CONTRIBUTIONS BY INDIVDUAL AND GROUP STRATEGIES FOR ORGANIZATIONAL LEARNING IN ARCHITECTURE, ENGINEERING AND CONSTRUCTION FIRMS

by

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ABSTRACT

Organizations with multiple operating requirements require support functions to assist in execution of strategic goals. This effort, in turn, requires management of engineering activities in control of projects and in sustaining facilities. High level strategies include employing engineering support that consists of a project management function encompassing technical and managerial disciplines. The architecture/engineering, and construction office (AEC) is the subject of this research.

Engineering and construction oriented organizations have experienced challenges to their abilities to learn and grow. This has potential detrimental implications for these organizations if support functions cannot keep pace with changing objectives and strategy. The competitive nature and low industry margins as well as uniqueness of projects as challenges facing engineering and construction. The differentiated nature of projects tasks also creates a need for temporary and dedicated modes of operation and thereby tends to promote highly dispersed management practices that do not dovetail very well with other organizational processes. Organizational learning is a means to enhance and support knowledge management for improving performance. The problem addressed through this research is the gap between desired and achieved individual and group learning by members of the AEC, and the members' abilities to distinguish between the need for adaptive learning or innovation. This research addresses learning by individuals and groups, and the strategies employed through an empirical study

(survey). A conceptual model for organizational learning contributions by individuals and groups is presented and tested for confirmation of exploitive or explorative learning strategies for individuals, and directions composed of depth and breadth of learning. Strategies for groups are tested for internal or external search orientations and directions toward the single or multi-discipline unit.

The survey is analyzed by method of principal components extraction and further interpreted to reveal factors that are correlated by Pearson product moment coefficients and tested for significance for potential relationships to factors for outcomes. Correlation across dependent variables prevented interpretation of the most significant factors for group learning strategies. However, results provide possible support for direction in supporting processes that promote networking among individuals and group structures that recognize the dual nature of knowledge - that required for technical competency and that required for success in the organization. Recommendations for practitioners include adjustments to knowledge acquisition direction, promoting external collaboration among firms, and provision of dual succession pathways through technical expertise or organizational processes for senior staff.

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Joy Tatlonghari at the Department of Industrial Engineering and Management Systems has been a present help to me in navigating the maize of administrative requirements since I restarted my academic career. Every office should have "a Joy".

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CHAPTER 1: INTRODUCTION

1.1 Introduction and Environment

Organizations with multiple venues and diverse operating requirements require support functions to assist in execution of strategic goals. The development of facilities to support the strategy requires a continuous effort for development, support and renewal of facilities and operational plans to sustain strategy through the expected lifecycle, until new strategic initiatives require new facilities or alterations. This effort, in turn, requires management of engineering activities in control of projects and in sustaining facilities.

High level strategies include employing engineering support that consists of a project management function encompassing technical and managerial disciplines. The support may be obtained by an "in-house" group that is a part of the organization or by an out sourced function. The architecture/engineering/construction office (AEC) will be studied for the purposes of this research. The AEC may be organized according to the more traditional functional department, project groups, or a matrix format and typically addresses ongoing renewal or planned upgrades of assets while maintaining a state of readiness to support the operational requirements resulting from unplanned events. The AEC operates essentially as would a firm engaged at the discretion of any parent organization or client. In a systems view, the flow of information and knowledge in this relationship is shown in Figure 1.

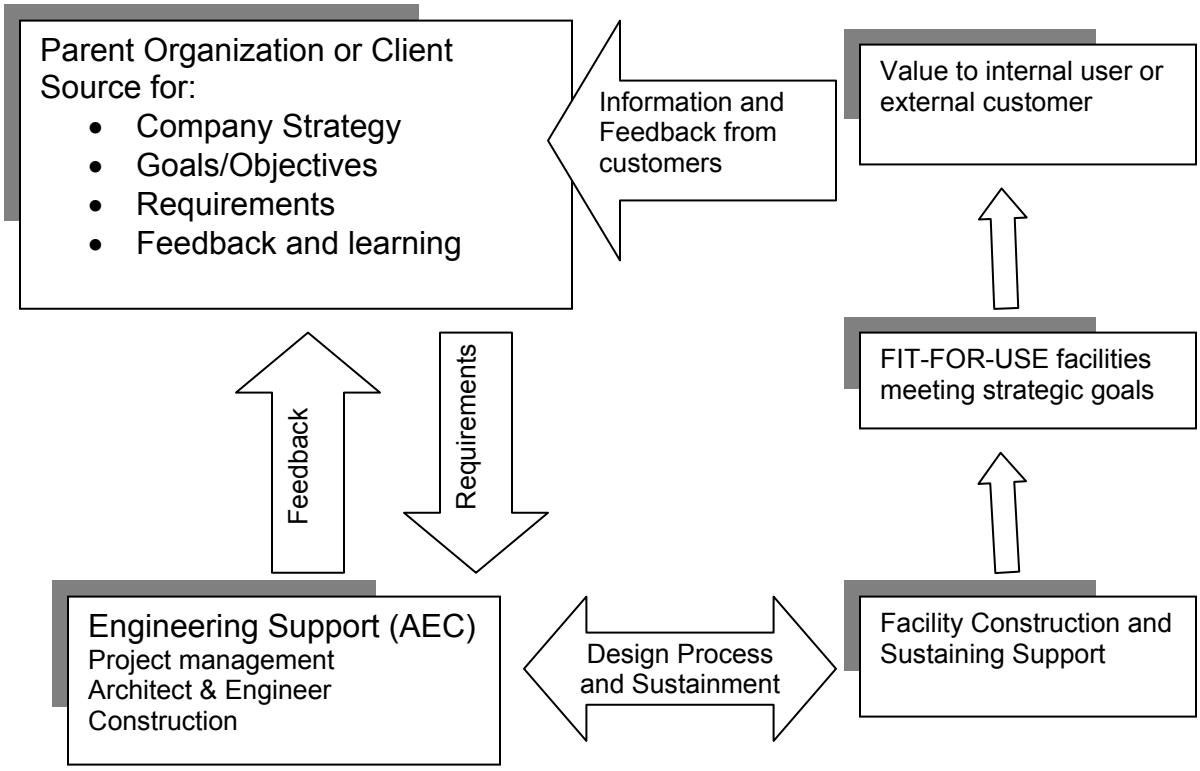

Figure 1. High Level Value Chain for AEC Function

1.2 Problem Statement

Various authors and business executives have stated that organizations and individuals that learn faster than competitors are likely to have the only sustainable competitive advantage, especially in knowledge intensive industries (Stata, 1989; Senge, 1990, 2006; Yeung, et al., 1999). However, engineering and construction oriented organizations have experienced challenges to their abilities to learn and grow (Federle and Chase, 1993; Ford et al., 2000; Kamara, et al., 2002; Love, et al., 2004; Chinowsky and Carillo, 2007). This has potential detrimental implications for these organizations if support functions cannot

keep pace with changing objectives and strategy. As asserted by Love, et al. (2004) construction oriented organizations did not embrace Total Quality Management initiatives partly for the error of confusing it with quality assurance. Ford, et al., (2000) found that engineering based cultures are likely to have difficulty in learning, unless they manage to evolve a "balanced culture". Cayes (1998) suggests that on the individual level, engineers may be "poor students" due to the perception of having to develop a singularity of perspective on the journey to expertise and development of aversion to risk. Failure to incorporate learning and knowledge into practices negatively affects performance. Soibelman, et al., (2003) state that according to the U.S. Building and Economic Development Committee, more than 50% of problems encountered on building sites are related to poor design. Causes sited are:

- Inaccurate design assumptions.
- Team members withholding of information.
- Incomplete or missing information.
- Poor quality of exchanged information.
- Various changes experienced during design.
- Multiple participants at different phases creating uncertainty in information validity.

This fragmented nature of the AEC environment calls for a need for learning and innovation to improve business performance to maintain competitiveness (Kamara, et al., 2002; Bresnen, et al., 2005; Puddicombe, 2006).

Attempts to improve responsiveness to client requirements and quality of design in the AEC environment have met numerous challenges (Kamara, 2002; Love, et al., 2004, Veshosky, et al., 1998). Established structural, cultural, and mindset paradigms are some of the issues responsible for the foregoing shortcomings. According to Veshosky, et al. (1998), they include:

- Concern over safety and cost of new products.
- Restrictive nature of externally applied codes and regulations.
- Unique nature (one of a kind) and transience of projects.
- Fragmented nature of the supply chain.
- Procurement system that fragments design, construction, and use.

Carillo and Chinowsky (2006) point out the highly competitive nature and resulting low industry margins as well as uniqueness of projects as challenges facing engineering and construction. Their studies found that 67% of US engineering and construction firms did not employ proactive problem solving, 37% did not have a technological solution for knowledge management, and 50% did not employ solutions such as communities of practice for knowledge sharing and cross pollination (Carillo and Chinowsky, 2006). Bresnen, et al. (2005) state that the single unit or differentiated nature of project tasks also creates a need for temporary and dedicated modes of operation and thereby tends to promote highly dispersed management practices that do not dovetail very well with other organizational processes.

Kotnour (1999) and Scarbrough, et al. (2004) describe the project environment as inherently conducive to learning. However, short term perceptions create opposing forces to transfer of knowledge between projects (Scarbrough, et al., 2004). Many engineering / design efforts, in spite of individuals' specialization, are carried out in multidisciplinary project settings. These settings provide a challenge to develop learning capabilities for an AEC specialty, in light of the need to translate between disciplines.

External threats exist in the internal AEC setting. In a parent organization environment, the sole client of the AEC function is a customer for whom engineering support may not be considered a "core competency", and it is essential for the AEC to consider the importance of maintaining a competitive, learning mindset, given the potential for introduction of external competition. Burdon and Bhalla (2005) described the rise in an outsourcing strategy in facilities and asset management, and found that cost considerations along with reliability, quality in the delivered product, and access to best practices as the top four considerations in contracting to out-sourced engineering and asset management rather than employing in-house talent. Additionally, Fergusson and Teicholz (1996) examined relationships between the facility development process and product quality and found that there is a tendency for the facility industry to optimize only in certain areas perceived as sensitive, thus producing a product that could be considered potentially sub-optimal. In summary, the AEC's organization is challenged by:

- Internal and external resistance, due to fragmented processes and a tendency to "sub-optimize" by paying attention only to certain business segments, which may have more powerful self –interests.
- Perception that expertise development and organizational learning are mutually exclusive.
- Internal differentiation that does not promote knowledge sharing.
- The nature of the industry – one of a kind projects, the restrictive, non-experimental nature of code adherence, and cost strategies that introduce new, external threats.
- Repetitive errors attributable to learning disabilities.

The problem to be addressed through this research are the gaps between desired and achieved knowledge outcomes by members of the AEC, whether individuals or groups, and the members' abilities to distinguish between the need for adaptive learning or innovation. This research addresses learning by individuals and groups, and the strategies to be employed. Emphasis is on that knowledge which may be regarded as tacit or procedural and involving "know how" or "know who". This knowledge reportedly comprises nearly 80% of that which resides in an organization (Botkin and Seeley, 2001).

1.3 Relevance of the Topic

Relevance of this topic can be described in terms of its importance to the areas of industry, the profession, and academics. These are listed in the following sub-sections.

1.3.1 Relevance to Industry

In industry, we desire to:

- Improve organization effectiveness by selecting structures and practices that enable knowledge creation and sharing between disciplines.
- Uncover areas of "lost opportunity" through connecting individuals to areas within the organization that have a need for the knowledge they possess.
- Prevent loss of knowledge when individuals retire or leave the organization, taking their experiential knowledge with them.
- Affect behaviors that support knowledge development through properly designed and applied performance metrics.

The predominance of project oriented work in the AEC environment offers new possibilities for learning (Scarbrough, et al., 2004). Therefore, opportunity exists for experience to translate to learning. However, the foregoing claims of reported gaps in AEC performance require investigation into how the gaps can be addressed through improved processes. This work seeks to discover how comparatively, individual and group learning strategies for learning translate to adaptation and innovation knowledge outcomes for given directions imposed by the individual or the group. Relevance to industry is through discovery and nurturing of processes and structures that enable improved performance through adaptive learning and innovation.

1.3.2 Relevance to the Profession

The profession of engineering management is a bridge between the traditional disciplines in engineering and management (Kotnour and Farr, 2005). The relevance of this topic is in the discipline specific and generalist areas of managing engineering and design, and management of the technology itself. Contribution to learning is through discovery of relationships, and means to recognize and improve performance through individuals, teams and technical disciplines. Management of the technology utilized in the design process as knowledge is a process available to improvement as demonstrated by the results of researchers such as Soibelman, et al. (2003), who attempted to capture knowledge in a multidiscipline environment through a planned checking process. The profession is served by improvement in recognition of regulatory compliance. Codes are restrictive in nature and may result in lack of innovation (Veshosky, 1998). Federal, state, and local regulations in complex technology driven systems frequently transcend discipline boundaries by being performance requirement based, and therefore demand a required level of coordination that can benefit from improved learning across technical boundaries.

1.3.3 Relevance to Academics

Relevance to academics is found inside and outside the engineering management discipline. In discussing the question for academics on producing a social scientific work, Easterby-Smith, et al. (2004) identifies relevance and novelty for a contribution to be

considered as significant. They present two processes identified by Locke and Golden-Biddle (1997), namely:

- Summarization or organization of knowledge in such fashion as to justify why the work presented is important.
- Identification and demonstration of a gap in knowledge (incomplete, inadequate, or incommensurate with research needed) and how the work addresses the gap.

Contribution of the research, as translated through definitions given by Miller and Salkind (2002) consists of:

- Use of existing research and theories on organizational learning and knowledge management to build new knowledge on what type of learning occurs in an AEC.
- Enabling of tests of hypotheses on individual, group/team and organizational learning relationships within an AEC.
- Careful definition of the research problem to allow for proper variable specification and development of a measurement tool to test the hypotheses.
- Contribution to processes or structures in engineering management that improve existing management tools.
- Utilization of existing learning concepts to develop evidence supporting a direction for AEC organizations to improve organizational performance through improved specification of learning directions.

- Integration of the study with prior results to develop a less ambiguous view of how learning takes place and factors affecting it.
- Discovery of future opportunities for study in other aspects of expert and social interaction within a technically based organization.

The research proposes to address these questions through examination of observable changes to bodies of knowledge that are perceived to have impact to performance or organizational change. Observation is through proper identification of practices and associations that influence learning in the AEC. What practices are relevant to organizational learning? Figure 2 depicts a model, which defines relationships between organizational learning and those bodies of knowledge that are potentially observable and relevant. The relationship of learning to knowledge management is as a contributing process to that and other bodies of knowledge. This model originates with Jashapara (2004) and further presented by Carillo and Chinowsky (2006).

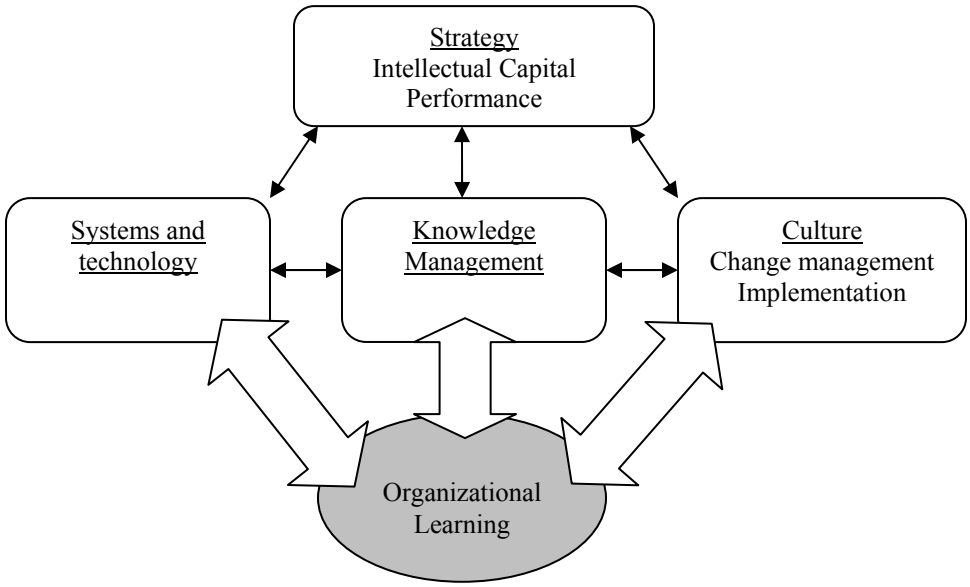

Figure 2. Potential Impacts of Organizational Learning on Bodies of Knowledge
(after Jashapara, 2004 in Carillo and Chinowsky, 2006)

Other potential bodies of knowledge are influenced by learning. Kotnour and Farr (2005) identify several potential bodies of knowledge beyond this model yet are related to knowledge management. These are:

- Core Processes – Including change, project and knowledge management, strategic management and systems engineering.
- Life Cycle issues – Including new products and technology, value chain management, and production.
- Enabling Processes and Tools – including the quantitative methods, quality management, and the development of the engineering workplace.

Learning, if effective, should support development of core processes that add to the capacity for making decisions affecting performance, life cycle issues, and enabling processes or tools. Scarbrough, et al. (2004) state that learning and knowledge are intertwined in a mutually reinforcing process as learning produces new knowledge and knowledge affects capability for future learning. Therefore, the learning process has to be understood to enable increased or better knowledge, which in turn, can improve the learning process further.

1.4 Research Questions

The research question to be addressed is:

"How do expertise and group learning contribute together for effective organizational learning in an AEC?"

The sub-questions that arise are:

1) How do individual actions contribute to organizational learning and performance?
2) Can internal differentiation and competition between project and non-project learning be overcome by learning strategies?
3) Are explorative behaviors important to the AEC?

Some of the implications for practitioners and the profession are the following:

- Should AEC organizations focus more on development of deep or broad skill sets for individuals given methods used for individual learning?
- Do groups need to become more interdisciplinary or should they be trained to more readily recognize experts outside their boundaries?
- If exploitation is more prevalent in the AEC, does innovation matter?

1.5 Conceptual Model

1.5.1 Knowledge and Learning

As shown previously in Figure 2, knowledge management is a key process in connecting strategy to actions and application of technology through enhancing knowledge management. However, management of knowledge starts with recognition of knowledge that potentially is used, which in turn, is a product of learning. Thus, organizational learning is a contributory process. How do we know when learning has been adopted as a practice or if learning is constructive or useful? A conceptual model is necessary to help identify the processes and constructs of organizational learning so that observation can be made of the system.

There are several ideas of learning. Learning can be intentional, consisting of classroom, training, simulation or other processes on an individual or group level, or other, less formal processes, such as those in congenital learning, experience, vicarious learning, grafting or deliberate search (Huber, 1991). Casey (2005) labels the types as formal,

informal, or incidental. The major constructs of learning as described by Huber (1991), are:

- Knowledge Acquisition
- Information Distribution
- Information Interpretation
- Organizational Memory.

The type of knowledge sought is also important. Dorf and Byers (2007) identify conceptual learning and operational learning as being differentiated by the "know – why" and "know – how" of things. Knowing why a concept works is useful in developing cause and effect relationships (Dorf and Byers, 2007). Knowing how in operations yields information that assists in adaptation. The model needs to take into account both types of learning, if attempting to account for adaptation and innovation.

Learning in an experiential sense can be a potential change in a permanent behavior resulting from a reinforced practice (Houston, 1991). Huber (1991) defines organizational learning as a change in the *range of potential behaviors* when an organizational unit obtains information. Successful learning need not necessarily lead to some immediate change in behavior, but a change in knowledge that enables better decisions. An interesting aspect of this definition is that learning may not be beneficial, and may not necessarily lead to improved performance (Huber, 1991; Miner and Mezias, 1996). Therefore, *effective* learning needs to be distinguished from those practices that may not lead to positive future outcomes.

Argyris (1994) states that when an organization achieves an outcome that was intended by design for action or when a mismatch has been corrected, learning has occurred. However, like Huber, Argyris and Schon (1996) acknowledge that learning can lead to negative consequences or misconceptions. Others, such as Yeung, et al. (1999) and Senge (1990, 2006) as discussed in Chapter 2, say it is more than performance, but elements of the organization and its culture that change as a result of learning.

The aim of learning by the organization is to capture tacit knowledge, or that which resides in the "know why" and "know how" of individuals and transform it into codified or explicit knowledge that is recoverable and reusable. Many authors direct their attentions to how tacit knowledge is converted to explicit, as most knowledge resides as tacit knowledge, in the minds of employees (Nonaka, 1994, Botkin and Seeley, 2001, Truran, 1998).

1.5.2 Development of Constructs for the Conceptual Model

The conceptual model is based on the actions of the entities (individuals, groups and organization) in a technically oriented organization and treats them as contributors through processes that results in learning and attainment of some performance related goal. Organizational learning research is scattered across different scientific fields, and the literatures approach learning from differing perspectives, taking positions reflecting expertise in cognitive and behavioral theory, sociology, organizational theory, or

technology (Huber, 1991, Lähteemäki, et al., 2001; Miner and Mezias, 1996). Table 1 is a comparison of organizational learning processes as posited by several authors

Table 1. Processes in the Literature on Learning Organizations

Author(s)	**Attributes**
Argyris and Schon (1996)	Acquiring, Processing, Storing
Brandon and Hollingshead (2004)	Presence of Enablers, Marching of tasks to expertise, Shared mental model development, Subsequent convergence
Bose (2004)	Collection, Capture, Refinement, Storage, Management, Dissemination
Casey (2005)	Environmental interface, Actions, Dissemination, Meaning (Parsons theory)
Dorf and Byers (2007)	Problem identification, Analysis, Solution generation, Solution selection, Implementation, Evaluation of results.
Huber (1991)	Acquisition, Distribution, Interpretation, Organizational memory
Lee, Lee, Kang (2005)	Accumulation, Sharing, Utilization, Internalization
Nonaka (1991, 1994)	Individual Learning, Sharing, Conceptualization/Crystallization, Justification, Networking
Popper and Lipshitz (2000)	Action, Outcomes, Reflection, Insight, Incorporation to knowledge and belief systems
Senge (1990,2006)	Actions, Dialogue and Systems thinking, Building shared vision, Team learning by prototype development (U process)
Szarka, Grant and Flannery (2004)	Acquisition, Transfer, Application, Development of shared reality
Szulanski (1996)	Initiation, Implementation, Ramp –up, Integration
Yeung, et al (1999)	Idea generation, Idea generalization, Identification of learning disabilities

These concepts describe actions in which an outcome results as an acquisition of information converted to knowledge through matching of the information to some preconceived model or vision. However, strategies, methods and directions shaped by behaviors and belief systems influence the outcomes. Transfer and sharing of knowledge among individuals and groups is of particular interest in this research.

The organizational learning literature contains many references to the descriptive prerequisites or enablers alleged to affect learning effectiveness. The model recognizes

these elements but will not be address them directly except through their implications for the methods employed by individuals and groups. Table 2 is a comparison of these "enablers" considered by their respective authors as instrumental to building a learning organization. These enablers are organizational aspects that affect learning across the major actors and their actions.

