tell me about yourself. Each of us are individuals, whose special qualities and competencies make a difference in the research. Please answer the following questions as accurately as possible. These questions are an important part of the research and will have a positive contribution to the results of this study.

1. Are you male or female? 1) Female, 2) Male
2. What is your age (as of your last birthday)? 1) 18-21, 2) 22-30, 3) 31-40, 4) 41-55, 5) 56 or older
3. How many years of work experience do you have? 1) 0-5 years, 2) 6-10 years, 3) 11-15 years, 4) 16-20 years, 5) 20 or more years
4. What your highest level of education attained? 1) high school/GED, 2) some college, 3) 2-year degree, 4) 4-year degree (BA/BS), 5) Master’s degree, 6) Doctoral or professional degree (PhD, JD, MD, EdD)
5. What was the major for the highest level of education attained? 1) no major, 2) business, 3) engineering, 4) physical sciences, 5) social sciences
Appendix F

Sample Introduction Letter

From: Steven Price, NC State University
Subject: Problem Solving Research Participation

March 15, 2008

Dear Colleague:

I am currently conducting problem solving research as part of my doctoral studies at North Carolina State University. I would greatly appreciate your participation by asking that you take a simple survey (the link is provided below) to offer your thoughts and insight concerning your individual approach to thinking through and solving problems. Each of the questions has been developed to help explain the problem solving process, but participants are NOT being asked to solve problems – simply responding to the questions as honestly and spontaneously as possible.

The online survey should take you about 30 minutes to complete. Your participation is completely voluntary, secure (no personally identifiable information), and sanctioned by the Internal Review Board of North Carolina State University. You may withdraw from the survey at any time; however your participation indicates your informed consent to participate. Your willingness to take a few minutes to share your experiences and opinions would be of great value to this research effort.

The following secure link is provided by Survey Monkey and will connect you to the study survey until April 15, 2008, at which point data will be compiled:

http://courses.ncsu.edu/psy720/lec/001/hybrid/survey.html

At the end of the survey, you may request a copy of the final report via e-mail. Your e-mail address will not be linked to your answers or to the survey.

Thank you very much for helping with this important effort.
Appendix G

The Problem Solving Confidence Survey

Introduction

Thank you for participating in this important research concerning problem solving by volunteering time to complete this survey.

The survey is divided into five sections (Parts I to V) and contains 95 questions. Many participants have completed the survey in just over 30 minutes – simply responding to the questions as honestly and spontaneously as possible. THANK YOU once again for your time.

In order to progress through the survey, please use the following navigation links:

Continue to the next page of the survey by clicking the Continue to the Next Page >> link.

Go back to the previous page in the survey by clicking on the Previous Page link. This will allow you to move back in the survey to look over the previous answers.

Finish the survey, by clicking the Submit the Survey link on the Thank You page.

100%
Below are 12 sentences with a choice of endings. Please rank each ending (only one choice per row and per column allowed) according to how best the sentence describes how you learn. Using the spaces provided, please rank as

4 = Most like I learn  
3 = The second best way I learn  
2 = The third best way I learn  
1 = Least like I learn

### Part 1

1. When I learn

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<th>4 - Most like I learn</th>
<th>3 - Second best way</th>
<th>2 - Third best way</th>
<th>1 - Least like I learn</th>
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<tbody>
<tr>
<td>I like to deal with my feelings</td>
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<td>I like to think about ideas</td>
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<td>I like to do things</td>
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<td>I like to watch and listen</td>
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### Part 2

2. I learn best when

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<td>I listen and watch carefully</td>
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<td>I rely on logical thinking</td>
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<td>I trust my hunches and feelings</td>
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Part II

Please respond to the questions below by indicating how true or false each statement is about you. Please respond by selecting the answer that most accurately applies to you as

1) Always False
2) Somewhat False
3) Neutral
4) Somewhat True
5) Always True

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**Problem Solving Capacity Survey**

**Part III**

Please respond to the questions below by indicating how much you agree or disagree if each statement is about you. Please respond by selecting the degree that most accurately applies to you. You can:

1) Strongly Disagree
2) Somewhat Disagree
3) Equally Agree and Disagree
4) Somewhat Agree
5) Always Agree

Please answer the following:

<table>
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<tr>
<th>Statement</th>
<th>1 - Strongly Disagree</th>
<th>2 - Somewhat Disagree</th>
<th>3 - Equally Agree and Disagree</th>
<th>4 - Somewhat Agree</th>
<th>5 - Always Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>42. It bothers me when instructors don't tell students the answers to complicated problems</td>
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<td>43. Truth means different things to different people</td>
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<td>44. Students who learn things quickly are the most successful</td>
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<td>45. People should always obey the law</td>
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<tr>
<td>46. Some people will never be smart no matter how hard they work</td>
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<tr>
<td>47. Absolute moral truth does not exist</td>
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<tr>
<td>48. Parents should teach their children all there is to know about life</td>
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<td>49. Really smart students don't have to work as hard to do all that well</td>
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</table>
Problem Solving Capacity Survey

Part IV

Please respond to the items as honestly as possible so as to most accurately portray how you handle personal problems, NOT how you think you should solve them. Please read each statement and respond by selecting the answer based upon your agreement or disagreement with the statement as:

1) Strongly Agree
2) Moderately Agree
3) Slightly Agree
4) Slightly Disagree
5) Moderately Disagree
6) Strongly Disagree

Please answer the following:

<table>
<thead>
<tr>
<th>Item</th>
<th>1 - Strongly Agree</th>
<th>2 - Moderately Agree</th>
<th>3 - Slightly Agree</th>
<th>4 - Slightly Disagree</th>
<th>5 - Moderately Disagree</th>
<th>6 - Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>I am usually able to think of creative and effective alternatives to my problems</td>
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<td>02.</td>
<td>I have the ability to solve most problems even though initially no solution is immediately apparent</td>
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<td>03.</td>
<td>Many of the problems I face are too complex for me to solve</td>
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<td>04.</td>
<td>When solving a problem, I make decisions that I am happy with later</td>
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<td>05.</td>
<td>When I make plans to solve a problem, I am almost certain that I can make them work</td>
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<td>06.</td>
<td>Given enough time and effort, I believe I can solve most problems that confront me</td>
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<td>07.</td>
<td>When faced with a novel situation, I have confidence that I can handle the problems that arise</td>
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</table>
Problem Solving Capacity Survey

Part V

Each of us has special qualities and competencies that make a difference in this particular research. Please answer the following questions as accurately as possible.

91. Your gender is:
   - Female
   - Male

92. The age on your last birthday was:
   - 18 – 22
   - 23 – 30
   - 31 – 40
   - 41 – 50
   - 50 or older

93. How many years of work experience do you have?
   - 0-5 years
   - 6-10 years
   - 11-15 years
   - 16-20 years