Table 2. Enabling Elements Affecting Organizational Learning

Author (s)	**Elements**
Argyris and Schon (1996)	Communication Channels, Information Technology, Environment, Procedures, Incentives
Bose (2004)	Culture, Technology, Infrastructure, Measurement
O'Dell and Grayson (1999)	Culture, Technology, Infrastructure, Measurement
Fiol and Lyles (1985)	Culture, Strategy, Structure, Environment
Yeung et. al. (1999)	Culture, Competencies, Consequences, Governance, Capacity for Change, Leadership
Lähteemäki, et al. (2001)	Social Structure, Technology, Goals
Marr, et. al. (2003)	Alignment of knowledge creation approach

Inspection of the comparison yields semantic differences; however, several concepts are similar. Bose (2004) and O'Dell and Grayson (1999) and their use of "infrastructure" is similar to "structure, processes and technology". "Governance" as presented by Yeung, et al. (1999), is also related to "structures and processes" that infer knowledge sharing. Inclusion of measurement (Bose, 2004) and consequences (Yeung, et. al., 1999) infer reward systems that enhance intrinsic and extrinsically motivated action. Marr, et al. (2003) discuss alignment of individuals to teams and that of teams to their respective organization in terms of "epistemological views" or how individuals and organizations believe knowledge is or should be created. Fiol and Lyles (1985) present a view of environment that not only includes a description of conditions that enable or drive

change, but also describes a similar alignment. The elements in Table 2 are presented in more detail in Chapter 2, with respect to their influence on learning methods.

1.5.3 Model Architecture

The conceptual model is shown in Figure 3. This model relies on the three major actors that interact on behalf of the organization to affect and outcome, and as a result, achieve a performance determined outcome and a knowledge outcome. Learning can occur in three entities, individual, group or team environment, and throughout the organization. It also occurs in two learning related levels, through the development of either adaptive or innovative knowledge. Learning passes from individual to group or team to organization and back again. This model supports the theory that learning in larger or more complex organizations requires passing from individual to group to organization.

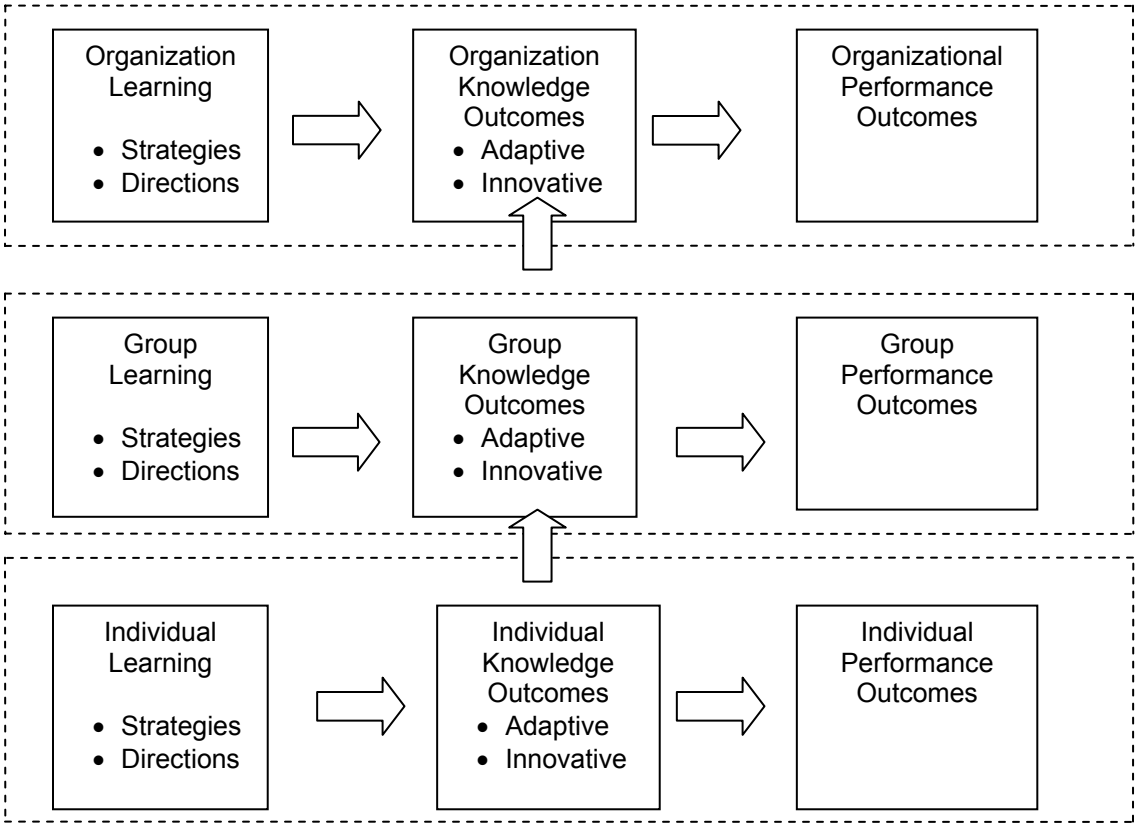

Figure 3. Conceptual Model for Organizational Learning

The process is shown as a two dimensional flow of knowledge that occurs at and between levels (individual, group, organization). Type of knowledge outcome that occurs is a function of the strategy and direction. A performance outcome also may result. Strategies are composed of methods that defined at the end of Chapter 1. Directions are defined according to experience and the research interest. Outcomes are either adaptive or innovative. The following section explains the constructs of the model.

1.5.4 Constructs of the Conceptual Model

This model is built on the idea that knowledge is created or transformed in three types of entities. Individuals act independently, as groups and as agents of the organization. Outcomes result from interaction between learning from other agents as well as that from direct experience and may be incorporated, lost or ignored. This model is also affected by enabling and disabling elements that are known to influence the process at each level, but these will not be studied directly except through selection of the methods and directions used for individuals and groups. The constructs are derived through the concepts presented in Chapter 2. Four concepts drive the structure of this model:

1) Definitions of individual, team and organizationally derived knowledge and knowledge at their boundaries.
2) Circumstances (methods through directions) that result in knowledge.
3) Concepts of adaptation and Innovation as knowledge outcomes.
4) Recognition that learning begins with individuals and progresses through groups, and ultimately into organizational memory (though it is also recognized that knowledge also passes from organization or group to individual as well).

Defining the processes as a set of individual and team activities to enable observation of their individual effects is particularly important in a setting that depends on "individual contributors" (subject matter experts) to develop solutions to relatively short term problems. The model also intends to observe differences in knowledge at "boundaries" between single and multiple discipline oriented group directions. This is of particular

interest in the research for defining management practices in an environment containing several diverse technical subjects.

The concept of what constitutes knowledge must be defined for the research as differing schools of thought define it differently (Cross and Sproull, 2004). A knowledge transfer perspective focuses on the cognitive, social and organizational aspects of knowledge movement, while the constructionist perspective states that knowledge cannot be taken out of context easily (Cross and Sproull, 2004). That is, the circumstances around that knowledge are part of the condition of its applicability, as the receiver will tend to apply his or her own meaning to the knowledge as it applies within their own experience. Chapter 2 will introduce the construct of knowledge in terms of the dimensions that will enable its measurement.

The third concept mentioned above is whether learning should be adaptive or innovative. These strategies will affect methods employed. A common thread among many OL theories is the concept of differentiating between adaptation as the result of exploitation, and innovation as resulting from exploration. Argyris and Schon (1996) use the concepts of single loop and double loop learning, while Fiol and Lyles (1985) used low and high level learning to distinguish adaptation from deeper learning of cause and effect. Nonaka (1991, 1994) stresses going directly to knowledge creation through the use metaphors, analogies, and redundant structures and proposes sustainability through creation of redundant functions in an organization and a mechanism that creates a "knowledge

spiral". The importance of knowing whether learning leads to adaptation rather than innovation is important to management in degree of change needed to respond to environmental changes.

Finally, performance outcomes should be positive if the knowledge is beneficial and practice is competent. The pragmatic view of learning suggests that if knowledge is able to be transferred and reapplied, and is beneficial, performance should be improved. Enabler and disabler elements are known to exist, but are not proposed for measurement, themselves, since the scope of this research is limited to relationships among learning methods and the relationships of those methods to the outcomes in both knowledge and performance.

1.6 Research Objectives

The objectives of this research are to:

- Develop a conceptual model of how actions by individuals and groups lead to learning in an AEC and how strategies and directions guide methods employed.
- Translate the model to a research model that uses methods employed by individuals and groups, and definitions of knowledge and performance outcomes as described in the literature.
- Conduct a survey that reveals relationships between methods and the outcomes, and answers the research questions through tests of the hypotheses.

- Analyze the results of the survey and develop a list of recommendations for management in AEC organizations and for future researchers in individual and group contribution to organizational learning.

1.7 High Level Methodology of Research

The focus of research, according to Argyris (2004), is to describe the universe in as complete a manner as possible. This, as he describes, motivates scholars to study it as it appears. He goes on to warn that as such, scholars become agents of the status quo and that further, research methodologies, by the very nature of the context in which they are conducted (e.g. in his top-down theory of action) violate the premise of being completely neutral or do not make that viewpoint transparent (Argyris, 2004). He suggests promotion of implementable as well as internal and external validity, productive mindset and transparency in research to counter the defensive mindset often encountered when studying organizational issues that may prove potentially embarrassing or threatening (Argyris, 2004). It is with this mindset this research should address itself, given the perception basis of the data and information to be gathered.

The overall methodology is:

1) Define the research problem and translate to questions that are relevant to industry, the profession and academics.

2) Research and understand the literature that is relevant to the subject by constructing coherence through synthesizing of texts by those authors working in the organizational learning domain and those working in the industry specific domain. Locke and Golden-Biddle (1997) found that in organizational studies, manuscripts first re-present and then organize existing information to establish a context for contribution that is supported by the previous work. In this way, new research has a foundation upon which to build itself. Information in Chapter 2 means to identify gaps in knowledge and provide areas for opportunity in the conceptual model.
3) Generate a conceptual model to address the research questions through the understanding of the existing system and generation of a model that expresses as accurate a representation of the system that is presented and test, in this case, the interaction between individuals and groups with respect to the learning of useful knowledge and the comparable effectiveness of that learning.
4) Define the scope of research, its limitations and the organizational/industry setting with which it is connected.
5) Operationalize the research through establishment of a well defined program to detail what measurements and how they will be made to enable receipt of valid data.
6) Design an instrument for collecting data through application of what has been learned from prior research, using those concepts and connecting them to measured outcomes.

7) Collect data from a sample of a population of AEC organizations by implementation of a series of steps for survey and response.
8) Analyze the data through application of descriptive and inferential statistics.
9) Interpret and discuss results to demonstrate proof or non-proof of the hypotheses under test. The findings are applied to lend external validity.
10) Produce a final report that provides implementable validity to the results and lays the groundwork for additional study to address gaps or weaknesses found in the research.

A high level map of the research process is shown as Figure 4. The research methodology is structurally similar to that proposed by Miller and Salkind (2002) for research in the social sciences. The methodology depends on experience to assist in the validation of theoretical conditions (Emison, 2004).

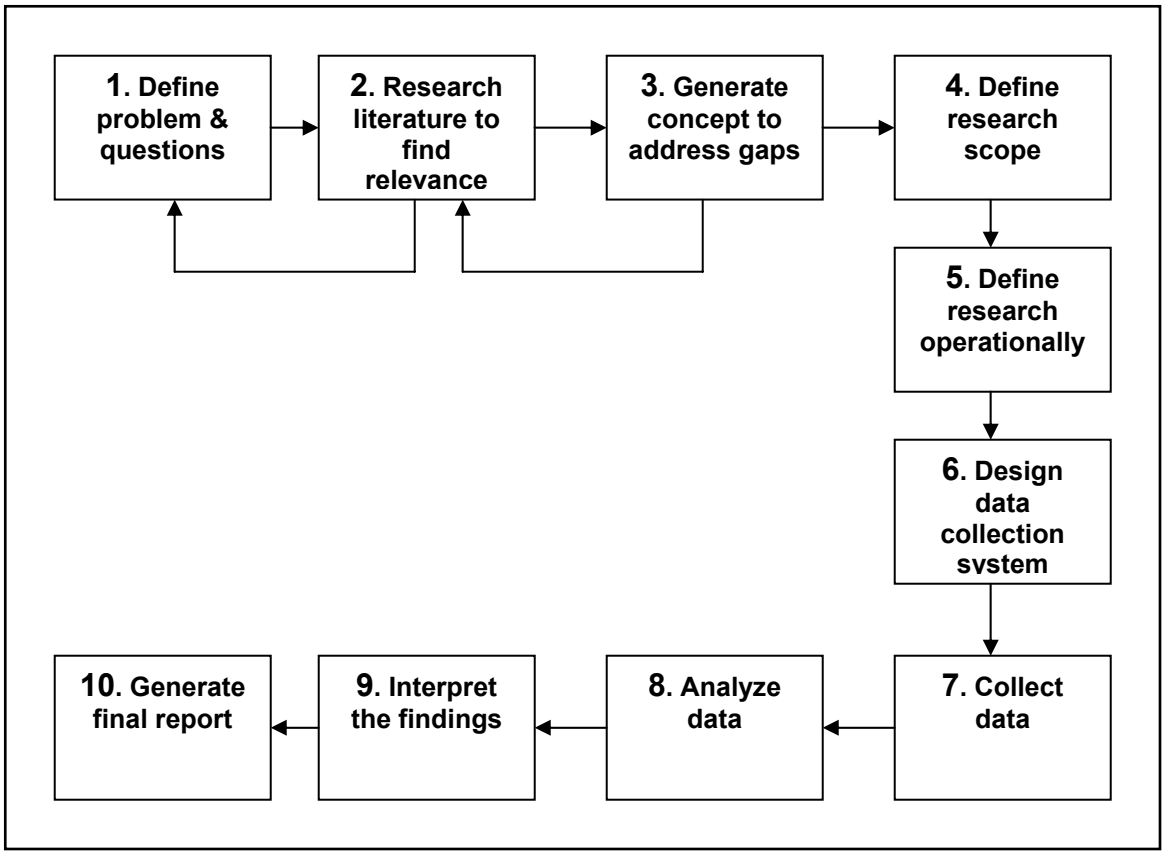

Figure 4. High Level Research Methodology

1.8 Limitations of the Research

Engineering and technically oriented organizations are highly varied in structure, strategy, and the context or environment in which they operate. This research concerns itself specifically with architectural/engineering and construction (AEC) management organizations that manage technology and the problems of infrastructure driven by the organizational overall market strategy in an environment driven by client/customers, competitors, and regulatory entities. As previously mentioned, enabling conditions,

though known to operate as a part of the learning model, are not investigated due to the limits of the scope of the research. Focus is on the methods that result from these conditions and the relative effectiveness of those methods when exposed to individual directions in learning and the directions groups take as single or multi-disciplinary structures.

This research does not seek to test psychological or sociological behaviors and barriers to learning in the technical organization, but to discover what management practices may be instituted to improve or make more reliable, technical performance, knowing that certain psychological and social barriers likely exist in the form of disablers and are in operation.

1.9 Definition of Important Terms

It is necessary for the purposes of establishing boundaries and clarification, to define important terms as applied in the research.

1.9.1 Adaptation

As inferred from Cyert and March (1963, 1992), a behavior that results in a decision rule (response) to an external condition, leading to some intended and preferred state, subject to the biases and preference of that system.

1.9.2 Architecture/Engineering/Construction (AEC)

Architecture/engineering engineering is a group or sub-organization that provides architectural and engineering design services along with support for implementation of a design in the service of a project as well as the continuing operational readiness of a facility or group of facilities. An AEC is composed of differing specialties that must be assembled to create a complete system.

1.9.3 Best Management Practices

Best management practices are those activities conducted by individuals and groups within the organizational environment to accomplish some set of goals or objectives. These practices are verified and legitimized locally as being comparatively effective at achieving the desired outcomes by their employment.

1.9.4 Community of Practice

A community of practice is informal group of subject matter experts or individuals with common interests, acting out of a pragmatic idea to further their collective and individual knowledge in the subject area. A community may be formal or informal (Soo, et al., 2002) and is bound by a shared expertise and motivation for joint enterprise (Wenger and Snyder, 2000). Communities can be differentiated by their informality and extent that crosses group boundaries.

1.9.5 Expertise

A subject matter expert is an individual whose educational and experiential background qualifies that person as a holder of a certain amount of tacit knowledge on a particular subject that is valued locally by the organization or group. Litzinger et al. (2002) and Vick (2002) note that experts are those who notice meaningful features or patterns not noticed by others and that understanding of a problem is deep but conditionalized to a set of circumstances.

1.9.6 Functional Group

A functional group is a formal organization of individuals who share a common area of expertise or subject matter and perform similarly designed functions or processes in a similar technical area. Functional groups are structurally organized by the discipline of specialization, for the purposes of this study.

1.9.7 Innovation

By the definition of Yeung, et al. (1999), the result of a firm's willingness to experiment or "take risks". Cyert and March (1963, 1992) define innovation as the result of search that has less certain, more distant benefits. Innovation is associated with learning that is sometimes disruptive of existing goals, means, or assumptions. Innovation, for the purposes herein, is associated with creating knowledge by drawing connections not heretofore seen.

1.9.8 Learning Directions

Conditions imposed on or by the learning entity that may consist of certain aspects of what is learned or the format of learning. In this research, individual directions are in the area of depth or breadth of knowledge, while those for groups are based in single or multiple technical disciplines.

1.9.9 Learning Methods

Means as a part of an activity or as a separate action, that result in acquisition or realization of information that has potential for use in executing a strategy. They are influenced by various styles as further explained by Yeung, et al. (1999), Huber (1991), or Nonaka (1994), in terms of either exploitive or explorative and direct or indirect.

1.9.10 Organizational Learning

Organizational learning is a social and cognitive process by which a collective mindset or realization occurs and requires individual learning as a prerequisite (Love et al., 2004). The process mediates between experiences of its individual members and the culture established by its members (Love et al., 2004). Elkjaer (2004) further reiterates this definition in stating that the social activity is derived from participation and is a practical rather than strictly cognitive process that cannot be separated from work.

CHAPTER 2: REVIEW OF THE LITERATURE

2.1 Learning and Knowledge

Learning and knowledge in the AEC environment should be defined before strategies directions and methods can be identified. Therefore, a review of existing and current literature is necessary so that a reasonable basis exists for the assumptions made for the conceptual model. This chapter is organized to provide this information as follows:

- Learning within the context of this research.
- Definition of knowledge, framed to the conceptual model.
- Organizational learning within knowledge management.
- Learning methods, in terms of their enabling elements and strategies.
- Learning methods in the AEC environment and practices from case studies (presented to refine methods employed and to set up the research approach).
- Definition of knowledge and performance outcomes.
- Definition of the research model in terms of the research direction.

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2.1.1 Learning Methods / Processes

Learning, as described by Huber (1991) is a processing of information that yields something that enables that entity to make a selection. Argyris and Schon (1996) define it on an organizational scale as acquisition of information of any kind by any means, for good or for ill. What is learned and how it is learned is a product of the learner. To that

end, individuals in an enabled environment should be self directed, according to James-Gordon and Bal (2003), if they are to learn to their development potential. Cyert and March (1963, 1992) describe decision making in organizations as adaptive behavior consisting of:

- Shifting of search to attain predetermined goals.
- Paying attention to that which it sees as "valuable".
- Adjusting its search priorities and rules around that which has brought it success.

The same for which can likely be stated for individuals. The implications for this research lie in identification of:

- Methods of learning that promote effective boundary spanning in groups.
- Knowledge that is considered useful or meaningful.
- Learning that is adaptive or innovative.
- Discovery of differences between individual and group strategies.

Likewise, the definition of learning with the emphasis on recognition of something the organization finds potentially useful is put forward by Huber (1991), and Cyert and March (1963, 1992). Learning is a process affected by the perception of utility in organizations as well as individuals.

Argyris and Schon (1996) state that the general schema of organizational learning is said to consist of a process of acquiring, processing and storing information as well as "unlearning", in which an obsolete strategy or concept may be discarded in the process. Argyris and Schon's (1996) model uses theories of action (espoused theories) and theories in use, the prior construct being used to explain or justify a behavior or pattern and the latter used to explain the actual performance. Supporting these theories of action are the processes of first order or single loop learning that connect a detected error to cause, and corrects, leaving values, assumptions and norms essentially unchanged (Argyris and Schon, 1996). Double loop or second order learning results in a changed theory in use, as well as its strategies of use, assumptions, and values (Argyris and Schon, 1996). Fiol and Lyles (1985) defined a similar structure, consisting of low and high level learning that differentiates between learning in a well defined environment through repetition (low level) and learning in an ambiguous context (high level), through new insights that adjust cultural views. This difference between simple adaptation and deeper change has the potential to alter culture and norms.

Organizational learning is a process often modeled after individual learning. Popper and Lipshitz (2000) point out similarity in learning by individuals and organizations through examination of the process steps, outcome of experience or action, followed by reflection, conceptualization or insight, and subsequent retention of the knowledge and adjustment of behaviors using the new knowledge by experimentation or incorporation

into knowledge and belief systems. The only significant difference is the absence of dissemination of meaning in individual learning (Popper and Lipshitz, 2000).

The Plan – Do – Study (Check) – Act (PDSA) cycle, as originally proposed by Shewart and later adopted by Deming (Pyzdek, 2003, Evans and Lindsay, 2005) is the basis for the learning process suggested by Love, et al. (2004), Kotnour (1999), and Fergusson and Teicholz (1996) for learning in a project environment. The PDSA cycle is regarded as planning based and is depicted in Figure 5.

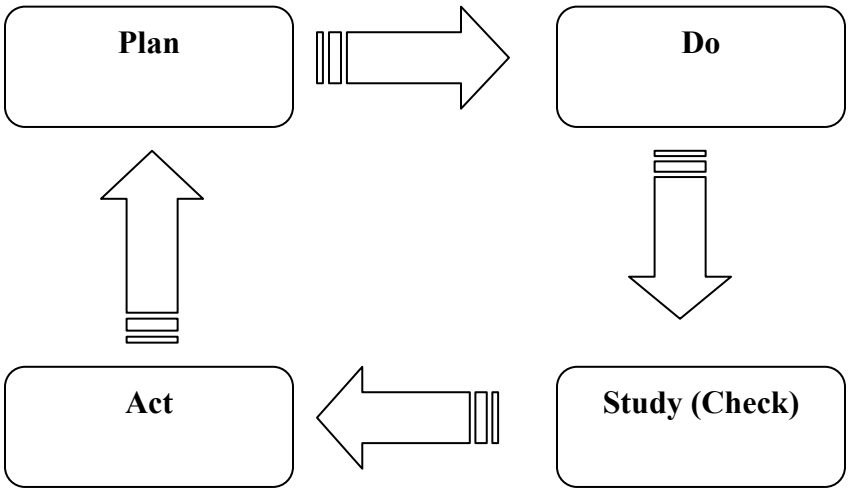

Figure 5. The Shewart-Deming Cycle

The type of learning supported by double loop theory carries with it numerous implications for all the phases of the Shewart – Deming Cycle, one of which is the

specification of methods that promote the type of behaviors that produce this type of learning, rather than merely drawing direct inferences from observations from the "Do" stage. The "methods" are a central theme to this research.

Nonaka (1991, 1994) addresses the learning process as a means of knowledge creation. According to Nonaka (1994), the dynamics of dealing with a changing business environment require that organizations not only manage knowledge efficiently but also become adept at creating it. The process Nonaka (1991, 1994) describes is one of a knowledge "spiral" involving successive cycles of social interaction coupled with individual interpretation, which is illustrated in Figure 6.

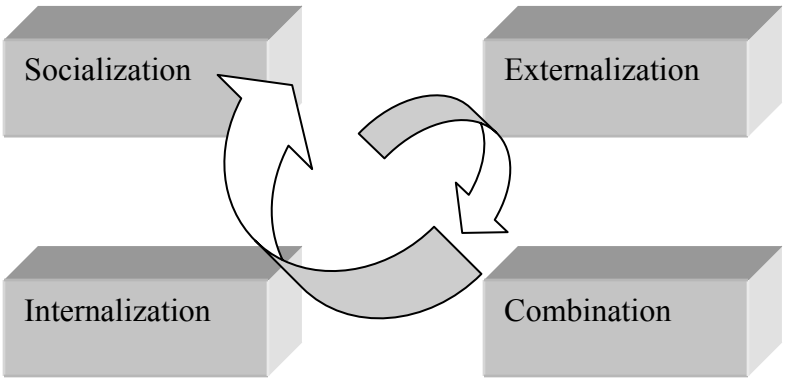

Figure 6. The Knowledge Spiral Concept (after Nonaka, 1994)

Nonaka's (1994) concept of the spiral begins with individual knowledge transferred through tacit – to – tacit socialization, followed by externalization when tacit becomes explicit through dialogue and use of metaphors. Explicit concepts developed by group interaction are assembled and analyzed through the process of combination, followed by

an iterative process of internalization in learning by doing, thus making explicit knowledge tacit, to the individual. The process repeats itself on a widening scale, both in terms of the epistemological (knowledge) dimension and organizational (scale) dimension, resulting in a growing spiral of influence (Nonaka, 1994). Implications for the AEC, presented by these models, are based in effectiveness in planning and checking at each level (methods) to enable effective learning and how learning in social (group) settings occurs.

Casey (2005) presents the learning process based on the assumption of individual learning as an inherently social process. Learning is driven by inconsistencies between activity systems, resolved by dialogue and debate (Casey, 2005). This is similar to Senge's concept of reflective conversation except that no clear differentiation is made between continuous (adaptive) and reflective (innovative) learning. Four functional prerequisites of individual adaptation feed organizational learning as (Casey, 2005):

- Environmental Interface – adaptation
- Activity – reflection subsystem and goal attainment
- Dissemination – Diffusion and knowledge transfer or integration
- Meaning – memory subsystem or pattern maintenance.

Casey proposes the model as a guide for both individual learning and at the organizational level to measure the effectiveness of the phase being considered (Casey, 2005). However, the model does not take into account dynamics of power (Casey, 2005).

Blackler and MacDonald (2000) address the question of power in collective learning by describing the separation of power from expertise that has resulted from specialization in modern organizations. Learning has moved from more routine activities in established groups to a loose assemblage of agents whose collaborative efforts result in a new activity under which no one person or group is in unilateral control (Blackler and MacDonald, 2000). This affects how the AEC organizes its efforts through groups as opposed to individual contributors and how the separation of power from expertise may affect those who must gravitate between team based and individual projects.

Yeung et al. (1999), presents a model of the learning process, shown in Figure 7. This model uses the environment of the business, coupled with the capabilities of the firm to drive performance outcomes. This model uses generation of ideas, followed by generalization, for distribution of the knowledge through the firm. Recognition of errant behaviors (disabilities) is essential to avoiding practices that thwart learning.

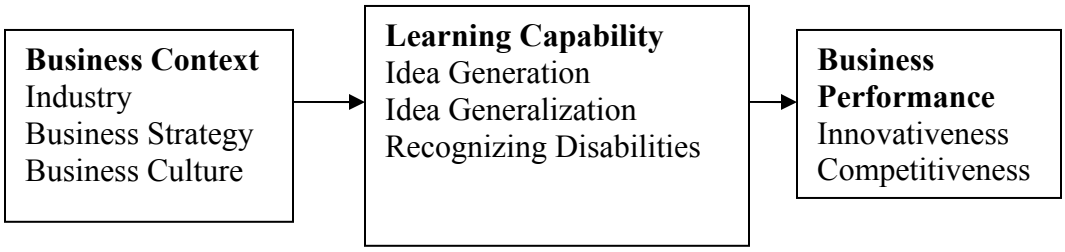

Figure 7. Model for Learning in Business Performance (Yeung, et. al., 1999)

The basis of this model is that organizations learn and demonstrate its effectiveness through business performance, as well as new capabilities through exploration and exploitation. (Yeung, et al., 1999). The findings on the concept of idea generation are summarized by Yeung, et al. (1999) as follows:

- Learning style of a firm is affected mostly by business strategy and culture. Industry characteristics appear to play a minor role.
- Most firms adopt competency acquisition and continuous improvement to learn, rather than experimentation and benchmarking. Experimentation is associated more closely with new product introduction.
- Benchmarking is least likely to result in new ideas.
- Learning organization cultures often continually reinforce new ideas and continuous improvement through education.
- Learning cultures are reinforced through their human resources processes.
- Adhocracy cultures, particularly in technically aligned businesses, use competency acquisition to good effect.
- Given proper management support, continuous improvement as a learning strategy can help change a company's culture over time.

Generalization of ideas is taking ideas and transferring them into other segments of the organization, and is based on the following precepts by Yeung, et al. (1999). These results reflect responses from a wide range of businesses:

- Recognition and negotiation of boundaries that are longitudinal, horizontal, vertical, external and geographic.
- Generated ideas must be tied to strategy.
- Contingency in thinking, which in turn requires thinking about causality.
- Demonstration of repeatable capabilities.
- Ideas must have impact, that is, ideas are implementable.

These behaviors are important in terms of determining what constitutes successful learning for generative or potentially innovative outcomes.

Huber (1991) proposed a series of constructs that explain the basic sub-processes and the learning types described by Yeung et al. (1999). These processes are shown in Table 3. This research addresses primarily those in Huber's "acquisition" construct.

Table 3. Knowledge Constructs and Learning Sub-processes (after Huber, 1991)

Knowledge Constructs	Contributing Sub-processes
Knowledge Acquisition	**Congenital learning** **Experiential learning** **Vicarious learning** **Grafting** **Searching/Noticing**
Information Distribution	
Information Interpretation	**Cognitive maps (mental models)** **Media Richness** **Information Overload** **Unlearning**
Organizational Memory	**Storing/Retrieving Information** **Computer Based Organization Memory**

Huber (1991) defines the acquisition sub-processes as follows:

- Congenital – what an organization knows at its birth and its environment will determine what and how it searches for information. It is generally a function of the industry and strategy type.
- Experiential – Intentional search based on increasing accuracy about cause and effect relationships. This may include organizational appraisals, experimenting organizations (improving adaptation or exploitation), formal organizational experiments (enhancing adaptability and exploration), unintentional learning, and learning curves.
- Vicarious – Searching through the experience of others, such as benchmarking.
- Grafting – Acquisition through recruitment of new members or organizational units who bring new knowledge.
- Searching and Noticing – Performed by scanning, focused search, or performance monitoring.

The distribution of information determines the breadth of organizational learning (Huber, 1991). Distribution is usually addressed by technological enablers such as the use of information technology systems for collection and recall of information. Development of socially constructed systems for distributing knowledge, and the transfer of individuals are based in practice or human resource methods. This research addresses to the latter of these two aspects through testing of strategies.

Interpretation of information presents the question of whether all organizational units derive the same meaning from the information (Huber, 1991). Factors affecting this ability to interpret are the uniformity of mental or cognitive maps, uniformity of framing of the information, richness of the media used to convey the information, the pre-existing information load on the units, and the amount of "unlearning" that might be necessary to discard old knowledge in favor of new (Huber, 1991). Learning capabilities and capacities result from these views

While Nonaka (1994) focuses on creativity aspects of innovation, Farid et al. (1993) acknowledges the innovation process directly, not in opposition to creativity, but to emphasize the process aspect. They describe a process that operates on three levels – the individual, the technical aspect, and the organizational, and consists of (Farid, et. al., 1993):

- Recognition that a problem exists.
- Observation and data collection
- Conscious concentration on the problem ends and subconscious data processing.
- Moment of insight.
- Formal evaluation of results against criteria.

Though simpler in terms of individual/team interaction, the "jump" from conscious concentration to moment of insight demonstrates the need for understanding the criteria for going from continuous improvement to innovation. The differentiation between

individual, group or team, and organizational behaviors in the identification of learning types and how learning at one level is transferred to another level is significant to this research. Engineers in a routine or sustaining or a contributory role must be able to transfer "institutional" (or that which is previously learned) knowledge to projects. Projects must in turn pass along information to those who can benefit the continuance of the asset. This research proposes to examine these behaviors through the methods described in Sections 2.3 and 2.4.

2.1.2 What is Knowledge?

Knowledge is what is believed and valued based on its meaningfulness as an accumulation of information (Kamara, et al., 2002). It is the product of learning, so its components must be known so that learning can be recognized. Knowledge can be of one of two basic forms. It can be either tacit (in peoples' heads) or explicit (written down or documented in a database). Truran (1998) describes an intermediate form, as with electronic messages. Tregaskes, Sheehan and Poole (2004) describe five "brands":

1) Insight – source of best practices.
2) Network – access to collective reflection and causality.
3) Project data – results of experience.
4) People – knowing "who knows".
5) Procedural – knowing rules and procedure.

Botkin and Seeley's (2001) finding that much of the tacit knowledge is "know who" or "know how", makes evident the need to discover how knowledge in tacit form can be addressed, as it makes up a significant portion of these knowledge brands.

As actionable knowledge, Cross and Sproull (2004) consider knowledge in terms of its contribution to some present assignment or problem and has the dimensions of:

1) Know how or know what.
2) Directions to other sources of relevant information.
3) Reformulation of the problem.
4) Ability to be validated.
5) Ability to be legitimized.

Knowledge that is not useful is considered not actionable and cannot be qualified by the dimensions described above. No relationships in their study revealed that all five of these components were present in each case, but at least three components were present in all cases (Cross and Sproull, 2004). They also found that:

- Only 13% of solutions involved declarative or explicit knowledge.
- 70% of referrals were to other people rather than databases.
- 45% of sources were valued for redefining problems and pointing out possible ranges of consequences of action.
- 49% of sources helped validate plans through reinforcement.

- Legitimization was valued at critical junctures when those who opinions were considered influential (as perceived by others) were consulted (Cross and Sproull, 2004).

These findings are important for development of inquiry as to how to spread tacit knowledge to others in the organization. Cross and Sproull's (2004) study concluded that certain aspects of relationships would have an impact as to the type of knowledge sought:

- Perceived expertise is important in predicting the receipt of four of the five components of actionable knowledge.
- Characteristics of the relationship between information seeker and expert influenced who was sought for knowledge.
- Hierarchal superiors are consulted for solutions, referrals, validation and legitimization, while peers were sought for problem reformulation.
- Weak relational ties are important to solution development, but strong ties are important to reformulation and validation.
- Boundary spanning yields solutions.

On the industry level, project managers need knowledge in four areas (Kotnour, 2005):

- Knowledge of Processes
- Knowledge of Tools
- An intrinsically driven need to ensure success in the organization

- Knowledge of how to accomplish organizational goals.

This means that knowledge must have a construct comprised of content (technical, process or procedural), a context (setting or environment) and relationship between participants. It is not enough to know the "what or how" but also the "why" or and implication of any decision making. Internal processes, procedures and intent, also play a role. The above knowledge types are useful in helping to define what types of knowledge are useful and in what setting. They are also important to this research for providing definitions for the constructs that will be measured. Using the foregoing, a summary of knowledge types is assembled to assist model development. Table 4 summarizes knowledge outcomes used in the model that are based on the foregoing arguments.

Table 4. Knowledge in Adaptive and Innovative Forms.

Individual / Group / Organizational Knowledge

Adaptation – generally associated with continuous improvement or incorporating new developments. Generally attributed to exploitive behavior (March, 1991)

- Know How – How do we do it?
- Know What – What is it? What is its form?
- Know Who – Who knows about it?
- Directions to sources of information – Where can we find out about it?
- Ability to add validity – Is it accepted as fact?
- Ability to add legitimacy – Is it acceptable in the sight of recognized authority?

Innovation - associated with "creating" new knowledge or doing new things or doing things in a different way – usually disruptive of established criteria. Assisted by information seeking behavior associated with explorative behavior or drawing metaphors and analogies for things not normally thought of as having a relationship.

- Insight and Novelty – Seeing connections not seen before, what is different?
- Problem Reformulation. – Does seeing the problem differently reveal anything?
- Discovery of Deep Causality – What is the real cause?
- Generalization for other areas – Can it be transferred and translated?

2.2 Organizational Learning and Knowledge Management

Why study organizational learning in engineering management? In Chapter 1, the importance of knowledge in design and execution in practice is evident through deficiencies experienced by practitioners and industry. The creation or awareness of these deficiencies arises as knowledge from the learning process. Learning feeds the acquisition, transfer or diffusion of knowledge as implied in Figure 2. How does learning relate to knowledge management? The literature generally treats knowledge management as an overarching series of processes through which learning operates at individual, group and organizational levels. However, Zack (1999) defines knowledge management as a thing and a process, "containing what we believe and value on the basis of meaningfully organized accumulation of information". Kamara et al. (2002) define two approaches that drive knowledge management, namely the supply (push) driven and demand (pull) approaches that result in strategies regulating use of technologies, structures and performance metrics. They summarize the state of knowledge management in the AEC as being fragmented, and in need of innovation, improved business performance, and better client satisfaction (Kamara, et al., 2002). Experience in the AEC environment reveals two primary issues, namely content and context of knowledge that change over the course of the project, and knowledge transfer across projects and improved overall business processes (Kamara, et al., 2002). Therefore, improved learning methods through strategies should facilitate improved knowledge transfer and innovation. Scarbrough et al, (2004) see learning and knowledge intertwined in an iterative and mutually reinforcing process in which learning produces new knowledge and knowledge

impacts future learning. However, knowledge management implies a larger set of processes of which organizational learning is a single operation.

Soo, et al. (2002) describes four main components of a knowledge management system:

- A database
- An organization language subsystem
- Transfer subsystem
- Processes for improving absorptive capacity and internalization of new knowledge.

Organizational learning (OL) is a sub-process assisting in the acquisition, transfer and development of absorptive capacity for internalization. However, OL also depends on the presence of a database, the language and transfer systems. The difference is that OL is the process that enables knowledge management to take place. Knowledge can not be managed if it can not be understood, or when attempts to translate by others in the organization do not provide meaningfulness in the context of their application. Learning must also support creation of new knowledge, or innovative behaviors.

According to Carillo and Chinowsky (2006), knowledge management as a strategy from the engineering and construction perspective involves understanding of how explicit (knowledge in databases) and tacit (human resources) knowledge sources interact and employment of strategies to support both approaches. Carillo and Chinowsky (2006) highlight two basic approaches - explicit or information technology (IT) that involve

development of a means of transcribing and organizing information that can be transferred, and human resources that involve relationship building and making it necessary to know "who knows what" through identification of and dependence on experts. Carillo and Chinowsky (2006) also found uniqueness or novelty of projects along with high competition and low margins makes knowledge management a well suited strategy for AEC firms, but challenges to implementation of this strategy and its supporting processes included time constraints, lack of standardized processes, a culture that did not support learning, or insufficient funding. Another feature was that knowledge management was treated as though it were an 'add on" or separate activity, and design oriented firms had to depend on communities of practice to preserve technical competency (Carillo and Chinowsky, 2006). It is this author's experience, that AECs tend to be exploitive and knowledge is demand driven. The motivation for competitiveness also drives a strategy for combining of IT improvements while developing relationships that enable information sharing that can be made explicit. An approach incorporating both strategies should be considered, though it is beyond the scope of this research.

2.3 Learning Methods through Strategies

2.3.1 Background

Argyris and Schon (1996) argue that a theory of organizational learning has to take into account interactions between individuals and entities at higher levels to be of use to practitioners. Miner and Mezias (1996), suggest that learning be addressed at individual,

group, and organizational levels. Therefore it serves to identify learning first in terms of the roles played by each of the major actors as well as what constitutes constructive learning (knowledge). The conceptual model identifies learning through the major entities found in the AEC, the individual, work group (team is implied as a type of a group), and the organization. The literature review presents the aspects used to define the methods that arise from strategies and their enabling conditions, learning outcomes and performance outcomes at the individual, and group level. Learning methods at the organizational level, though not included in the model to be tested, are presented to assist in drawing connections to the individual and group aspects.

2.3.2 Strategies and Methods of Individual Learning

The level and quality of social contact have been identified as key elements of learning opportunities for technical professionals. The literature describes information seeking behavior of engineers and scientists to be highly dependent on access to and relationships with other individuals. Veshosky (1998) lists information seeking behavior by technical professionals *in general order of most to least used* as:

- Conversations with colleagues
- Trade journals
- Conversations with others in the firm
- Clients
- Lectures

- Reports
- Sub-consultants
- Product literature, vendors, external colleagues, professional journals, demonstrations, industry technical publications, seminars, academic courses, conference proceedings, short courses and professional conferences.

Figure 8, which follows, provides a model from which to test differing methods driven by strategies and directions for individual learning.

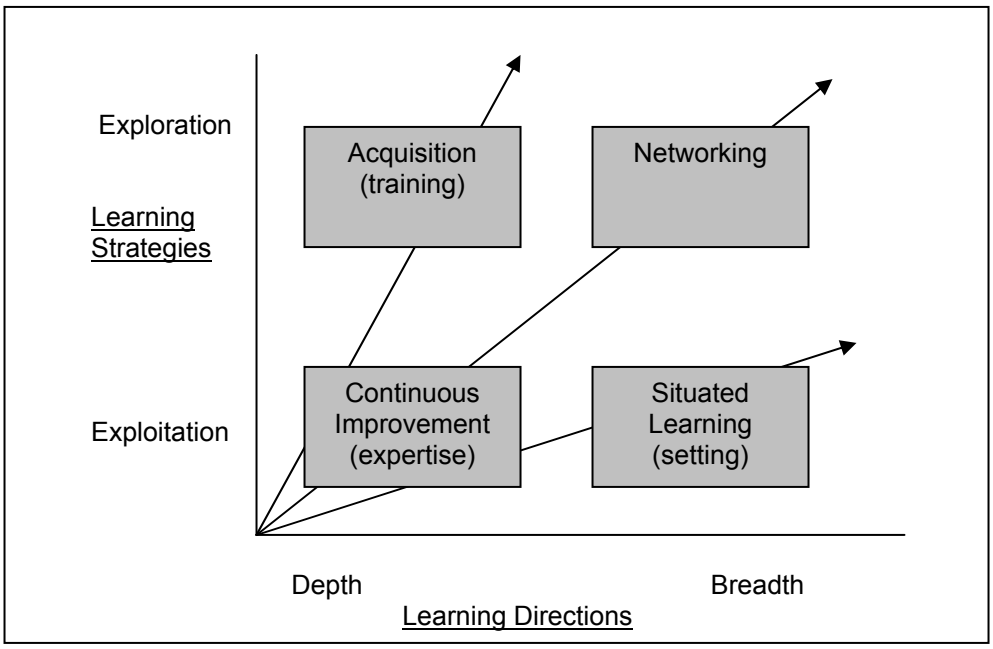

Figure 8. Strategies, Methods, and Directions for Individual Learning

The model for individual methods and directions is based on the idea that as individuals move from exploitation of existing knowledge or reliance on internal knowledge, toward acquiring new knowledge, they take on a "systems" view. Methods are grouped in associations related to whether they utilize existing knowledge stocks (exploitive), or

those associated with creating or acquiring new knowledge or transforming knowledge in some new way are considered explorative. The following review examines elements that affect learning strategy and methods of learning for individuals from the standpoint of the current literature and relevance to the research. First, a summary of learning enablers at the personal level is presented, followed by a summary of the methods that are shown in the preceding Figure 8.

The individual is at the core of organizational learning (Argyris and Schon, 1996, Senge, 1999, 2006, Nonaka, 1994). However, the individual has to want to learn (James-Gordon and Bal, 2003). Therefore, appealing to motivation and intent is the key to individual action. James-Gordon and Bal (2003) offer the following constraints that influence individual learning:

- Perception – Vision as to what is attainable
- Cultural – Affect of past experience on one's expectations of achievement.
- Emotional affecting motivational – Fear of failure.
- Intellectual – Capacity for accepting learning as a continuous activity.
- Environmental – Impact of environmental conditions (change) on risk taking.

Farid, et al. (1993) describes some of these as constraints or "blocks" to creativity in individuals in the AEC environment. These factors are (Farid, et. al., 1993):

- Perception – Function of point of view.

- Culture – As dictated by society and the organizational environment.
- Emotional State – Function of personality.

Comparison of enablers proposed by these two sets of authors reveals the similarity of the constructs involved in discerning individual behavior in learning and creativity. An important aspect of this learning in the work environment is its self-directed nature. These may consist of self-paced training, intentional search, or knowledge seeking from others. The value engineers presumably place on others with similar interests and areas of expertise leads to knowledge seeking from them.

Argyris and Schon (1996) use the concept of first and second order learning. Adopting a second order learning mentality proves difficult due to an inherent need for unilateral control (Argryis and Schon, 1996). Senge promotes a model that contains elements of Argyris and Schon's second order learning as well as systems thinking. Senge's (1990, 2006) three core learning capabilities consist of:

- Aspiration – consisting of personal mastery and shared vision.
- Reflective Conversation – including dialogue.
- Understanding Complexity – systems thinking or the "Fifth Discipline".

Aspiration consists of clarifying one's own personal vision and how personal learning connects to that of the organization (Senge, 1990, 2006). The development of personal mastery is important for generating and sustaining creative tension (Senge, 1990, 2006).

Boyatzis and McKee (2005) describe a similar mechanism involving Boyatzis' intentional change, part of which is the visualization of the ideal self, followed by the gap analysis that results in experimentation at a personal level.

Mental models influence how we each view the world and the assumptions we hold. Dialogue is required to reveal patterns of interaction that result in differences and deficiencies that inhibit the formation of shared vision (Senge, 1990, 2006) that shape these models. It is through the application of reflective inquiry (dialogue) and advocacy that Senge proposes generative learning that challenges personal mental models to achieve shared vision (Senge, 1990, 2006). Nonaka (1994) also describes tacit knowledge in terms of technical (what) and cognitive (causal) knowledge, and calls the cognitive elements of tacit knowledge, mental models. Dialogue, while essential for groups, must begin with individual willingness and capability.

Systems' thinking is the resulting concept necessary for revealing patterns and clarifying the interrelated actions and their effects on the whole (Senge, 1990, 2006). Senge states systems thinking is a reason for organizing detail and dynamic complexities in a way that clarifies causality (Senge, 1990, 2006). The result of Senge's explanation is a process by which the individual moves from thinking "inward" to thinking on a wider or broader scale to enable incorporation of knowledge from others.

Nonaka (1994) emphasizes knowledge creation through three factors that induce individual commitment in knowledge creation; they are:

- Intention – How the individual views the world and attempts to make sense of the object observed.
- Autonomy – The ability to express autonomous behavior that introduces the possibility of new knowledge development through self motivation.
- Environmental Fluctuation – The introduction of disruption to old patterns can result in new pattern formation, revealing new relationships.

Nonaka (1994) further emphasizes fluctuation as a process disruptive to old patterns so that new patterns might be experienced. Individuals therefore, with a certain amount of autonomy, can reflect on problems to get at causality (Nonaka, 1994). Degree of fluctuation in the environment may have a positive of negative influence and be a function of rapid project turnover, or changes in the work structure, culture or policies and procedures.

James-Gordon and Bal (2003) describe learning methods of design engineers that combines experience, cognition and behavior, and perception in a self paced and self directed format. James-Gordon and Bal (2003) described situations in the design environment in which engineers first turn to colleagues and then to experts and finally explicit or written information for assistance when encountering unfamiliar situations in technology application. This situation points to the importance of tacit information in

individual learning. O'Dell and Grayson (1999) state that knowledge and best management practices are in peoples' heads. This "tacit" nature of knowledge is often difficult to make explicit. This is the strategy learning might take in development through continuous improvement

According to James-Gordon and Bal (2003), self development requires continuous commitment on a long term basis; therefore, individuals must take responsibility for their own development. The significance in understanding the drivers of individual learning is in knowing two types of motivational drive by individuals, those which are intrinsic and extrinsic (Tannenbaum, 1997). Intrinsic motivation drives learning for its own sake while that which is extrinsic expects a positive outcome or reward. Therefore, the organization's reward system and individual's alignment to the organization are factors in operation of motivation. Individuals will pursue learning programs and self education they see as having a positive impact on their success in the organization.

Other authors (Litzinger, et al., 2002; Vick, 2002) describe learning in terms of expected development. Litzinger, et al. (2002) state that expected expertise development takes an average of approximately ten years and is based on conditionalized learning, that is, experiential in the sense that patterns or meaningful features begin to be recognized. Vick (2002) defines quality of expertise in terms of six characteristics. These are:

- Quickness and Accuracy – the ability to use "backward and forward" reasoning.

- Better Self Knowledge – Taking time to check and recognize limitations to the problem.
- Ability to Anticipate – ability to anticipate implications to proposed solutions.
- Depth of Understanding – ability to see underlying concepts.
- Insight – ability to change problem representation through creativity.
- Domain Specificity – Individuals are seldom expert in many areas (Vick, 2002).

Vick (2002) also states that what distinguishes experts is their experience at or near the boundaries of their domain, that is, breadth of experience figures prominently into their future stock. Similar to this is Iansiti's (1993) and Truran's (1998) mention of the need for systems oriented individuals to possess "T-shaped" skill sets that contain not just depth of knowledge in an area of expertise but also intimate acquaintance with the potential systematic impact of their particular area. That is, the development of expertise has to accommodate the context in which it exists and recognize the larger "picture" in which it exists and why it is (or is not) important.

Huber (1999) cautions against maximization of project team efficiency by limiting access by experts to diverse assignments, owing to dilution of expertise. In keeping with Huber's (1999) assessment, Vick (2002) recommends assignment rotation or planning for experts that takes them beyond their current assignment to prevent this obsolescence. This suggests providing processes to increase breadth of experience. If exploitation of expertise has to balance against opportunity for renewal and new learning, an issue exists

between individual and group or team learning with respect to the "balance of learning". This leads to a question of whether there is more value in learning things in great depth as opposed to attaining breadth of experience for individuals. This defines a direction for learning by individuals.

Kotnour (2005) suggests that capabilities are enhanced within the project context by assignments that successively further develop an individual's skills by:

- Participation in increasingly complex projects,
- Starting with shorter duration and less cross functionally complex projects and gradually going to longer term, more complex projects,
- Beginning with high oversight and eventually tapering off frequency of reporting,
- Employing feedback and after action review in all cases.

This implies the longitudinal qualities of expertise development, as well as making it difficult to establish just where the "organization is" in terms of its capabilities for an environment containing individuals of differing skill levels. March's (1991) assertion that diversity in experience and learning pace is, in the longer term, better for an organization. This infers that expertise can initially be resisted by diversity but ultimately enhanced.

Nonaka (1994) promotes the idea of networking through teams as a means of sharing ideas that change in their meaning according to the receiver's experiences, thus yielding knowledge not previously revealed. Borgatti and Cross (2003) develop their hypotheses

on the basis that knowledge creation is a social process and use that basis for developing their position for the type of knowledge being sought as dependent on relationships.

Physical setting is the focus of attempts to capture the impact of the "situatedness" of knowledge on exploitive (adaptive) learning (Tyre and von Hippel, 1997). Tyre and von Hippel, (1997) assert that setting provides an environmental context that results in its own set of conditions Furthermore, those persons of differing work backgrounds would "see different things" given the same setting (Tyre and von Hippel, 1997). In two cases, Tyre and von Hippel (1997) found physical setting to be important to learning through its transition from engineering setting to the field or manufacturing. Differences in methods between field and office are likely to be based on very different circumstances. Engineers and architects in an environment that gravitates between office and field are likely to encounter others whose knowledge they must translate through their own experience set, to provide "on the spot" solutions Nonaka (1999) provides examples of learning that results in new insights, owing to changes in setting that allowed observations of behaviors not previously foreseen.

2.3.3 Strategies, Methods and Directions of Group Learning

Collaborative processes are important because no one person embodies the breadth and depth of knowledge necessary to comprehend complex organizational problems (Tyre and von Hippel, 1997). Therefore, it is important to understand learning in groups.

Figure 9 depicts the strategies, methods and directions selected by this research for learning by groups.

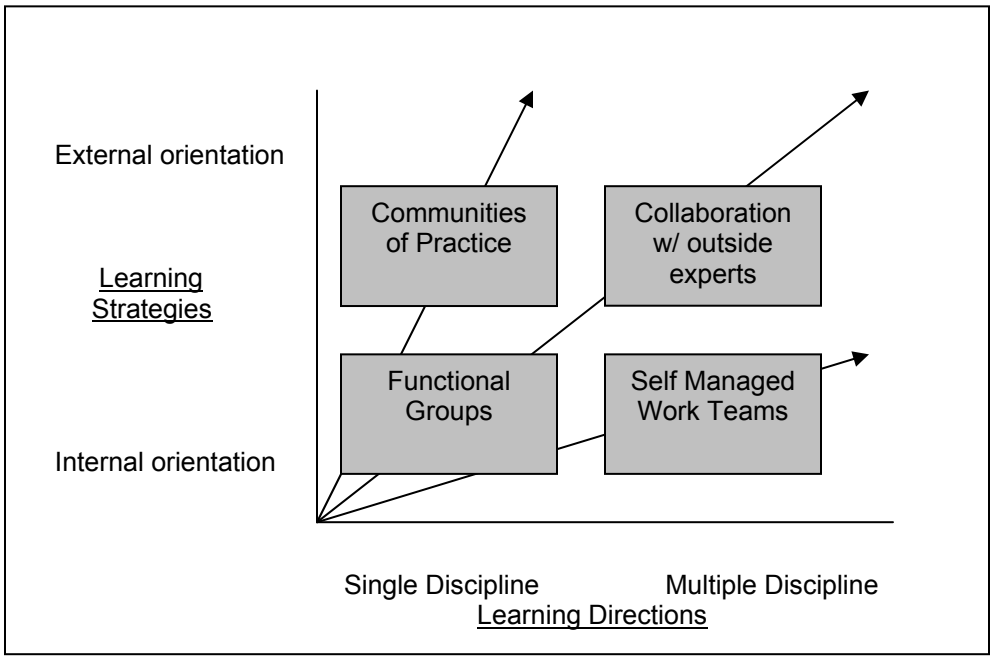

Figure 9. Strategies, Methods, and Directions for Group Learning

Concepts of communication and capture of tacit information, development of shared reality through group inquiry, and use of social structures to spread knowledge to other settings for creativity are themes in literature on group learning. Capture and codification of tacit information requires a collaborative process (Reinmoeller and Chong, 2002, Botkin and Seeley, 2001 Nonaka, 1991). Building on the idea of collaborative processes, DeVilbiss and Leonard (2000) promote partnering behaviors, and individual behavior driven by motivation, as the foundation of learning in groups, needed for potential organizational learning. Therefore, group learning is directly in debt to individual

learning. However, do individuals have to become more interdisciplinary or do groups need to learn to "handle" expertise in the AEC? This is one of the underlying questions driving this research.

Edmondson (1999) defines team (as a form of group) learning as a process in which a team takes an action, obtains and reflects on feedback and makes changes to adapt or improve. This is a form of developing collective reflection. However, Edmondson (2002) also found the "variegated" nature of learning in teams to be a constraint to organizational learning. That is, learning at the team level could be so localized as to prohibit shared understanding across group boundaries. This implies that groups must find a balance between collective (internal) inquiry and outreach beyond the group. The group learning methods in Figure 9 reflect generally recognized differences in whether a group prioritizes internal or external search. This research ues these internal / external directions as a dimension for determining extent of interface between individual expert and group or project team.

Group or team structure itself plays a role in learning at the group level. Szarka et al., (2004) and Cross, et al. (2001) promote the idea that teams are superior to functional groups owing to their cross disciplinary nature and diversity of thinking. However, Szarka, et al. also discuss achieving this advantage in a state of internal competition in a non-threatening situation with balance between centralized and decentralized control by management, and adoption of an inclusive and participative atmosphere.

Development of shared reality is essential to diffusion of information and team learning (Senge, 1990, 2006, Nonaka, 1994, Szarka, et al., 2004). Szulanski (1996) explains that shared meanings make behaviors understood and predictable. An environment that promotes some autonomy, coupled with commitment is essential. However, strategies associated with achieving this model of theories-in-use involve power sharing with those who have competence and are relevant to the question or decision at hand (Argyris and Schon, 1996). The question arises as to how this competency and relevancy are decided. Groups must develop capabilities to select and collaborate with experts – a means of allowance for "power sharing" through expert power.

Scarbrough, et al. (2004) stress the importance of team reflection in the project setting so that habits are formed that will enable knowledge learned to transcend project boundaries. Senge (1990, 2006) and Edmondson (2002) stress both reflection and dialogue at a group level along with complementary technical skills to achieve a sharing of experience that further develops into collective insight. The importance of dialogue to is to create a setting of equality of ideas, before discussion is conducted as to strengths and weaknesses (Senge, 1990, 2006) of individual ideas. All group methods depend on dialogue. However, dialogue would stand to be all the more important to collaboration with experts outside the recognized group boundaries and with those outside technical disciplines where differences and novelty prevent immediate recognition of value and also due to the need to counter tendencies toward closed or unilateral decision-making.

Cross, et al. (2001) point out the tendency of networks of engineers and scientists as being five times more likely than other professionals to rely on other persons for immediate information than on a database of codified knowledge. Borgatti and Cross (2003) reiterate these relationships through "intentional search" in networks and investigated the functional aspect of the relationships through case studies of two research groups and found statistical support for the following:

- Knowledge of another's area of expertise leads to knowledge seeking from them.
- Value of another's expertise in relation to the subject of search leads to seeking knowledge from them.
- Access to another's thinking leads to seeking knowledge from them.
- Relationship between physical proximity of the players and accessibility/value expectation of the seeker as to whether the knowledge was worth overcoming any physical barriers.

These are implied prerequisites for an interdisciplinary network that learns to collaborate with experts beyond its immediate boundaries. Nonaka (1994) examines more closely, the interaction of new knowledge with existing shared and personal vision in his "Networking Knowledge" model. This model examines the knowledge creating process as new knowledge is introduced to the team setting. Justification of the knowledge is an important part of the process that involves holding the knowledge to the firm's standards of operation but may go beyond simpler standards of cost/profit or efficiency (Nonaka,

1994). Management's objective is to determine the standards against which that new knowledge must be evaluated (Nonaka, 1994).

Another concept promoted by Nonaka (1994) is that of the self-organized (managed) work team, composed of members with different functional classifications, placed into an autonomously operating group. The basis of the idea rests in Lewin's (1951) "field" theory in which a dynamic whole is created, based on interdependent or complementary roles rather than similarity as encountered in a functional group. The difference between this and the networking concept as applied to this research is the degree of use or dependence upon external (to the group) expertise to supplement knowledge.

Brandon and Hollingshead (2004) suggest certain aspects of team maturity in terms of whether the team functions as a cohesive group with common knowledge or as a simple collection of individuals. These aspects point out the role of participation and the potential importance of the roles played by senior or key staff members with higher institutional knowledge and therefore, higher levels of validation potential. Brandon and Hollingshead (2004) also found:

- Requirements for agreement over group task, commitment of group members in participation, and frequent communication to speed up convergence (shared mental model development).
- Need for good fit between task definition and available expertise to address the task.

- Positive relationships exist between time of exposure of the group to task information and accuracy of the OL.
- Task/reward structures should stress creation of interdependence and encourage on-going dialogue and discussion.

Carlile (2004) suggests further that capabilities required to handle knowledge at group boundaries, consist of the following:

- Development of a common language for members to use to assess /access each other's information.
- The need for members to recognize and learn about the differences and dependencies between them when novelty is present.
- Capability to transform domain specific knowledge to reveal how knowledge affects all concerned through consequences across boundaries.

This infers that self managed work teams may have some advantage due to common language and recognition of differences.

March (1991) cautions that effective communication and coordination are needed for an organization to learn, but that "fast" *individual* learning is not likely to result in effective organizational learning without taking into consideration the participation of a diverse set of experienced and inexperienced individuals. Likewise, Cross and Sproull (2004) conclude that situated learning can take place at the group level; however, as learners take knowledge from the group, it was not clear what the group takes from members at its periphery. This finding implies that groups with more "open" environments, such as

multidisciplinary groups that engage in collaboration with experts may have some advantage, though more challenges resulting from personnel turnover. Self organized work teams might have a disadvantage should there be a high rate of personnel turnover.

Communities of practice (CoPs) as defined by Wenger and Snyder (2000) are informally bound groups of people, sharing common expertise and who have a passion for a joint enterprise. Communities of practice may be formed of functionally similar experts who are assigned to diversely populated groups or teams as a way to "keep in touch" with peers. According to Brown and Duguid (1991), CoPs demonstrate the advantage over more traditional functional groups by being able to go beyond canonical learning practices that would other wise blind problem solvers to unconventional approaches. Their informality is also a potential weakness as they usually lack legitimized power unless supported by the organization (Wenger and Snyder, 2000). The concept of CoPs has grown with emphasis on structuring to interdisciplinary teams. However, Wenger and Snyder (2000), Thompson (2005), and Botkin and Seeley (2001) recommend that organizations proceed carefully in support of CoPs, as forced attempts at cultivation may result in their "going underground" or driving people out of the organization socially. Narrow definition of a community's role or not providing the correct infrastructure can also lead to "myopic" learning as it did for Ford's "RAPID" process, which did not foresee the tire - vehicle incompatibility problem with SUV's in the late nineties (Stewart, 2000). CoPs represent a method for leveraging expertise through selection and collaboration between its members and the group.

2.3.4 Strategies and Methods of Organizational Learning

Organizational learning is said to be more than the sum of the learning by its individuals (Love, et. al. 2002, Yeung, et. al., 1999). This implies that some realization of a new or unique value comes from the knowledge brought about by individuals acting in a collective. Carlile and Rebentisch (2003) define organization learning as a social process composed of multiple actors possessing unique knowledge and interests, all contributing through relational cycles in that the nature of learning is flow of knowledge across boundaries. According to Argyris and Schon (1996), there are those in the scholarly literature who take the value neutral position that organizational learning itself is a paradoxical concept, that it is not always beneficent, and that it is doubtful that organizations have learning capability. Argyris and Schon (1996) answer these challenges by defining what the organization is, namely a collectivity that:

1) Makes group decisions,
2) Delegates authority to an individual to act on behalf of the collective and,
3) Defines who is and is not a member of the collectivity.

Under these conditions, evidence of organizational learning comes through individual actions in response to delegation of authority and affects a unit or multiple units of the organization. In response to the challenge of the beneficence of organizational learning, Argyris and Schon (1996) note that organizational learning has to be considered in the context of how it is perceived, whether desirable or undesirable. Capability is addressed through identification of the gap between prescriptive enablers and effective implementation of learning (Argyris and Schon, 1996). Organizational learning, itself, is

not addressed directlyin this work, due to the limited scope of this research. However, the elements of OL are known to operate and are represented in the literature presented here to enable a better understanding of the organizational elements that affect how individual and groups operate. Figure 10 represents those elements.

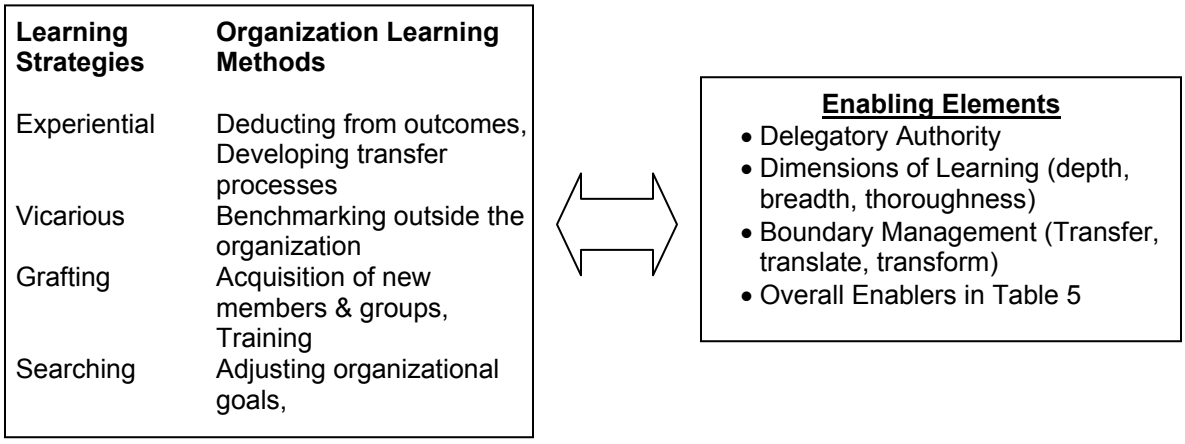

Figure 10: Strategies, Methods and Enablers for Organizational Learning

Management of roles and groups through their definition comes through delegation by the organization. According to Senge (1990, 2006) roles are part of the infrastructure required by organizations to intervene in the "deep learning cycle". Therefore, roles in organizational learning must transcend simpler reporting relationships, and stress a communicator and enabler role for management. Nonaka (1991, 1994) describes the frontline employee as requiring support to sort out ambiguity and clarify the apparent chaos owing to the noise created by day-to-day responsibilities. Management's responsibility is to challenge the employee to learn through expression of metaphors

needed to apply knowledge and to give chaos "orientation" by relating back to strategy (Nonaka, 1991). Wisniewski and MacMahon (2005) stress the need for the supervisor or manager with direct reports to take on the role of championing the learning efforts by front line employees. Therefore, the organization, through delegation, defines authority and roles and manages those roles.

As stated previously, Huber (1991) presents a definition of learning, in terms of the types of information seeking conducted. However, he also states that organizational learning must have three other elements, these are:

- Breadth – More units within the organization that learn,
- Elaborateness – The capability of more units to develop varied interpretations,
- Thoroughness – The ability of more units to develop uniform comprehensions about the interpretations (Huber, 1991).

Facilitating the development of education and training are of importance in addressing these requirements, particularly when group learning is involved, since groups tend to develop their own interpretations or meanings from the information. Therefore, organizations must have a learning strategy that aligns with the goals of the organization.

Learning in the organizational context requires transfer/translation processes and actions. Szulanski (1996) notes that a distinction must be made between translation by diffusion as opposed to process transfer. Szulanski (1996) as a distinct event defines transfer whereas diffusion occurs over a less well defined period. Translation is important to

project based organizations where units must adapt learning by absorption and reflection, thereby enabling application of knowledge to other settings (Scarbrough, et. al., 2004). A sustaining engineering environment lacking clear project lines, may have a disadvantage for a structured system for retaining knowledge, but individuals may retain knowledge as tacit knowledge. Therefore, individual based practices may have a direct bearing on organizational learning capability through the ability to assist translation processes and actions. Translation may mean a group learns a new way of operating, owing to one of its members' participation in a community of practice and bringing that information back to the group and defining its meaning in terms the group can understand and use. These cases may benefit by means of codifying this knowledge.

According to Veshosky (1998) and Carillo and Chinowsky (2006), engineers in AECs, have difficulty communicating across boundaries, so it should be important to describe and understand boundary management's role in controlling or constraining knowledge transfer, so that steps may be taken to moderate its affects. Satisfactory boundary management, according to Carlile (2004), must address informational, interpretive and political approaches, depending on the novelty, dependence, and complexity of uniqueness or differences in knowledge. The processes by which Carlile (2004) ties together knowledge between disciplines is:

1) Transfer – Information processing, more easily handled by a common language

2) Translation – Requiring interpretation to develop common meaning and possibly making trade offs between individuals/ groups/teams.
3) Transformation – Managing potential conflict at pragmatic or political boundaries by translating knowledge and visualizing potential common consequences.

Knowing what type of boundary is to be managed should provide a clue as to the type of solution or approach is needed to overcome those differences. However, transformation requires a deeper understanding. This is similar in some ways to what Yeung, et al. (1999) term the "generalization" of knowledge. Recognizing generalization for OL consists of observing the following (Yeung, et al., 1999):

- Recognition and negotiation of boundaries
- Ideas or knowledge tied to strategy.
- Contingency thinking for the inevitable what – if scenario.
- Repeatability of the idea or concept in practice.
- The idea or knowledge must have impact, as defined by Argyris' contention that inquiry requires action.

The success of the transformation is dependent upon the capacity for representing knowledge that is comprehended in spite of its novelty and differences across groups. Therefore, the organization needs to know whether translation or transformation that is more complex is required..

March (1991) suggests the rate of adaptation in organizations should be slowed to prevent "false learning" and simultaneity of changes, thereby reducing environmental "noise" that may block true meaning. March (1991) goes farther in his examination of exploration and exploitation as search (learning) strategies and concludes that a mix of diverse individuals (fast and slow learners) is more desirable if attempting to balance between the two strategies. This would allow for learning by continuous improvement, if exploitive, or by grafting, if exploratory. Strategies that depend on exploitation in favor of variability reduction are seen as self-destructive in the long term, but exploration has returns that are more distant and less clear (March, 1991). Fast individual learning is seen by March (1991) as detrimental to socialization within the firm and to the development of shared mental models. Grafting, by introduction of new members or acquisition of new groups, must be carefully managed, in these cases.

2.3.5 Enabling Elements Affecting Overall Organization

Yeung, et. al. (1999) call them elements of a learning 'architecture", Fiol and Lyles (1985) described them as "contextual elements", and Tannenbaum (1997) uses the term "work environment" to describe elements that are considered necessary to enable the functioning of an organization that learns. Some authors agree (Yeung, et al., 1999; Senge, 1990, 2006; Love, et al., 2002) that all of these elements need to be present in some form in order for a "learning organization" to exist. The idea is that when collective learning supersedes the individual effort, learning has become a part of the culture

(Yeung, et. al., 1999). Senge's (1990, 2006) supposition is that learning at the individual, group and organizational level is embedded in a firm's culture.

The research recognizes these as part of the enabling elements that apply across individual, group or team, and organizational boundaries to describe the organization. There are semantic differences among authors on nomenclature of some elements. However, there is general agreement on their characteristics, if not those considered the most influential. Table 5 displays the elements and comparative treatment by the authors. These elements are not discussed in detail but are presented to assist in understanding where they apply in decisions regarding the use of learning strategies.

Table 5. Comparison of Overall Enabling Conditions by Author

Attribute	Yeung, et al (1999)	Senge (1990, 2006)	Argyris and Schon (1996)	Nonaka (1994)
Culture	The firm's mindset, collective memory & what outsiders think the firm represents.	Individual & core identity of the business.	Theories of action, Theories in use, organizational inquiry	Shared experience and use of interdependencies to connect teams and handle changes
Governance (Structure)	Organizational design and communications	Use of strategic architecture, theories, tools, and methods	Organizational structure, communications, spatial environment, procedure	Self organizing teams, communications, requisite variety, Internal networking.
Leadership	Coaching, facilitating, teaching	Designers, teachers, stewards	Assessment of the Learning Culture	Articulation of metaphors, giving shape to chaos
Strategy*	Addressed within the business context	Needs to connect to core business in exploratory and exploitive modes	Probe into the firm's environment through second order learning	Knowledge creation should be emphasized for developing strategy
Environment	Rate of change directs type of learning (direct / indirect)	Dynamics that affect stability and learning emphasis	The setting in which the firm exists and responds.	Amount of fluctuation that can create new interaction
Learning Competency	Develop competencies through training and staffing	Develop through generative learning, reflection and action	Single/Double Loop and Deutro-learning, Causal tracing	Metaphorical thinking and use of analogies
Performance Management	Appraisal & rewards systems that encourage learning	Careful application of causality and reinforcing feedback	Use of intrinsic incentives	Evaluation standards for justification and convergence
Capacity for Change	Examination of how processes encourage learning (adaptation)	Building adaptive & generative organizations	Ability to diffuse through the organization through elimination of defensive routines	Sustained through knowledge spiral, redundancy
Alignment**	Address through learning styles and culture	Address as a prerequisite to enable individuals to empower team learning	Dependent on levels of aggregation of teams or organizations	Induction of synergistic action through use of redundant responsibilities

* Suggested by Fiol and Lyles (1985) **Posited by Marr, et. al. (2003)

The preceding enabling elements of organizational learning are regarded as prerequisite or concurrent with the learning operation. These enablers are contributory to individual, group and organizational learning. There is general agreement on what a learning organization should "look like" based on these enablers, but different authors place different emphasis on different aspects. This may be attributable to areas of focus within past research. It is proposed, based on the review of the literature, that the organization that learns may be expected to behave thusly:

1) The firm adopts of a culture that values learning and process approaches, while recognizing and adjusting for differences in cultural types within the organization.
2) The firm provides a structure that encourages or enables learning and sharing of knowledge while maintaining focus on goals to strategy.
3) The firm promotes individuals as leaders who, as Tannenbaum (1997) asserts, "see the big picture" and understand their role and share their mental models.
4) The firm connects learning to business strategy and furthers learning as part of it.
5) The firm understands the dynamics of the environment and is agile enough to adopt coordinated action involving changes through policies and governance.
6) The firm integrates learning through practices and means that assist in building competencies within its groups and individuals.
7) The firm provides for intrinsic and extrinsic rewards for learning and applies them in the proper context to encourage passing knowledge on from one unit to another.

8) The firm uses adaptive and transformational processes in building capacity for change, and understands as an organization which context in which to use adaptive or transformative change.
9) The firm aligns understanding of knowledge in ways related to that of individuals and groups that are charged with contributing to the knowledge stock of the firm.

2.4 Identification of Learning Disablers

Huber (1991) notes that learning need not always increase the learner's actual or potential effectiveness and those entities can incorrectly learn or learn incorrectly. Miner and Mezias (1996) and Fiol and Lyles (1985) caution against learning disabilities that result in superstitious learning. Yeung, et al. (1999) notes the identification of learning disabilities as one of three building blocks for building learning capability in a learning organization. Table 9 summarizes disabilities as identified by the various authors.

Definition of specific cause or set of causes for these disablers can be difficult due to interactions of the many variables identified in individual, group, and organizational learning. Senge (1990, 2006) describes the detail and dynamic nature of cause and affect as consisting of different effects seen in different parts of the system at different times and the unobvious consequences resulting from interventions. Yeung, et al. (1999) state the presence of just one disability can negate the positive results of learning. Therefore, what is important to know, as asserted by Senge (1990, 2006) and Yeung, et al. (1999) is how to identify disabilities. This research does not seek to discover learning disablers but

must consider their presence and allow for this through the questions to be presented intended to connect methods to knowledge outcomes.

Table 6. Comparison of Learning Disabilities in OL Literature

Author(s)	Senge (1990, 2006)	Yeung et. al (1999)	Szulanski (1996)	March (1991)	Tannenbaum(1997)	Farid, et. al. (1993)
Learning Disabilities	Non-systems thinking	Lack of gap perception	Barren context of transfer	Lack of balance between fast/ slow learning	Lack of awareness of value in learning	Goal ambiguity
	Externalization (assigning blame)	Simple-mindedness	Defensiveness	Imbalance between exploitation & exploration	Failure to connect learning to new tasks	Arbitrary task assignment
	Illusion of pro-activity	Homogeneity in ideas	Arduous relationships	Diffusion of expertise	Fear of taking risks in learning situations	Inequitable work load distribution
	Event fixation	Tight control of units	Causal ambiguity		Lack of individual accountability	Lost opportunity to exercise knowledge
	Short term views	Decision paralysis	Lack of absorptive capacity		Lack of support by direct management	Management ignorance or refusal to accept learning
	Causal ambiguity	Superstitious learning (causal ambiguity)			Lack of supportive policies and practices	
	Skilled incompetence	Inability to diffuse (transfer) learning				

2.5 Performance Outcomes

Learning, as referenced by Huber (1991) and Argyris and Schon (1994) is not necessarily for always for good, but from a pragmatic standpoint, is considered necessary for advancement of goals and objectives of the firm. However, according to Cyert and March (1963, 1992) collectives do not have goals, only people have goals. People in organizations form groups to bargain within the firm, establish objectives, and eliminate conflict among individuals' requirements (Cyert and March, 1963, 1992). Therefore, measurement of performance is ultimately necessary at the individual, group and organizational levels if it desired to determine true learning effectiveness at these levels. Due to the scope of this research, performance outcomes can only be measured indirectly, through questions that address perceived effectiveness of learning and impact to the project, group, and firm. The outcomes given in Table 7 will be used to assist in devising questions pertaining to individual and group learning as it relates to the perception of increased performance. Quality perspectives for determining success are nearly universal in facilities. Is it constructible, maintainable, or can it accomplish its intended function? Can it be adapted or changed in function? Is it expandable? Timeliness – given the challenges about the fluctuating environment in the construction industry, along with responsiveness, are also important considerations. Finally, are the processes and procedures upon which successful performance is based, successful at facilitating that performance?

Table 7. Performance Outcomes

✓ **Successes/ Failures in projects and routine work at individual level**
- Budget/Schedule
- Quality of the product - constructability, fitness, future adaptability, maintainability.
- Response to request – timeliness, thoroughness in investigation or diagnosis.
- Availability for implementation follow up
- Satisfaction of participants

✓ **Successes/Failures in projects at group level**
- Budget/Schedule
- Quality of the product (see above)
- Degree of coordination – How well did disciplines communicate with each other?
- Response to other groups during design and construction phases
- Group satisfaction with participation

✓ **Successes/Failures in projects at organization level**
- Achievement of profit or budget motives
- Schedule and resource utilization rates met
- Quality of work meets goals and objectives for strategic operations and longevity
- Adequate documentation was received for future reference and use by operators

✓ **Successes/Failures in process/procedure at non-project levels**
- Processes and procedures were in place for predicted and unforeseen conditions
- Processes and procedures enabled exchanges across boundaries

2.6 Case Studies in the Literature

Two issues arise on the subject of organizational learning research in the AEC. One issue is whether the previous research is adequate or complete and its impact to the intent of the proposed research. The other is whether the direction of the proposed research addresses a significant gap in the existing body of knowledge and is the gap addressed in a way that is important to the body of knowledge. Previous case studies are used to examine these issues, and to determine the current state.

Previous research has focused on varying degrees of participatory involvement by the researchers, utilizing retrospective analysis, questionnaire and interview approaches for data gathering, while others have employed the research action perspective as popularized by Argyris and Schon (1996). March (1991) adopted mathematical simulation tools to predict learning outcomes. Many authors in organizational learning have argued for more empirical study, stating that while a plethora of models and theories have been proposed, few examples of good empirical research exist, that take advantage of others' works or attempt to reconcile practice related prescriptive approaches to more academic non-prescriptive literature (Huber, 1991, Miner and Mezias, 1996, Tannenbaum, 1997). According to Chinowsky and Carillo (2007), a minimal amount of research exists in the construction area, in spite of a wealth of information on OL.

The following tabulated summary of research assists in definition of a better understanding for identification of gaps in existing knowledge. While not intended to be inclusive of all possible experiences, it reflects of the type and nature of the direction of previous efforts. This summary is limited to examination of that research conducted in technically based organizations, but is not specifically targeted at the AEC. A lack of available case studies on the specific type of organization investigated is evident. Table 8 lists the general type of research conducted within the case study and the direction or major findings of that research. Most of the research consists of initial questionnaires, followed by more detailed information gathering by

use of questionnaire, interview, or review of internal documents, where allowed. Fewer case studies were attempted with the use of action research methods. These generally tended to be longer term, focused studies conducted on one organization.

A feature of organizational study is that while ideas and concepts are static objects, organizations themselves, are not. In two cases within the literature studied, ongoing organizational changes affected expected results, due organizational changes that resulted in unavailability of subjects, transfer of personnel, uncertainty expressed by subjects, and changes in priorities that negated hoped for data collection. If the object of organizational learning is to effect change, it is to be expected that subjects will not remain static for the benefit of the researcher or if something is really "happening inside the black box". The transience of organizations in a competitive environment makes the necessity of valid approaches all the more important due to the nature of the learning phenomenon.

Table 8. Authors and Research Direction on OL Case Studies

Author(s)	Research Type	Theme	Area of Learning
Blackler & McDonald(2000)	Action research	Affect of changing nature of expertise and power that affects decentralized collaboration. *	Decentralized Learning
Bresnen, et. al. (2005)	Interview, review of internal documents	Interaction of change initiatives with established routines in construction project organizations.	Local boundaries derived by teams
Carillo & Chinowsky (2006)	Interview, survey	Practices are used to conduct knowledge management activities in design & const.	General application of knowledge management practices
Carlile & Rebentisch (2000)	Interview, review of documents, ethnographic	Impact of novelty (across boundaries) on transfer and integration of knowledge.	Impacts to transferability of knowledge
Edmondson (2002)	Questionnaire, interview	How adaptation is affected by incomplete or failed reflection on actions, defining learning disablers.	Impacts to adaptation
Ford, et. al. (2000)	Action research	Impact of engineering culture and external environment on developing a learning organization per Senge's model.*	Application of Senge model in high technology organization
Gardiner and Whiting (1997)	Interview, questionnaire	Development of learning organization in a well entrenched culture by altering the environment.	Environmental aspects of LO creation
Kamara, et. al. (2002)	Interview at multiple levels	Comparative study of practices employed for learning and knowledge management in AEC's.	Experience in knowledge management
Szarka, et. al. (2004)	Review of team work documents and presentations, interviews	Practices employed for developing quality improvements through learning in a team competition.	Use of team competition to promote learning
Tannenbaum (1987)	Empirical (questionnaire)	Learning environment enablers that enhance adaptation.	Enablers for adaptation
Truran (1998)	Exploratory interviews	How knowledge is transferred, Affect of "T-shaped" skills.	Individual competencies
Tyre &von Hippel (1997)	**Interviews, review of internal documents**	**Impact of situatedness (physical setting) to learning in plant/ engineering lab environment.**	**Impact of situated learning (proximity)**

Miner and Mezias (1996) issue caution concerning interventionist research as a vehicle for organizational learning research, due to the potential for unintended outcomes by interactions with complex systems. They also advocate study of populations of organizations as a means of capturing a more representative sampling of processes (Miner and Mezias, 1996).

2.7 Gaps in the Existing Literature

The prior work, while important to the concept of organizational learning in general and to engineering organizations, is incomplete and inadequate to the setting proposed herein. The following summary demonstrates the areas through which gaps exist in the present research that are relevant to the present case of defining best practices in an AEC that must excel in an environment demanding both adaptation and innovation. Existing research is inadequate regarding AEC organizations owing to the existence of little literature that addresses AECs in the framework of a facilities environment. While the literature describes deficiencies in organizational learning, little attention has been given to how learning can be integrated in a firm that relies on both group and individual learning. Additionally, the literature stresses the difference between adaptation and innovation, but except for Lounamma and March (1987) and March (1991), little emphasis has been made for research into how organizations can perform both functions well.

Authors within this review have made note of the gaps existing in the body of knowledge that require further study. These gaps are explained in relation to the research questions:

1) *How do individual actions contribute to organizational learning and performance?*

Borgatti and Cross (2003) call for more research into discovery of what relationships are needed for groups to leverage collective expertise in a transactional view of moving knowledge across boundaries. Individual expertise is a prerequisite. Carillo and Chinowsky (2006) identify expertise and tacit information as the firm's most important asset, but admit there is no "one size fits all" strategy to capturing it. Given the descriptions provided by Vick (2002), and Truran (1998), for effective expertise, the right direction for development of expertise and expression of knowledge to explicit forms that can benefit group and organizational learning is needed.

2) *Can internal differentiation and competition between project and non-project learning be overcome by learning strategies?*

Cross and Sproull (1991) found that while learning can take place at a group level, there was an unknown as to what groups take away from members at their periphery. Carillo and Chinowsky (2006) call for development of a means to determine the impact of certain groups in terms of a cause and effect mechanism to enable

measurement of value added. The AEC subjects of this study stress the deployment of individual contributors, in coexistence with project teams. The question also arises concerning whether the dynamics of an environment such as that represented by a group of individual contributors also work with a project team environment or does conflict result that negates learning. Szulanski (1996) recommends that resources should be devoted to developing learning capacities of groups and to foster closer working relationships. This needs to be understood in an environment where individual contributors compete internally with teams for resources.

3) Are explorative behaviors important in the AEC?

Argyris and Schon (1996) and Huber (1991) recognized that not all learning is beneficial. Cross and Sproull (2004) examined the attributes of what they call "actionable knowledge" to establish a defined set of qualities to actionable or meaningful knowledge., but limited this definition to immediately useful knowledge. March (1991) points out the difference in learning outcomes in regards to exploitive and explorative behaviors. According to March (1991), strategies that depend on exploitation in favor of variability reduction are seen as self destructive in the long run, but exploration has returns that are more distant and decidedly less clear (March, 1991). As to effectiveness of search, Huber (1991) admits a lack of conceptual work and field testing of theory on the distinction between focused new search (external search) and search within existing databases or internal sources for information for

solutions. Processes such as that described by Carlile and Rebentisch (2003) focus on knowledge transfer and transformation but do not necessarily provide for acquisition of new knowledge, and appropriate interactions between areas of specialization have to be identified so as to increase understanding across boundaries (Carlile and Rebentisch, 2003). Therefore, we seek to define what constitutes effective learning in an AEC and whether this knowledge is the result of adaptive learning or innovation.

Researchers have been critical of the literature in organizational learning for past focus on development of new models without empirical research to verify and validate already existing models (Argyris and Schon, 1996; Easterby-Smith, et. al., 2004; Miner and Mezias, 1996; Huber, 1991). This work proposes to refine existing models into a more specific framework for an application relevant to the AEC industry and profession.

2.8 The Research Model

The approach used by this research is to capture information from individual and group contributions through actions and perceived results. The model uses the definitions and concepts from the literature and places those concepts into the context of an AEC by selecting methods based on strategies and applying them through directions experienced by individuals and groups. Learning methods are from the items discussed in Section 2.3. Learning and knowledge / performance outcomes are defined in terms of those discussed in Sections 2.1 and 2.5.

These hypotheses are drawn on the theory that while experts strive to improve, groups take that knowledge and strive to innovate. In addition, individuals must either become more interdisciplinary in their thinking or groups must become more willing to "take on" outside expert help. The hypotheses are:

- H1: Individual methods involving greater frequency of networking are more strongly correlated to innovative knowledge outcomes for individuals than other methods.
- H2: Group methods employing greater frequency of collaboration with experts (beyond group boundaries) is more strongly correlated to innovative knowledge outcomes for groups than other methods.
- H3: There is a significant positive correlation between individuals that use networking methods and groups that use collaboration with outside experts.

The first hypothesis posits that more frequent dependence on individual networking leads to more frequent higher order learning outcomes. The second hypothesis states that groups need to learn to use experts from beyond their boundaries to extend their learning into innovation. The final hypothesis infers that individuals who utilize networking are positively correlated to groups that use collaborative methods with experts outside their boundaries.

The basis for the research model defined for the strategies, methods and directions previously described, is shown as Figure 11.

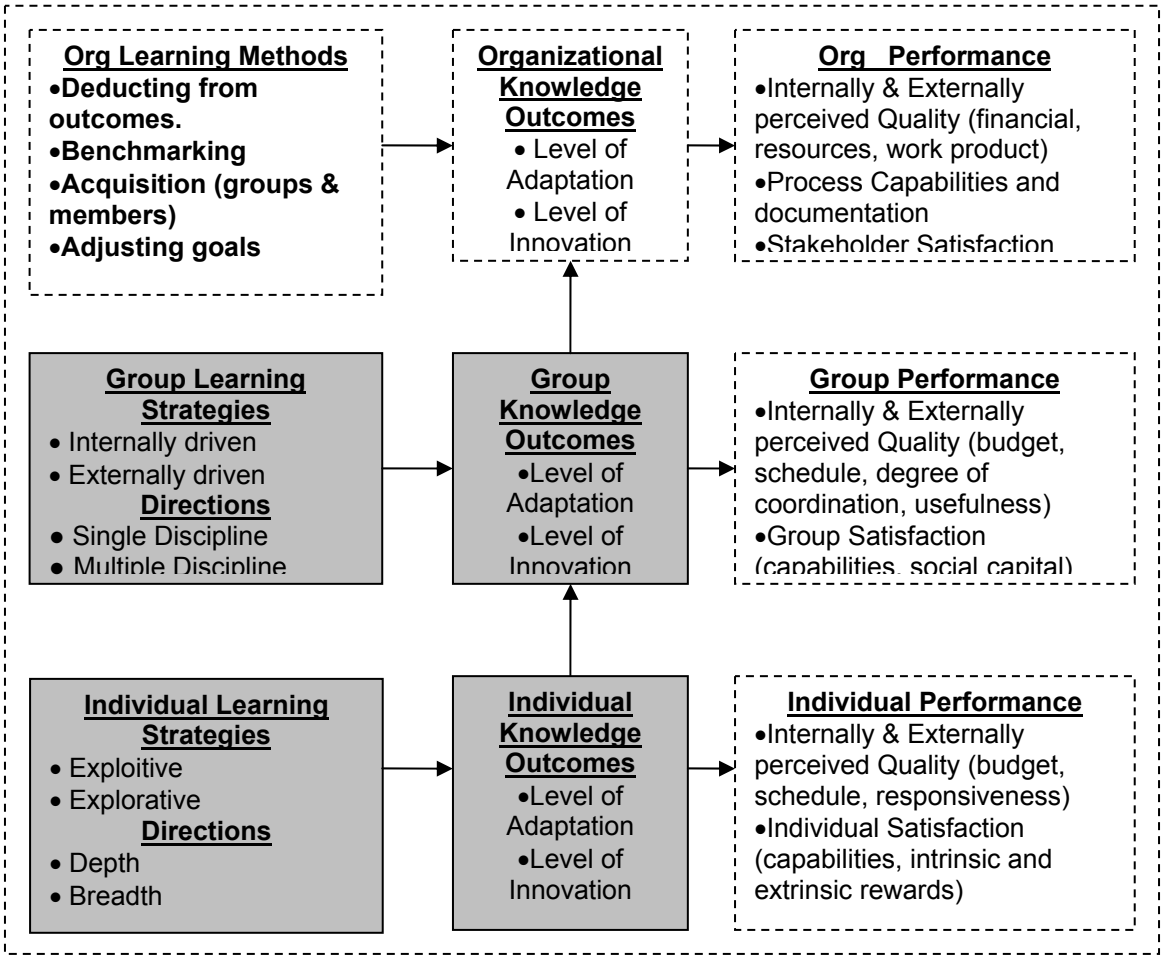

Figure 11: Basis of Research Model

Using the figures derived for individual and group learning and the basis of the research model, the operational model defined for testing is defined by Figure 12.

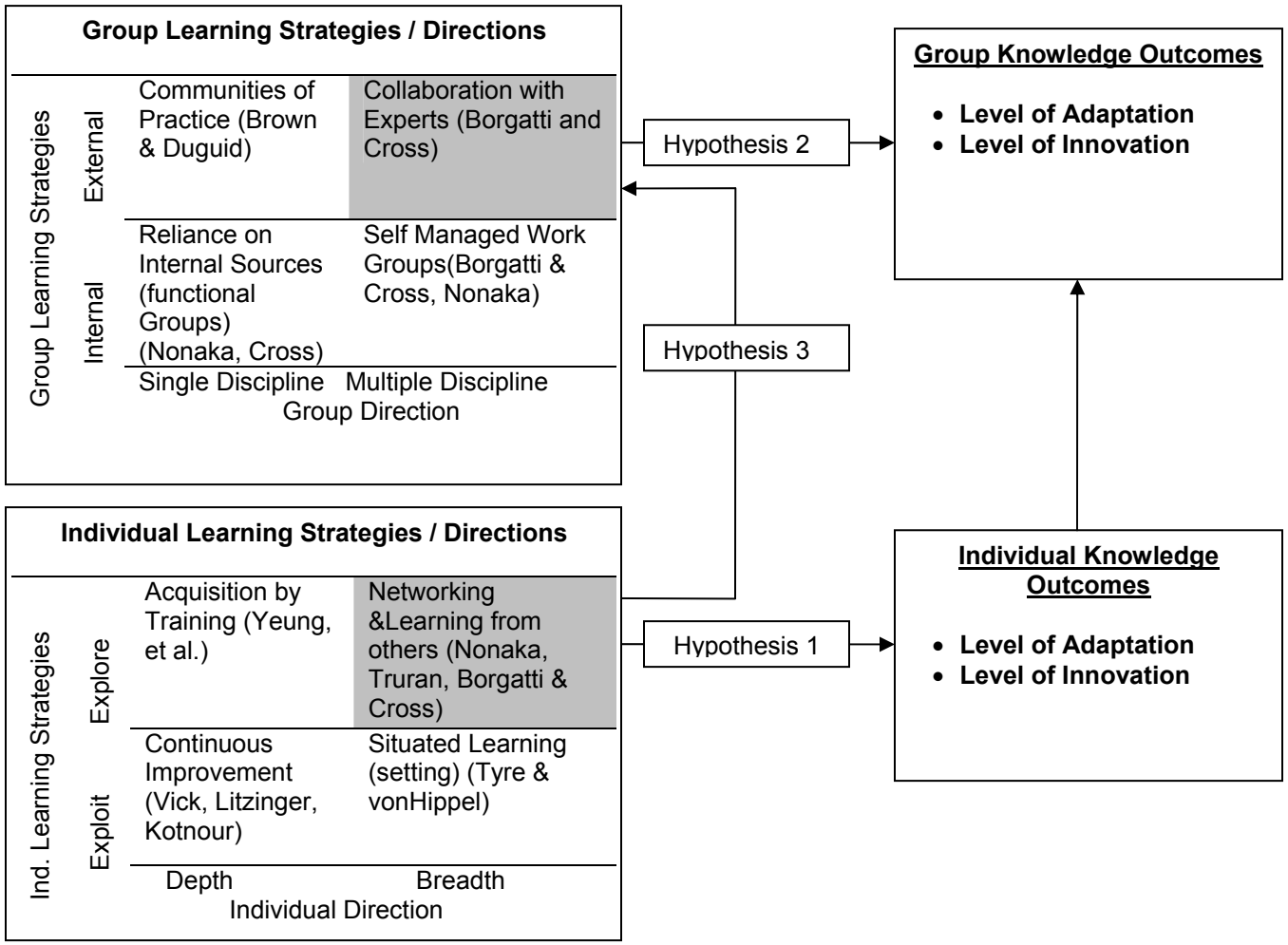

Figure 12: Research Model

The operational model contains the elements that will be tested against knowledge outcomes. The methods that result from strategies and directions derived from the definitions obtained through the literature survey.

The proposed research methodology is outlined in Chapter 3. The proposed methodology will demonstrate exploration of gaps in the knowledge in terms of the following questions:

- Does the problem concern basic concepts such that knowledge produced will build on an existing body of knowledge?
- Will the investigation result in testing of some theory?
- Does the research problem allow for careful specification of the variables involved and use of the most precise and appropriate methods?
- Will investigation of the research problem lead to contribution to methodology by discovery or refinement of practical tools?
- Will the research problem utilize relevant concepts using evidence and techniques?
- Will integration of this single study into a planned program of research produce results that are more meaningful than those prior?
- Will there be opportunity for future application to academics?

CHAPTER 3: METHODOLOGY

3.1 Introduction and Requirements

The objective of the chapter is to outline the approach and methodology of the proposed research. Requirements outlined by Miller and Salkind (2002) are presented first, so that connections can be drawn between the proposed theory and the literature.

The establishment of a properly defined line of research requires a methodology that supports these previously defined requirements:

1) The body of knowledge of organizational learning within the architecture, engineering, and construction organization will benefit through new understanding of how learning strategies can be employed in individual and group learning settings. The literature suggests that explorative behaviors lead to learning for longer term levels of competitiveness. In this research, learning is measured through frequency of knowledge outcomes defined as adaptive or innovative. The researcher adds the contexts of expertise development on an individual scale, and group structures used to frame learning and performance activities to the strategies, so that evidence can be found for possible relationships.
2) The theory is tested by a questionnaire, administered to extract the information required to enable testing of the previously stated hypotheses.

3) The research problem is specified in terms of constructs (Learning Strategies and Learning Directions) which are further defined by variables for the individual and groups. Strategies are defined in terms of whether they involve exploitation of existing knowledge or explore for new knowledge by going beyond discipline or group structure boundaries.
4) The intent of this research is that results of this study can be further integrated into a larger body of research on organizational learning, engineering management, and engineering management in AEC organizations, in particular.
5) Expectations are that future research can benefit through revelation of relationships between the constructs of learning not explored or suggested by the results of the research, an example of which is further opportunities for detailed study of applications or techniques employed by individuals in service of a particular method that supports a given strategy.

The approach must provide for continuity between research questions, research model and the hypotheses through a cycle of refinement and checking to achieve face or content validity. Figure 13 assists in clarifying these relationships.

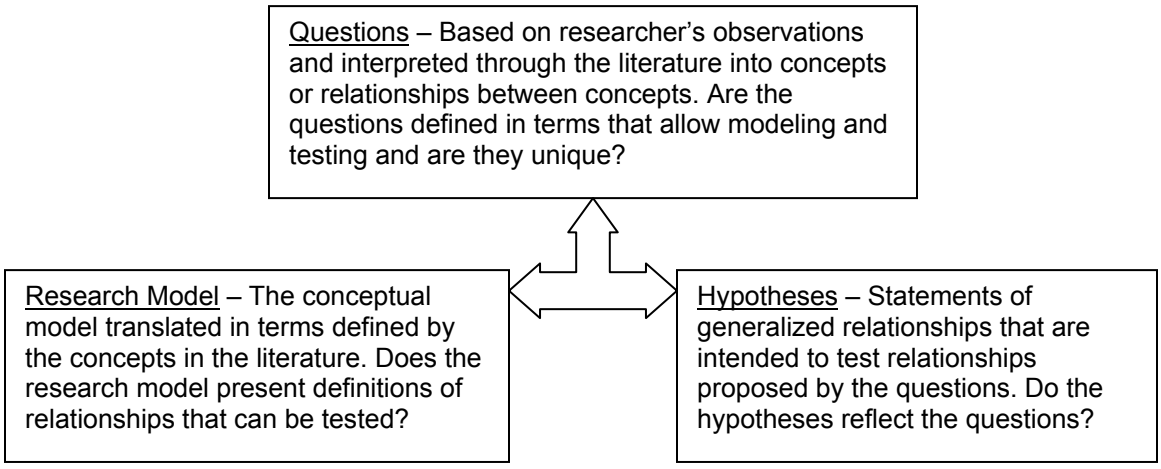

Figure 13:Linking the Research Model, Questions and Hypotheses

The requirement for alignment dictates the researcher engage in a cycle of checking the research model, questions and hypotheses to retain alignment among all three areas.

3.2. Approach

The research uses an a priori approach, in which a theory of learning is explained through its constructs. Ahire and Devaraj (2001) describes a theory as a set of interrelated constructs and propositions that present a systematic view of phenomena by specifying relations (hypotheses) among variables that must be measured indirectly through observable indicators. The constructs enhance understanding of the investigated phenomena; therefore, interest is more in relations between the constructs than the observed variables in theory testing (Ahire and Devaraj, 2001).

Edwards and Bagozzi (2000) refer to this as the second part of the theory, in that constructs specified must be described by the measures.

The literature review presents varied interpretations of the phenomena of learning in organizations supported by authors of professional / industry orientation, academics, and engineering and social sciences. The research approach must therefore consider overlap of meanings. The interaction between variables requires the research to focus on clearly observable phenomena that indicate the type of learning and the approaches (methods) employed through the individual and group to transfer, translate or transform that knowledge.

The research is empirical in nature, or based on observation and interpretation of events or perceived experiences and outcomes. This approach is supported by authors such as. Huber (1991), who pointed out the lack of systematic field studies along with an absence of studies built upon the results of prior works, lack of interaction among researchers from different backgrounds, and the few number of independent investigators. Miner and Mezias (1996) called for more empirical research to help strengthen the bridge to practitioners. Easterby-Smith et al. (2004) compiled a list of what has been considered the most significant contributions to organizational learning in the last 30 years. Their paper (Easterby-Smith, et al., 2004) demonstrated the impact of empirical methods through introduction or addition of theory in four of the eight significant studies mentioned.

The empirical data is to be collected by questionnaire. This method is effective at providing a high quantity of information across the industry on practices. This observation will be indirect, through questions that depend on recounting of recollection by respondents. The target sample of the questionnaires will include a cross-section of the stakeholders at each firm sampled.

3.3 Research Methodology Process

The detailed research methodology process is presented in the following Figure 14.

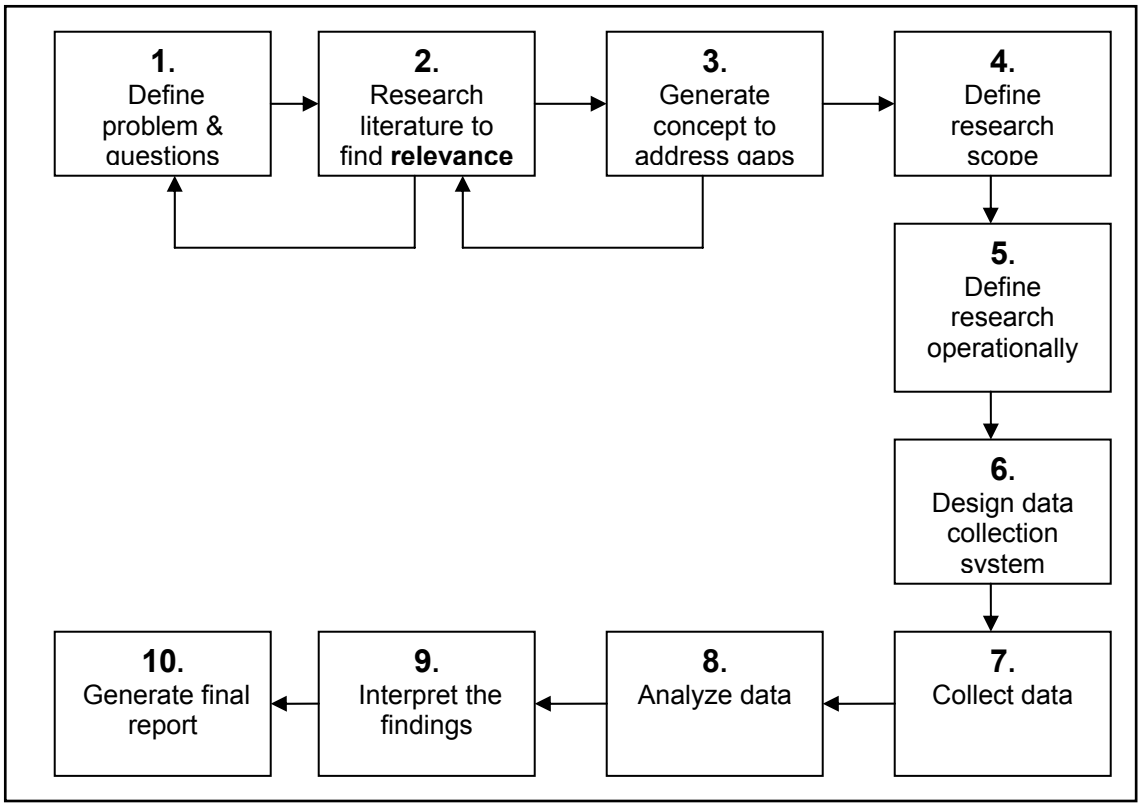

Figure 14: Research Methodology

3.3.1 Define Problem and Question

The objective of this phase is to reveal the questions that arise in response to the problem of improving innovation and improving information flow through learning in AEC organizations. The question is:

How do expertise and group learning contribute together for effective organizational learning?

The question is further refined through the sub-questions and issues that follow.

3.3.2 Research Literature to Find Relevance

Research of the existing bodies of knowledge in learning, knowledge and knowledge management to discover if the problem is understood, if it is unique, and to refine the research question. Synthesis of the knowledge found in literature by combination and comparison is used to uncover meanings not defined in prior research. This process is iterative as new information is discovered, resulting in refinement or a new direction. The gaps uncovered by this research are:

1) Individual expertise and tacit information are important assets. Given the nature of expertise, forms for converting that information through groups are needed (Vick, 2002; Truran, 1998; Carillo and Chinowsky, 2006).
2) Given the nature of the AEC (individual contributors interacting with groups), questions arise as to whether groups can incorporate knowledge from those at their periphery and what knowledge

individuals take from groups (Cross and Sproull, 2004; Carillo and Chinowsky, 2006; Szulanski, 1996).

3) Innovation in AEC units is not as prevalent through external search (Veshosky, 1998), though it is acknowledged that a mix of explorative and exploitive behaviors is important to the health of the organization (March, 1991). Therefore, if a learning "balance" is important, how does this translate to strategies for the individual and group?

3.3.3 Generate Concept to Address Gaps

A conceptual model is developed that reflects what is observed. The conceptual model provides the vehicle through which observation can be made of the behaviors that will either support or show lack of support of the theory. The conceptual model for the research is developed in Chapter 1 and is shown as Figure 3.

3.3.4 Define Research Scope

The research question is defined in terms that can be expressed through the model. The purpose of the phase is to provide a boundary for the research questions to make the effort for the researcher manageable and to create a focus for the research objectives to prevent misalignment between objectives and the research model. The research question is subdivided into the following questions:

1) How do individual actions contribute to organizational learning?

2) *Can internal differentiation and competition between project and non-project learning be overcome by learning strategies?*
3) *Are explorative behaviors important to the AEC?*

3.3.5 Define the Research (Operational) Model

Constructs must be defined for an operational model, as they are identified, through multiple item scales that represent their manifestations in practice (Ahire and Devaraj, 2001). They are translated to observable (measurable) behaviors or methods. The measurement instrument requires accurately described measures for the constructs that describe the concepts. Using the theories presented in the literature, strategies are selected that align to the research questions.

The research model theorizes that as individuals go from exploitive to explorative strategies, they become more aware of the system in which they operate. As groups go from internally driven to externally driven search strategies, they increase the span of their discipline familiarity or go beyond boundaries in search of information. The researcher uses depth and breadth of knowledge in individual learning as a means of expressing degree of expertise. Groups rely on structures to define roles and determine direction of action. The research model is derived in Chapter 2.

3.3.6 Design of Data Collection System

The data collection system must align with the operational definitions of the research model to insure that the data is valid with respect to the constructs. A questionnaire is proposed as the data collection instrument. The questionnaire is made up of constructs further subdivided into variables. Since variables are not observable directly (DeVellis, 2003), questions must be selected that reveal relationships (strength or weakness) indicating the presence of the variable or construct. Interpretations are required of the literature for definitions pertaining to actions that indicate presence of the particular variable or aspect of the construct. Edwards and Bagozzi (2000) present a view of constructs that includes four conditions for establishing causality for a variable associated with a construct. They are:

- Cause and effect between construct and measure must be distinct entities.
- The construct and measure must co-vary.
- Temporal precedence between change in the construct and change in the measure.
- Elimination of rival explanations for the presumed causal relationship.

These conditions will be used in developing items for the questions in the data collection model. The last of these conditions is of special concern in this research given the potential for confusion between learning strategies and tendency for individuals to gravitate between methods.

Tests of scale refinement and validation must be conducted to validate the field study. Ahire and Devaraj (2001) suggest the validity of the instrument must be developed from the following tests:

- Face and Content Validity – Appearance to what is intended and the rigor with which the instrument is developed.
- Criterion Related Validity – The extent to which the instrument predicts a set of criteria of interest.
- Construct Validity – The relationships of measures to their constructs and whether measures are of the same things or different things and consistent.

The initial phase of upholding validity is the development of face and content validity (Ahire and Devaraj, 2001). Face validity is achieved through conduct of a pilot study (Landaeta, 2003) and review by experts. Content validity is brought about by thoroughness of research, relevant literature, use of expert knowledge, and examination of case studies (Ahire and Devaraj, 2001). Criterion related validity, consist of examination of the instrument to see if it appears to measure what is intended to measure (Ahire and Devaraj, 2001). The focus of construct validity is empirical implementation and validation of the instrument and consists of:

- Unidimensionality – the extent to which observed indicators are strongly associated with each other and represent a single concept.
- Reliability – the degree of stability or consistency of a scale, as statistically determined by Cronbach's alpha (Bagozzi and Phillips, 1991).

Since some aspects of validity can be tested only through final analysis of the data collected, it is all the more important to develop face and content validity prior to conducting the full survey.

Ahire and Devaraj (2001) describe the post - refinement validation of the instrument, consisting of nomological validation. Nomological validation consists of verifying that constructs are related to each other in a manner consistent with the theory presented (Peter, 1981). This validation is performed through regression or correlation analyses.

Internal and external validity are revealed through execution of the field study by verifying relationships between variables and the degree to which findings support theory through prediction of future behavior (Nunnally, 1978).

The data collection model is shown in Figure 15. The variables for testing are shown inside their respective construct "boxes". Each oval represents the question numbers (groupings) that will be required to detect each variable. Each strategy is tested by asking four questions related to the explorative / exploitive aspects and research directions of the method. Three questions are proposed for exploitive and three for explorative knowledge outcomes for individual and group models. The intent is to reveal a stronger positive correlation between networking in individuals and innovative knowledge outcomes than using other methods derived from the strategies

coupled to directions. Likewise, group methods involving collaboration with experts outside the group are proposed as having stronger correlation to innovative group knowledge outcomes than with other methods tied to strategy – direction couplings. Finally, tests between individual methods using networking and group collaboration will be conducted to determine if a positive correlation exists that suggests methods for connecting individuals to groups in these formats promotes innovation learning. A total of 44 questions are proposed for individual and group learning and outcomes, with another 10 questions for firm and individual positions that reveal attitudes and capabilities toward learning, as well as demographic information for experience, position, and length of service.

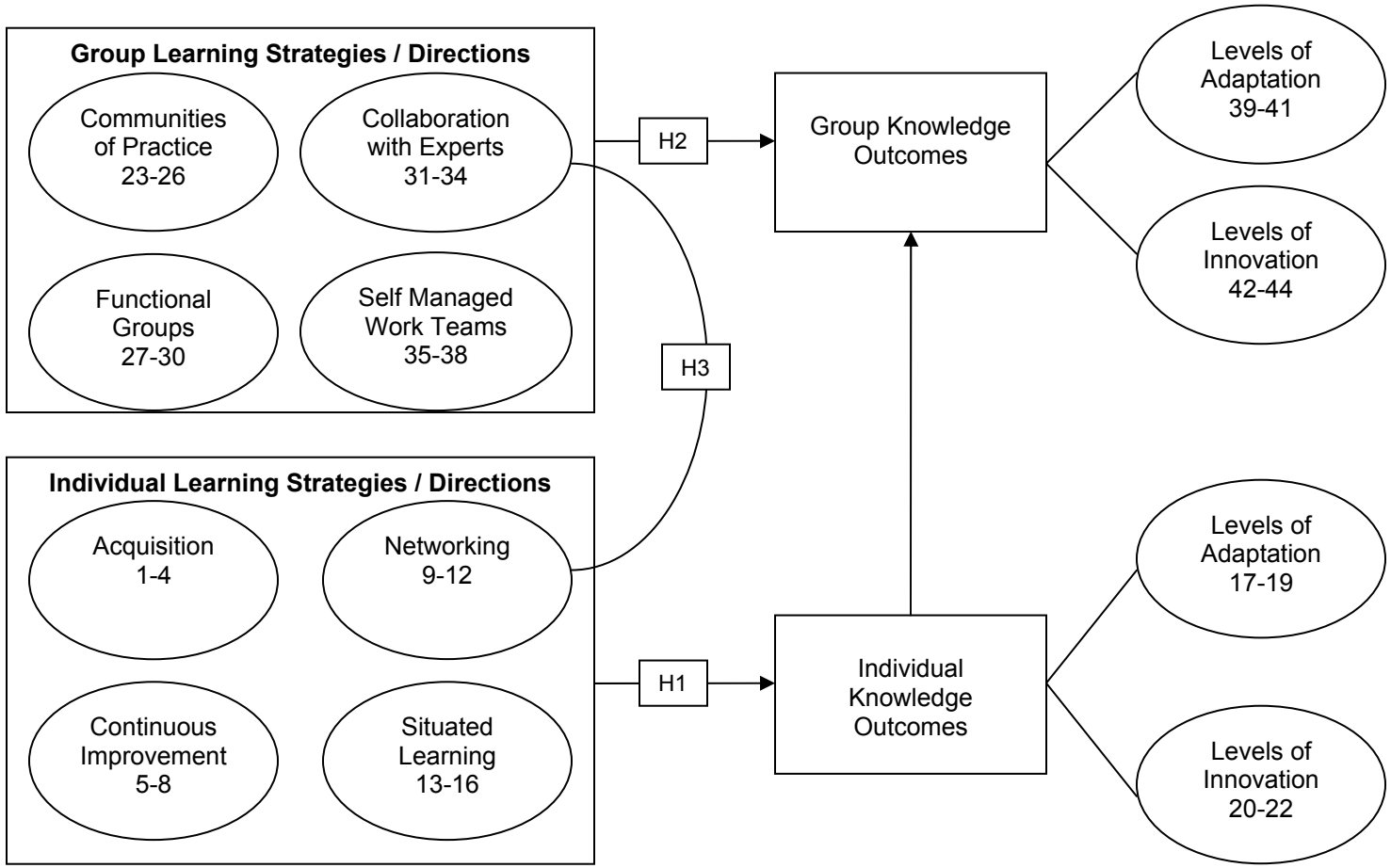

Figure 15 Data Collection Model

3.3.7 Collection of Data

Landaeta (2003) identifies a group of actions designed to provide for checks to insure that the data collection plan is executed in line with the research intent. The map of the data collection process is shown in Figure 16.

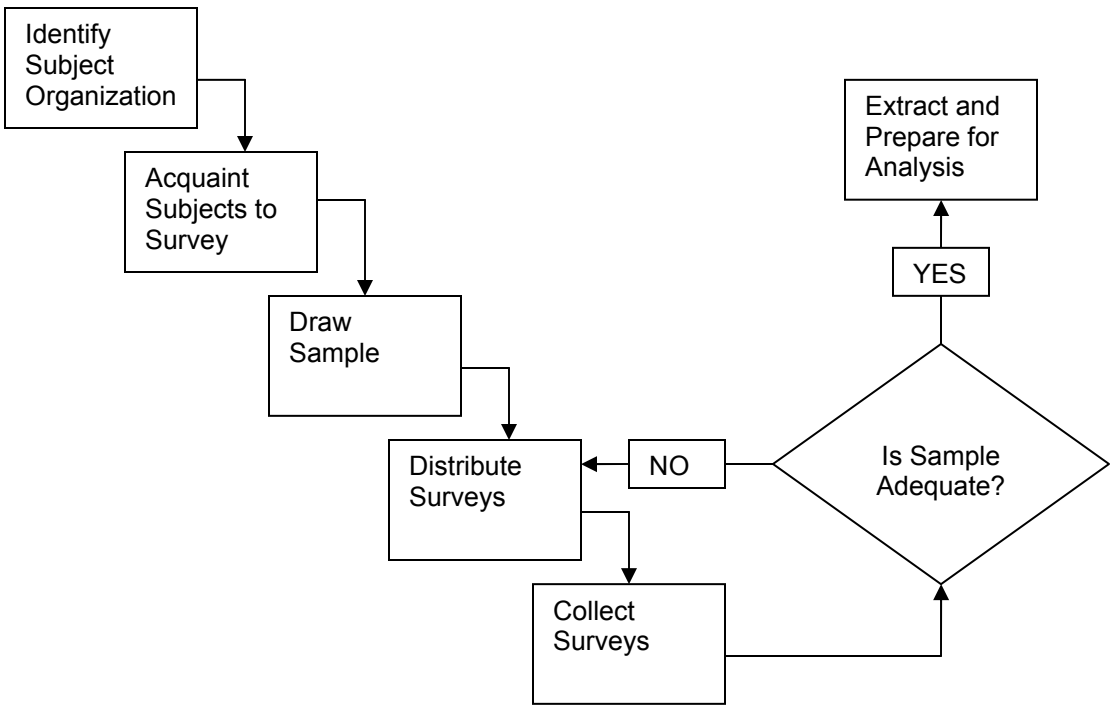

Figure 16. Data Collection Process (after Landaeta, 2003)

Identification of subject organizations for the survey is subject to scrutiny for relevance to the research model, position of the organization and range of activities that are commensurate with the direction of the research. Organizations of interest to this research should include as a part of their operations:

- Project and routine functions operating simultaneously.
- Use of technical subject matter expertise in design and development of projects.
- Employment of individual contributors as well as team structures that may be formal or informal.
- Capability of the organization to participate.

Candidate organizations were selected from member lists of the Florida Engineering Society and the Florida Section - American Society of Civil Engineers. Representatives were asked for permission to participate and if interested, offered a report of the results as a means of reward for participation in the survey. IRB policy requires informed consent prior to commitment for participation and was satisfied before contacting participants. IRB Letter of exemption is in the Appendix of this work.

Individuals selected as respondents are believed to represent a cross section of engineers and designers in architectural and engineering fields that *cross* disciplines. An issue that must be considered is provided by Bogazzi and Phillips (1991), who discuss the use of key informants. They caution that problems that could develop are:

- Being asked to perform judgments in a macro area or make inferences about more comprehensive processes and phenomena, than to what they are accustomed in their position.

- Over or under reporting of certain phenomena, because of length of service, job satisfaction and attitudes.

This issue may be difficult to overcome in that organizations sometimes select those who are considered internally as most suitable as prospective respondents, thereby removing randomness from the process, or increasing reliance on those who may have limited overall experience.

Appropriate sample size has been a topic of discussion by researchers (Nunnally, 1978; Cohen, 1992, Green, 1991, Rashidian, et al., 2006). Sample size for this survey is set using methods derived as rules of thumb that coincide with Cohen's (1988) power effects. Given the number of variables for the models at individual and group levels (4 predictor and 1 dependent), rules of thumb indicate that using an estimate of $N \geq 50+8m$, where $m = 4$, and N = number of respondents or is this case, 82. Cohen's procedure for lambda specifies the number of respondents at 81 by Table 1 in Green (1991). Other authors have used approaches that are more conservative. Based on a factor of 5 times the number of questionnaire items (Burns, et al., 2008), an estimate of approximately 110 respondents would be required for each model (individual and group). Other sources suggest that number of respondents should be set from 10 to 15 per predictor (Rashidian, et al., 2006). Nunnally (1978) suggests 100 for surveys containing 2 to 3 predictor variables. This questionnaire set a goal of 85 completed

samples. The number of surveys received was 79. The number completed and suitable for use is 72.

Surveys are distributed electronically. The growing popularity of on-line surveys is in part due to ease of delivery and mass contact in short time. Surveys are collected and downloaded for data gathering after a requisite time for completion.

A pilot study was required so the research design can be proven through preliminary testing. A pilot scale survey tests the questionnaire's constructs and variables for reliability and face validity and affords an opportunity for feedback from respondents on semantics or clarity. When developing a pilot scale test, considerations have to include:

- Size of the sample.
- Composition of the sample (DeVellis, 2003).

There are no hard standards for size of a pilot test sample. A pilot sample of approximately 10 – 20 respondents was utilized for both four – predictor variable models, representing approximately 15% of the final sample set size. The sample composition for this pilot test consists of individuals engaged in architecture and facilities engineering design and construction or construction management activities who practice in the Southeastern United States. Pilot testing may lead to:

- Unanticipated ideas or areas of focus, or areas needing control.
- Refinement of hypotheses, including the possibility of elimination of some.

- Testing of the adequacy of the statistical and analytical tests.
- Other feedback from the subjects that may lead to further improvements in the research method (Borg and Gall, 1989).

Composition of the sample will have an affect on the representation of the construct under investigation. The first (DeVellis, 2003) is whether a level of a certain attribute is present in the sample versus that of the frame being used. As an example, attitudes toward innovation may be different in older, more established firms than younger, leaner companies. Another issue involves whether relationships among items in the constructs have the same meaning for those in the frame as they do for the pilot sample (DeVellis, 2003). Given the specialized nature and interrelationships through professional societies and trade organizations in the AEC environment, the latter of these two threats will likely not be significant. Ultimately, the goal of the pilot test is to improve the validity of the instrument and reveal any glaring inconsistencies in reliability.

3.3.8 Analyze the Data

The objectives in this phase are to:

1) Assign values to the data collected through appropriate Likert scoring and develop descriptive statistical information that will be useful in describing the sample population and its characteristics.

2) Verify that the factors confirm the relationship and that there is a fit between the model and the data.
3) Validate the constructs to the extent in which the constructs correlate to each other and the theory in a way that is consistent with the theory or prior research (Nunnally, 1978).
4) Perform analysis to infer relationships through correlation among the variables to verify the nomological validity of the model.
5) Develop predictive validity (Nunnally, 1978) through testing of the hypotheses. This includes testing of the average scores of each construct and developing a correlation analysis for the variables using the average factor scores.

The process of analysis of the final sample data is summarized in Figure 17 below.

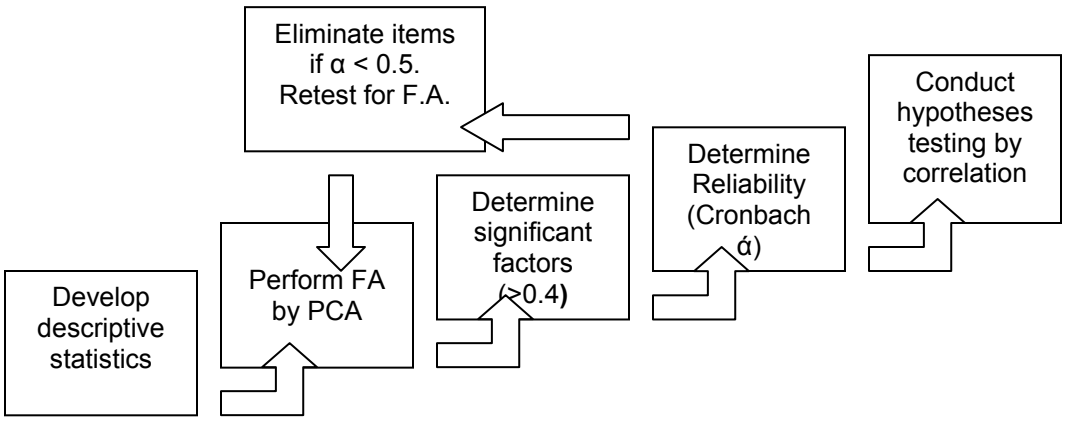

Figure 17. Data Analysis Process

Descriptive statistics consist of sample mean, and standard deviation, values that reveal the sample consistency or if there is a high degree of variation in the sample.

The statistical information also reveals learning tendencies of the organizations' respondents – and the perception the respondents have of learning allowances in their organizations. This is significant to understanding variability in the correlation of learning to knowledge outcomes.

The major source of error within a test is due to sampling of items (Nunnally, 1978). Reliability, through Cronbach's alpha, is used to determine internal consistency. Should alpha prove to be too low, either the test is too short (not enough items to explain the variables) or the items have little in common (Nunnally, 1978). A value of 0.5 for alpha is usually considered acceptable for new, less time proven questions, while a value of 0.7 is considered acceptable for established items (DeVellis, 2003, Nunnally, 1978). The pilot sample will test reliability, while the final survey will test reliability, factor analysis, and then back check reliability, should certain factors drop out of consideration.

Confirmatory factor analysis is the process of correlating factors to variables through factor loadings (Nunnally, 1978). The researcher desires to know (or confirm) what groupings of variables that measure a particular construct and if not, what they do measure or how the variables should be grouped. Confirmatory factor analysis (CFA) is the method of choice owing to the desire to use previously defined measures that describe a variable or construct and the principal components method for factor reduction, through evaluation of individual factor variances contribution toward total

variance. Once completed, certain questions may be dropped from the instrument as not being significant or lack of contribution to the variable or construct. Further confirmation through reliability testing is necessary, as shown in Figure 17, since too few questions will affect reliability.

Testing of hypotheses will use multiple linear regression analysis and correlation. Hypotheses are illustrated in Figure 15 and stated below. Hypotheses will be tested against the probability of rejecting the null hypothesis when it is true ($\alpha = 0.01$):

1) H_1: Evidence for higher positive correlation between networking in individuals and innovation knowledge outcomes than with other individual methods.

   H_0: Insufficient evidence to support the preceding hypothesis.

2) H_2: Evidence for higher positive correlation between collaboration with outside experts by groups for innovation knowledge outcomes, than with other group methods.

   H_0: Insufficient evidence for support of the preceding hypothesis.

3) H_3: Evidence for positive correlation between collaboration with outside experts by groups with networking by individuals for innovation knowledge outcomes.

   H_0: Insufficient evidence for support of the preceding hypothesis.

3.3.9 Interpret the Findings

The following information is expected for the individual and firm , by examination of descriptive statistics:

- Number of individuals completing the survey.
- Longevity of experience, longevity at present firm/total experience, and position.
- The position of the firm as to the support of learning capabilities.

Results of the analysis of the hypotheses are expected to show support or lack of support for the hypotheses. The intended results are to demonstrate a relationship that varies in strength between methods employed by individuals and groups, with results obtained in knowledge outcomes. The theory proposes that as individuals become more "systems" oriented through networking and groups more multi-discipline and outreach oriented, innovation outcomes for each become more evident, than with other strategies.

Should these relationships not be evident, there may be other issues that counter the proposed theory. They may be due to:

- Failure by the researcher in developing a scale between a construct and the measurement used (right theory – wrong measures)
- Reaching an erroneous conclusion about a theory by misinterpretation of results.
- Using a measurement scale that is too short or survey that is too brief.

- Failure to recognize and account for other variables that may have greater effects.
- Correlation of error terms among the variables.
- Results that suggest relationships that are counter to the theory presented (the theory is wrong).

It is necessary to be aware of any problems in evaluation and interpretation of the results so as not to lead to an incorrect conclusion. Care must be exercised in development of the survey and survey strategy. Chapter 4 will present survey development.

3.3.10 Generate Final Report

The objective is to generate a report relevant to the findings against the hypotheses and the research questions. Do the findings support or not support the hypotheses? Were they inconclusive? Is the theory supported, or is there insufficient support? What are the management implications for organizations wishing to improve the expertise of individuals while providing for learning on an organizational scale? How can an AEC office benefit from an innovative behavior over that which is adaptive or does each have its place? The intent is to share the report with experts and participating firms.

Weaknesses in the research and its conclusions are also highlighted, along with suggestions for improvement or refinement. Examination of results of analysis,

coupled with expert opinion and feedback from subjects is useful to this feedback. These are presented in Chapter 5.

Final conclusions are then drawn on the data collection model and its process, the hypotheses, the research model, and ultimately the conceptual model. Suggestions are made for further research in Chapter 6. Prior to publishing the results, steps are taken to insure the document meets the standards of the UCF Office of Graduate Research and electronic thesis and dissertation (ETD) requirements.

CHAPTER 4: SURVEY DEVELOPMENT

4.1 Why a Survey?

This research proposes a written survey or questionnaire that relies on individual recall of individual and group activities and outcomes. Karami, et al. (2006) surveyed 120 articles written for the top twenty management journals between 1991 and 2000, and found that 69% used questionnaire type formats and 38% used interviews for data collection, while 55% used simple random sampling and 28% use stratified random sampling for data gathering. The use of the questionnaire format affirmed its usefulness for providing efficient samples. Grunow (1995) previously found in his research of 300 journal articles, that techniques used for data collection consisted of several methods, but the most frequently employed were personal interviews (57.1%), followed by written questionnaires (51.8%), and document analysis (32.7%). Multiple methods were employed in some studies, as is implied from the above statistical data. Although Grunow (1995) did not come to a specific conclusion as to "best design methodology", he pointed out that concern should not be for methodology as much as for sound development of organizational concepts, theories, their empirical foundation, and relevance to practitioners.

Edmondson and McManus (2007) examined methodological fit in quality of management field research and found that prior work focused on:

- The state of prior knowledge about the subject matter as a determinant of what methodology to pursue.
- Focus on asking the right question and then picking the most powerful method for answering that question, rather than focus on method selection first.
- Distinguishing the purely qualitative from the quantitative, and hybrid designs.
- Using triangulation (multi-methods) when available.

According to the Edmondson and McManus (2007) definitions of state of theory, this research could be noted as mature or intermediate, in that well developed constructs and models are present. However, this research takes existing constructs and applies them to a specific setting by applying strategies (through methods) and directions that result from individual and group decisions. This type of research can be conducted by surveys and questionnaires through taking on a quantitative inquiry direction. They (Edmondson and McManus, 2007) also found that surveys and questionnaires assist in this research direction by testing specific hypotheses developed through logical argument built on prior work. This approach is positivist, through deemphasizing of personal bias or participation by the researcher, for concern of affecting the actual operating state of the subjects being studied (Johnson, et al., 2006).

4.2 Risks and Countermeasures

Risks to the research approach are threefold. First, there is concern that relationships between individuals and groups could be "missed" if there is any psychological discomfort on the part of the subjects (Miner and Mezias, 1996). Second is the possibility that the research fails to build effectively on prior work or "reinvents the wheel". This apparent weakness is addressed by assuring that the questions and thus the hypotheses and instrument devised for testing the hypotheses are unique. Third is lack of reliability and external validity that provides less convincing results that new contributions add to the body of knowledge (Edmondson and McManus, 2007). They cite the possible need for using a hybrid approach in the case of constructs built from diverse literatures. This implies the need for both qualitative and quantitative data collection as would be the case in action research or case study interviews. As diverse as the sources of the literature have been for this research, there has been good agreement on basic principles behind learning theory. Therefore, this risk is viewed as not significant.

External risk exists and is associated with the nature of on-the-job or experiential learning. There is the possibility that respondents may not be cognizant of the processes they use in on-the-job learning. Wording of the questions to allow for measurement of actions and results of learning will have to offer clarity. Berings, et al. (2006) suggest that work also address inter-rater reliability to increase the validity of the instrument by comparing and contrasting ratings of colleagues and managers.

The questionnaire will take into account the role played by respondents through comparison and correlation of respondents' input.

4.3 Item and Scale Development

DeVellis (2003) in his guidelines to scale development divides the subject of data collection into the following questions:

- What is being measured?
- What are the items that describe the variables?
- How are respondent attitudes being addressed?
- What is the format (type of scale)?
- How is expert opinion being furnished?
- Is a pilot test being conducted?
- How are reliability, factor analysis, and validity being addressed?

4.3.1 Items for Measurement

Knowledge building actions, the directions under which they are undertaken, and knowledge outcomes are measured. Measurement is through the generation of methods through strategies and directions. Outcomes are in themselves not readily evident, so questions must ask about actions and knowledge outcomes at individual and group levels that reveal accurate, reliable responses. Explaining the survey purpose and the potential benefits will be beneficial toward garnering answers that are

relevant to the subject as well as eliciting accurate and reliable answers. Using DeVellis' (2003) approach by developing questions from items, and the information from the literature, the following table is constructed, that displays important items or aspects of each value of the variables to be measured. Table 9, below displays these items.

Table 9.Individual Learning Constructs, Variables and Items for Data Collection

Construct	Variables	Method	Item
Individual Learning	Exploitation/ Depth	Continuous improvement, & development of expertise	• Learn by doing • Learn at work pace • Engaging successively higher challenges • Short term goal orientation
	Exploitation/ Breadth	Situated learning by moving between settings	• Moving between settings. • Using of available information. • Idea exchange with those in other settings. • Unexpected nature of challenges.
	Exploration/ Depth	Acquisition by formal learning (training)	• Separation of work and learning • Devoting specific blocks of time • Use of independent research • Longer term goal orientation
	Exploration/ Breadth	Networking with others of differing discipline to draw connections	• Participation in group of diverse disciplines. • Connecting learning to company goals. • Learning "what others know" • Motivation of worth to others in the network
Learning Outcomes	Adaptation		• Satisfaction • Immediate impact to knowledge • Impact to others' knowledge
	Innovation		• Knowledge addressing root cause • Results that change firm's processes • Knowledge generalized to other disciplines

Variables are drawn as methods, resulting from strategy / direction decisions. Strategies are cross-linked with directions; the methods are expressed by the use of four questions that describe each method. Some correlation is expected between variables, however, if hypotheses are correct, there will be measureable differences as determined by outcomes. Table 10 presents learning strategies and directions expressed in terms of single discipline or multiple discipline orientation and internal/external orientation for groups.

Table 10. Group Learning Constructs, Variables and Items for Data Collection

Construct	Variable	Method	Item
Group Learning	Internal / Single discipline	Functional Groups	• Emphasis on improving efficiency • Emphasis on improving effectiveness. • Informal/internal communication • Staying within well define technical boundaries.
	Internal / Multiple Discipline	Self organized work teams	• Sharing experiences and using dialogue to resolve differences. • Use of senior members' knowledge. • Combining of dissimilar knowledge. • Going to others inside the firm.
	External / Single Discipline	Communities of Practice	• Sharing through common interests. • Independence of search means • Focus on many aspects of one subject. for depth. • Members among diverse areas
	External / Multiple Discipline	Multi-discipline teams that collaborate with outside experts	• Focus on resources outside group. • Externalization of knowledge through codifying. • Recognizing relevant, valid expertise • Focus on going outside the firm for expertise.
Learning Outcomes	Adaptation		• Satisfaction • Results that assists in achieving goals • Beneficial impact to the firm
	Innovation		• Impact to the firm's assumptions and goals • New knowledge impact for other groups • Documentation for general consumption by others in the firm

Other questions are necessary to assist in describing the sample population and determining the orientation of the individuals and the firms. Table 11 displays the items to be tested for these aspects.

Table 11. Firm and Individual Orientation Items for Data Collection

Construct	Variable	Item
Learning Orientation of Firm	Position of the Firm	• Support for training and managing risk • Balanced development of new competencies and improving existing ones. • Rewards for individuals who learn. • Reward of groups for collective learning. • Orientation toward change of offerings and processes
Individual Orientation	Experience	• Total length of service • Length of service with firm. • Length of service in position • Fraction of time spent in training and teaching others. • Position title

The items in the preceding tables are proposed as unique measures of the respective variables. However, perhaps not all the possible identifiers of the variable, the items are to be translated to a question that measures relative degree of the effect of that variable.

4.3.2 Respondent Attitudes

Respondent position is addressed through questions about experience and hierarchy in the firm. In this case, questions establish the experience level and position (whether manager or contributor) of the respondents.

The power of recall itself is sometimes questionable. Miller, et al. (1997) examines the issue of recall by key informants. Though power of recall is often poor, research can be more effective if engaging in free reporting. This research requires that respondents provide answers as close to accurate recall as possible. Therefore, specific time based events are not being measured. Miller and his co-authors (1997) also recommend:

- Use multiple informants (respondents).
- Ask about concrete events – not opinions or concepts.
- Do not force recall of the distant past.
- Reinforce motivation by ensuring safety of responses (confidentiality).
- Consider that past strategies, degree of changes, and current profitability all play a part in accuracy of recall.

4.3.3 Scales and Best Management Practices

A five point Likert scale is used for the survey. A scale of five points does two things. First, it provides a measure of variability that enables measurement of differences. Second, it enables respondents to discriminate meaningfully by providing some finite distinction, and enabling neutral responses (DeVellis, 2003). The Likert scale intended for use in this survey resembles the following:

___ (Never) ___ (Rarely) ___ (Sometimes) ___ (Often) ___ (Very Often)

The intent of the scale is to gather data on relative frequency of employment of methods driven by a particular strategy and influenced by a direction (deep to broad in individuals and structures in groups), and impact of learning outcomes. The ability of this scale to effectively measure differences depends on the ability of the respondents to distinguish between the meanings of the responses. DeVellis (2003) suggests a similar scale but cautions that descriptors such as these may have slightly different meanings between respondents. The weakness of this approach is the requirement for closed questions that require the respondent to answer a predetermined set of answers. There may be error involved with understanding, or of what is meant by "sometimes" as opposed to "often". The respondent may also have information that is not part of the answer set. This is why questions of this nature must be very clear in their meaning between respondents. Another tool to assist understanding may consist of an explanation of the scale is to be provided along with the intent of the survey, to assist respondents in providing a response with more consistent understanding.

Further best practices applied to survey development will consist of the following:

- Demographics (organization and individual orientation) are placed at the end of the survey.
- Appearance of the questionnaire should be simple and clean.
- Informing the respondent of the expected length of the survey.
- Underline words that have special significance.

The survey will place the demographic information (based on Table 17) at the back of the questionnaire. The questionnaire will be brief with questions mostly being less than a one line, where possible, for brevity.

4.3.4 Evaluation by Experts

Content validity is improved by having experts review the items related to the questions for relevancy, clarity, and gaps (DeVellis, 2003). Experts may consist of those with knowledge of the subject (OL), experiential learning in technical disciplines, engineers or architects currently or previously engaged in managing groups, those experienced in developing and applying surveys, fellow researchers, and committee members. Panel experts can rate how relevant they think each item is for the variable or construct being examined. Experts may suggest items for removal or addition. Experts can also review for clarity or brevity, and point out awkward sounding or confusing items (DeVellis, 2003). Finally, experts review for potential gaps and suggest additional items or alternative items.

4.4 Pilot Scale Testing

Selection (non-random) was made from a list of individuals that engage in multi-discipline projects and facilities efforts in an engineering, architecture and construction organization. Participants represented a cross section of disciplines and

experience levels. The respondents all work for the same AEC firm but in different technical and project management areas. Stratified sampling was not considered on the basis of position (e.g. management or non-management) owing to the tendency of management and technical subject matter expertise roles being combined, thereby blurring the distinction between management, management of design, and the process of design itself. Furthermore, it would be difficult to estimate with any accuracy, the number of samples to be taken from each stratum (if management and design process were clearly separated) that are in proportion to that stratum.

The results of the pilot survey were analyzed (see Appendix A for Survey) for simple descriptive statistics, internal consistency (Cronbach's alpha), and Pearson's correlation, and participant comments. Fourteen engineers and architects attempted the survey an eleven completed all the questions. Table 12 summarizes descriptive information.

Table 12 Descriptive Statistics, Pilot Study

Variable	Mean	Std. Deviation	Min.	Max.
Total Years of Service	22.36	10.83	2	38
Years of Service at Present Firm	13.07	11.80	1	36
Years in Present Position	5.57	5.98	1	23
% time spent engaging in training and coaching others	16.14	14.92	1	50

Participants consisted of two "principal" engineers, two architects, two senior engineers, four lower tier engineers, and four discipline managers. The principal engineers and one senior engineer provided the surveys with the incomplete data. The

mix of engineers and architects represented six different technical disciplines. There is wide variation in experience level and perception of time spent in teaching and coaching others. This question had the highest variability in replies with exception of time spent in present position.

Results of reliability analysis (internal consistency) and review of correlation between individual questions is shown in Table 13. Analysis was by Minitab v 15©, for multivariate item analysis, which provides data on correlation (Pearson) within each group, average and standard deviation of responses and Cronbach's alpha.

Table 13. Variable Reliability Results for Pilot Test

Construct	Variable	Questions	Cronbach's α
Individual Learning Methods	Acquisition	1-4	0.047
	Cont. Improvement	5-8	0.448
	Networking	9-12	0.716
	Situated Learning	13-16	0.602
Individual Knowledge Outcomes	Adaptation	17-19	0.542
	Innovation	20-22	0.086
Group Learning Methods	CoP groups	23-26	0.673
	Functional Groups	27-30	0.188
	Networks	31-34	0.177
	Self managed teams	35-38	0.561
Group Knowledge Outcomes	Adaptation	39-41	0.805
	Innovation	42-44	0.587

Results of the reliability analysis indicate mixed results on consistency, based on an acceptable scale range of 0.5 to 0.7 (Nunnally, 1978). Unexpected negative or low alphas lead to the recommendations found on Table 14. Modification of the question as the source of low reliability has to consider the following:

- There may be low or even slight negative correlation among some of the variables in a factor, if no negative aspects of what is measured, exist in the factor.
- Examination of the wording (semantics) of the question may reveal potential for misinterpretation that caused the low reliability. Nunnally (1978) refers to this as measurement error.
- Too few factors (questions) do not provide better understanding of the problem, thereby requiring a longer test (Nunnally, 1978).

Table 14.Pilot Test Results: Sources of Internal Inconsistency

Variable	Cronbach's α	Revised α *	Action Taken
Acquisition	0.047	0.666	Modify Q3
Cont. Improvement	0.448	0.52	Modify Q6. This question was skipped by 2 respondents
Networking	0.716	0.727	Q12 semantics need to be clarified. Skipped by 1 respondent.
Ind. K Outcomes - Innovation	0.086	0.763	Modify Q22. Question expresses two concepts.
CoP Groups	0.673	___	Modify Q25 to improve semantics.
Functional Groups	0.188	0.627	Modify Q27.
Collaboration w/ experts	0.177	0.575	Modify Q32. Question expresses two concepts.

* if question is removed

Analysis of alphas suggests removal or revisions to some questions. Removal is not recommended, due to the need for a minimum number of questions to address complexity of the variable. A summary of recommended actions is listed in Table 15. Some questions may have been interpreted originally as conveying a heavily conditionalized idea or more than one idea. This is a challenge to adjust when

applying a set of directions to a set of methods, since respondents may have differing sets of experiences that result in differing interpretations of the same question. The revised questions were used in a second pilot scale test.

Table 15. Revised Survey Questions Resulting from Pilot Study

Q	Pilot Survey	Revised Question
3	I learn new things in my discipline by conducting independent research	I learn new things through consultation of academic and professional journals.
6	I learn at my own work pace	I learn through becoming more specialized in my discipline.
12	I learn new things to increase my value to others in the network as a source	I learn new things to be a valued part of a multidiscipline network
22	My knowledge is documented and available for use by others in the firm	My knowledge has been used to reveal new connections between my discipline and other disciplines to the firm's benefit.
25	We learn many aspects within a single discipline that may not be the domain of one individual	We learn different specializations within our discipline to become known as subject matter experts in the field.
27	We learn by emphasizing efficiency by improving existing processes and tools.	We learn through improving the efficiency of our work processes.
32	We learn by converting or codifying knowledge of others to formal knowledge for others to use	We learn by combining knowledge from all disciplines and placing it in a database for future use.

Other comments were received for the pilot study. One respondent was not certain how to answer Question #2 (*I learn new capabilities by taking time out from regular assignments for classes / training*) as a response to his or her prior experiences as a field engineer. This was the only comment to this question, and the question will remain. Another respondent questioned whether #6 (*I learn at my own work pace*) was an implication that some are 'forced to learn" as a response to environmental pressures, and one other respondent commented to Question #53 as to the technique of facilitating learning by "doing the work with his direct reports" in part to build trust, rather than being more delegating. Question #6 is proposed for replacement to make clearer (see Table 15), and Question #53 has been eliminated as it did not

directly relate to experience and it affected the Cronbach's alpha (0.338 with the question and 0.809 without it) for the variable regarding individual orientation.

A second group, consisting of 12 design and technical management professionals was selected for testing a revised survey. These respondents had not previously participated in the survey. The purpose of the second sample was to test the revisions to the questions to determine effectiveness (see Table 15). Sample characteristics of the second group are shown in Table 16.

Table 16: Second Group Pilot Test Characteristics

Variable	Mean	Std. Deviation	Min.	Max.
Total Years of Service	24.25	11.67	3	45
Years of Service at Present Firm	10.83	8.99	1	22
Years in Present Position	6.08	6.10	1	22

(% Time coaching and teaching was not tested in the second pilot)

Fewer senior staff level practitioners represented the second test group as in the first. However, experience levels in Table 16 are similar to those represented in Table 12. Resulting Cronbach's alpha was computed for each variable and is shown, in comparison with the first pilot test, in Table 17.

Table 17: Comparison of First and Second Test Internal Consistency

Construct	Variable	Questions	Cronbach α First Test	Cronbach α Second Test
Individual Learning Methods	Acquisition	1-4	0.047	0.757
	Cont. Improvement	5-8	0.448	0.143
	Networking	9-12	0.716	0.749
	Situated Learning	13-16	0.602	0.754
Individual Knowledge Outcomes	Adaptation	17-19	0.542	0.736
	Innovation	20-22	0.086	0.871
Group Learning Methods	CoP groups	23-26	0.673	0.558
	Functional Groups	27-30	0.188	0.310
	Networks	31-34	0.177	0.478
	Self managed teams	35-38	0.561	0.0
Group Knowledge Outcomes	Adaptation	39-41	0.805	0.821
	Innovation	42-44	0.587	0.799

Variables for Continuous Improvement, Functional Groups, and Networks variables still displayed weakness. Internal consistency decreased slightly for groups engaged in communities of practice. There are reasons for these results:

1) Differences in experiences between the two sample groups.
2) Clarity of questions to the respondents.
3) The questions do not relate to the variables/constructs as interpreted by the researcher.
4) Size of the sample.

Continuous improvement variable was addressed through clarifying Question 6 by inference that focus on *depth* of specialization as the direction of learning. Question 29 in Functional Groups variable is further clarified by asking if groups are bounded

by functional (e.g. civil, electrical, architectural) classifications, rather than by subject matter itself. The variable for Networks, though somewhat weak, was helped by adding an example to clarify Question 32. Results for the Self-Managed Teams variable were somewhat disappointing, given suitable results in the initial pilot. Question 37 was reworded to define "who" does the translation. Question 38 was also the source of negative correlation. A decision was made to narrow the focus of the question to members in the group itself, which is more in keeping with Nonaka's (1994) theory of learning in self managed teams. Table 18 defines the revised pilot survey and proposed final survey questions that address the possible causes for low alphas, listed above. The questions in Table 18 were used in the final survey instrument.

Table 18: Revised Questions Resulting from Second Test

Q	Pilot Survey (Revised)	Final Revised Question
6	I learn through becoming more specialized in my discipline.	I learn through focusing on my depth of specialization in my subject discipline.
29	We become specialized through staying within well-defined discipline boundaries.	We learn within our respective technical areas by performing our work within functional (organized by discipline) classifications.
32	We learn from combining knowledge from all disciplines and placing it into a database for future use.	No change – added an example to clarify the question's intent (e.g. drafting a new procedure or technical report).
37	We learn by using knowledge we get from each other and translating it for each member's use.	We learn through depending on each member of our group to translate knowledge for each other's use.
38	We learn primarily from others inside the firm	We learn primarily from others inside our group.

CHAPTER 5: DATA COLLECTION AND ANALYSIS

5.1 Introduction

This chapter summarizes the collection, handling, and analysis of the data, along with resulting model and hypothesis testing. Specifically, it is presented as follows:

- Sampling and survey conduct.
- Descriptive statistics.
- Factor analysis and reliability testing.
- Presentation of the revised model.
- Hypothesis testing.
- Expected and unexpected results and possible causes.

The following chapter will discuss implications of the research for practitioners and researchers, along with suggested improvements/approaches that could be made to this research.

5.2 Sampling and Survey Conduct

Sampling was performed by selection of members of the Florida Engineering Society and the American Society of Civil Engineers who are employed in firms engaged in multidisciplinary work either within or in partnership with other firms. Approximately 300 invitations were sent electronically, to members in over 120 firms, along with a link to a website containing the survey. The selection of

participants was guided by the researcher's knowledge or belief of that firm's potential for conducting multidiscipline design and design guidance. The survey remained open for three and a half weeks. Responses from 79 respondents were received. Removal of incomplete or unsuitable responses resulted in 72 responses that were suitable for analysis, somewhat below the objective (81 responses) that are recommended by Green (1991), but well above the number of independent variables plus 51, which is also used as a rule of thumb. Analysis was conducted using Minitab 15©.

5.3 Descriptive Statistics

Thru positions of the respondents were well distributed between less experienced and more senior engineers and architects. There were a higher number than expected executive level respondents. Entry level and less advanced staff made up 36.7% of the sample, while senior staff, project, or manager level made up 42.7%, and executives made up 20.6% of the sample. Table 19 displays the results of responses relative to experience, experience at the present firm, and experience in present position.

Table 19: Experience of Respondents (% responding)

Category (years)	1-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	20+ yrs	Median yrs	SD yrs
Total Experience	15.9	10.2	14.5	18.8	40.6	16-20	7.5
Longevity @ Present Firm	37.1	12.9	21.5	11.4	17.1	6- 15	7.5
Longevity @ Present Position	55.7	17.1	14.4	2.8	10.0	1- 5	5

The relative number of respondents who have been at the same firm or at their present position is indicative that there is recent mobility among participants in these firms, relative to experience. Likewise, positions reflect that there may be more recent changes in job description or are the result of other adjustments or recruitment.

5.4 Factor Analysis and Reliability

Chapter 3 provides an overview of how construct validity is developed. This section describes the results of testing for this validity through strength and grouping of factors, along with the resulting reliability. Factor analysis of each construct was performed by methods of extraction of principal components. Upon examination of the components, the initial number of factors was selected by examining eignevalues for relative weight of variability carried by the model. Factors with eigenvalues with values of one or less were eliminated from further review. An iterative process was adopted by testing the items (questions) in each factor that had loadings that appeared significant and eliminating those that either had no loadings that were significant (absolute value >0.4) or failed to correlate to a Cronbach's alpha of 0.5 or greater with the other items to which that item displayed apparent significance. The process also examined the degree for variability being carried by the model with intent to create as parsimonious a model as possible with the data. As a result, 4 questions in individual learning construct and 3 questions in the group learning construct were dropped. Two questions in the group learning outcomes were also eliminated due to inadequate reliability. The variables for "continuous improvement" in the individual

learning construct and "levels of adaptation" in the group learning outcomes construct were found not viable. Some of the questions that were eliminated were previously identified in the pilot study as problematic but had been revised for the final survey. However, two of the questions noted for improvement by the pilot study (Table 18) proved reliable for inclusion.

Unrotated factor analysis revealed factor loadings across rows and in columns that suggest multicollinearity. Nunnally (1978) suggests a procedure to condense the model prior then conducting rotation by one or methods to distinguish factors specific to variables (one question to one factor). Upon elimination of questions that did not load significantly, factor rotation by equimax method was utilized on individual and group learning constructs to clarify the factors, where loadings occurred across rows and down columns. The construct for individual learning outcomes was rotated by varimax method to overcome negative loadings. This resulted in well-defined structures that allowed weights to be identified and used with the raw data used in the hypothesis testing. The results of the factor analysis are shown in Table 20. Factor loadings for the rotated factors are sufficiently above 0.4. Cronbach alpha values are also above the minimum of 0.5, though two variables (situatedness and collaboration with experts) are low at 0.548 and 0.510, respectively.

Table 20: Results of Factor Analysis

Construct	Factor # & Name	Queston #	Avg. Factor Loading	Factor α	% Var.	Normality IQR/SD
Individual Learning	1 – Networking	7, 9 – 13	0.631	0.768	52.4	1.243
	2 – Situatedness	14 – 16	0.709	0.548		1.150
	3 – Acquisition	1 – 3	0.704	0.603		1.479
Individual Learning Outcomes	1 – Innovations	19 – 22	0.782	0.811	67.8	1.245
	2 – Adaptation	17 – 18	0.824	0.609		0.935
Group Learning Methods	1 – Internally Oriented	27, 28, 30, 35, 36	0.674	0.767	52.3	1.12
	2 – CoPs	23, 25, 26, 29, 37	0.616	0.689		1.483
	3 – External Collaboration	31, 33, 34	0.653	0.510		1.085
Group Learning Outcomes	1 – Innovations	41 – 44	0.736	0745	64.6	1.347

Variance carried by the factored model is shown in Table 20. The amount of variance carried by the factored constructs is indicative that the questions did not reveal as much knowledge about the variability as was expected.

Since hypothesis testing is a part of this research, a test for Normality of the data was necessary. Normality test used the weighted data to develop interquartile ranges, that when divided by the standard deviation of that variable, should be "approximately equal" to 1.3 (Mendenhall and Sincich, 1995). These results are also shown in Table 20. Generally, the data is suitable for hypothesis testing.

The resulting factors are aligned in general, to the original developed constructs in terms of questions. However, some variables either "dropped out", or were realigned with other variables, another indication of how development of multicollinearity resulted from items that can describe two separate variables. As a result, variables for continuous improvement, under individual learning and that for functional groups and self-managed work groups under group learning did not emerge as expected. Items under continuous improvement loaded either to the variable defined for networking or did not load significantly.

An exploration of the items and their associations presents a slightly altered pattern in which two new variables emerge from the combining of three variables in the original model. Items for functional groups loaded to a new category named "internal orientation", as it describes functional group behavior to some degree, but also focuses on internal group communication and use of institutional knowledge that might be expected in self-managed work groups. These methods reflect behaviors that are directed toward organizational processes. Discipline specific approaches loaded to the variable representing communities of practice. Tables 21 and 22 further display the alignments. Table 21 displays the alignment of items relative to pre and post analysis of the survey for individuals, while Table 22 displays those for group learning and outcomes.

Table 21: Definitions of Individual Learning Variables by Alignment of Survey Item

Pre – Analysis Individuals	Post Analysis Individuals
Acquisition Methods • Learns primarily by classes / training • Takes time out between assignments • Consults with academic / prof. journals • Long term goal orientation	**Acquisition Methods** • Learns primarily by classes / training • Takes time out between assignments • Consults with academic / prof. journals
Continuous Improvement • Learning through regular work process • Focus on improving depth of knowledge • Takes on progressively more challenging work • Short term goal orientation	**Continuous Improvement** (Not verified)
Networking • Participation in multidiscipline network • Connection to company goals • Values others' knowledge and adds value • Learns through interaction with those in network	**Networking** • Takes on progressively more challenging work • Participation in multidiscipline network • Connection to company goals • Values others' knowledge and adds value • Learns through interaction with those in network • Exchanges ideas with colleagues in field
Situatedness • Exchanges ideas with colleagues in field • Learns through unexpected situations • Moves between settings • Gathers data relevant to the situation	**Situatedness** • Learns through unexpected situations • Moves between settings • Gathers data relevant to the situation
Outcomes • Self satisfaction • Impact to immediate assignments • Recognition as source of knowledge • Usefulness in determination of causation • Usefulness in redefining 'what or how" • Usefulness in connecting to other disciplines	**Outcomes** • Self satisfaction • Impact to immediate assignments • Recognition as source of knowledge • Usefulness in determination of causation • Usefulness in redefining 'what or how" • Usefulness in connecting to other disciplines

Table 22: Definition of Group Learning Variables by Alignment of Survey Items

Pre – Analysis Groups	Post Analysis Groups
Functional Groups • Increasing efficiencies of work • Increasing effectiveness of solutions • Informal communications • Functional classification (single discipline)	**Internal Orientation** • Increasing efficiencies of work • Increasing effectiveness of solutions • Informal communications • Use of meetings and constant dialogue • Use of senior members' institutional knowledge
Community of Practice • Common interest in subject matter • Small group or individual independent research • Specialization for group expertise • Distributed membership among teams	**Community of Practice** • Common interest in subject matter • Specialization for group expertise • Distributed membership among teams • Functional classification • Dependence on each member to translate their knowledge
Collaboration with Experts • Drawing on resources outside group • Combining knowledge into explicit form • Learns new connections to others based on expertise • Drawing on resources outside firm	**Collaboration with Experts** • Drawing on resources outside group • Learns new connections to others based on expertise • Drawing on resources outside firm
Self-Managed Work Groups • Use of meetings and constant dialogue • Use of senior members' institutional knowledge • Dependence on each member to translate their knowledge • Learning through others inside the group	**Self-Managed Work Groups** (items realigned to internal orientation and CoPs)
Outcomes • Group satisfaction • Impact to immediate assignments • Usefulness of group's knowledge to others in firm • Usefulness towards reexamining goals and assumptions • Transferability and translation of knowledge to others • Explicit knowledge used to change process or procedures	**Outcomes** • Usefulness of group's knowledge to others in firm • Usefulness towards reexamining goals and assumptions • Transferability and translation of knowledge to others • Explicit knowledge used to change process or procedures

5.5 Presentation of the Revised Model

A revised version of the research model can be developed, using the factored variables. The model does not have the ability to test for adaptive as opposed to innovative knowledge in groups. The revised variables for communities of practice and, what is identified as internal orientation, appear to take on slightly different meanings. Internal orientation contains elements, including improving efficiencies and effectiveness, use of informal as well as formal communication and dependence on institutional knowledge. This suggests use of exploitive methods. Communities of practice carry the same traits as defined in the original model, with exception of exclusion of independent research, inclusion of a functional classification, and dependence on individual members to make their knowledge understandable for others to follow. These attributes seem to describe an emphasis on subject matter and applying that subject matter to groups through distribution of the membership. The revised model is shown in Figure 18.

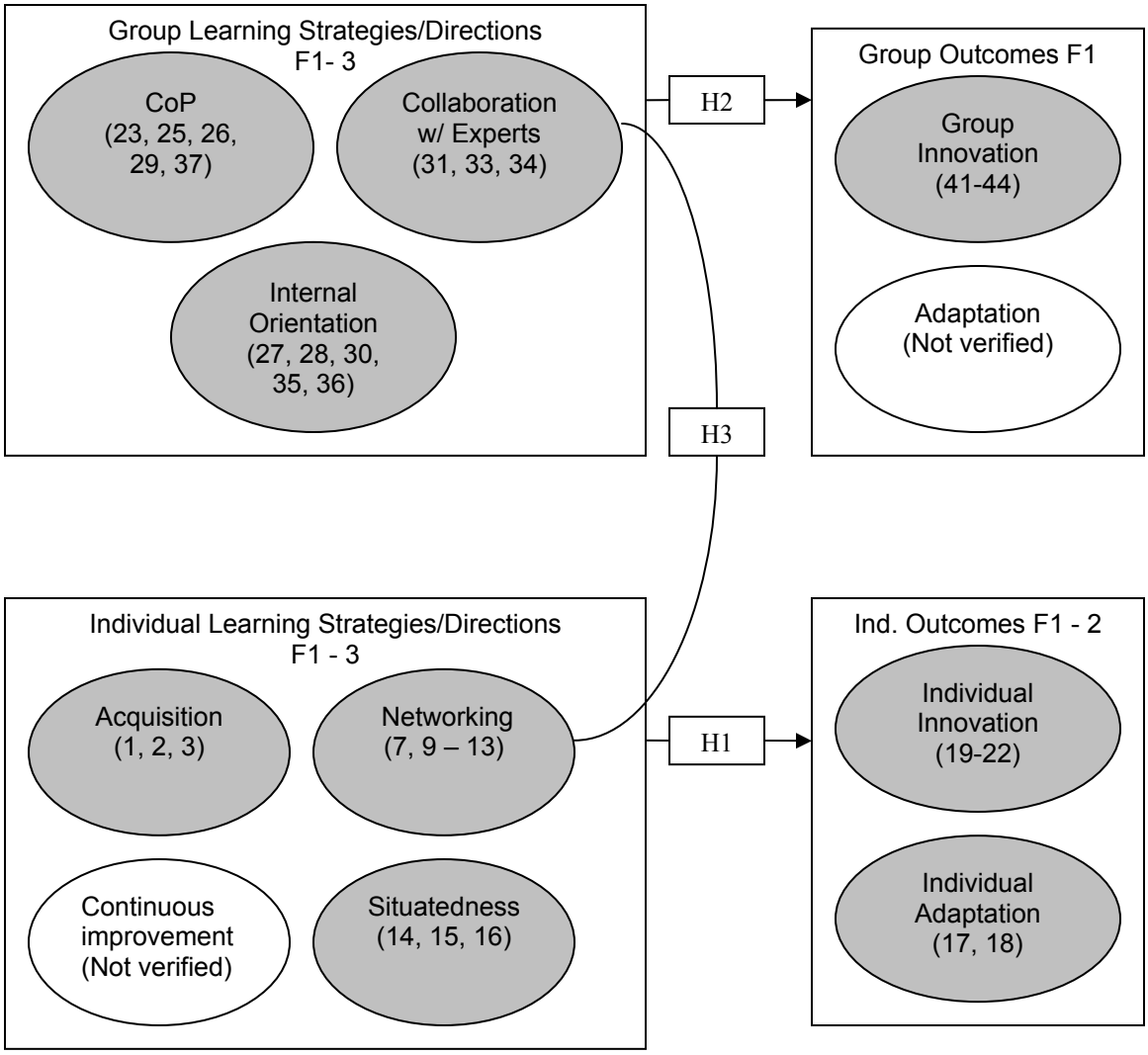

Figure 18: Revised Research Model

The question of how well construct validity is served should be examined with respect to the revised model. Learning outcomes are generally in line with the original model as envisioned. However, the absence of a reliable variable for group adaptive knowledge raises a question as to the true "innovativeness" of group higher order

learning. Either the items selected to measure adaptive learning were not the correct ones (Questions 39 – 41), or respondents may have interpreted the higher order learning selections in terms of experiences that were more adaptive. Lack of reliability of the adaptive group outcomes variable is likely attributable to a wider range of responses between "Sometimes" and "Often" in the responses for group adaptive outcomes. This may reflect more uncertainty by individual members, of outcomes in their projects. Alignment of items in learning strategies for groups appears to have reorganized not so much to internal v. externally driven behaviors or single v. multidiscipline behaviors, but to methods that lean toward assignment success as opposed to behaviors that promote technical specialization. Collaboration with outside experts was less evident.

5.6 Hypothesis Tests

Hypothesis tests were carried out by using Pearson's correlation, which can indicate the strength of a relationship, but does not indicate that the relationship by causality does indeed exist. The relation must also be assumed as linear. Multiple regression analysis was not utilized due to the suspicion that dependent variables were correlated with each other. This was confirmed during hypothesis testing.

5.6.1 Hypothesis 1

The first hypothesis explores the relationship between learning strategies and outcomes for individuals. It states, *Individual learning methods employing greater frequency of networking are more positively correlated to innovative outcomes than*

other methods. A Pearson correlation analysis found that evidence does support the contention that networking strategies do correlate more strongly at the alpha level of 0.01. Results are included in Table 23.

5.6.2 Hypothesis 2

The second hypothesis states that, *group learning methods employing greater frequency of collaboration with experts beyond group boundaries are more positively correlated to innovative outcomes than other methods*. Evidence does not support this hypothesis, as correlation for the variable was not significant at $\alpha = 0.01$ or 0.05. However, the correlation was significant at $\alpha = 0.01$ for both internal orientation and community of practice strategies. Further testing of these two variables found correlation between the two variables at 0.419 with $p = 0.000$. This was evidence that the two independent variables were also correlated. A second significance test was conducted using the expression:

$$t = (r_{xy} - r_{zy}) * \sqrt{[\{(n - 3)(1 + r_{xz})\} / \{2(1 - r_{xy}^2 - r_{xz}^2 - r_{zy}^2 + 2r_{xy} * r_{xz} * r_{zy})\}]}$$

where t is the student's t statistic, and r_{xy}, r_{zy}, and r_{xz} are the correlation coefficients for the two dependent variables to the independent variable and that between the two dependent variables respectively (Blalock, 1972). The value was tested against that for the critical value for $\alpha = 0.01$, and was found not significant. Therefore, no conclusion is made concerning whether internal orientation or communities of

practice strategies have a stronger correlation to group outcomes. Results are shown in Table 23.

5.6.3 Hypothesis 3

The third hypothesis states, *there is a positive correlation between individuals who employ networking and groups that use collaboration with experts beyond their boundaries*. There was no evidence for support of this hypothesis. Both internal orientation and communities of practice strategies correlated to networking more strongly (at $\alpha = 0.01$), while collaboration with experts correlates weakly at $\alpha = 0.10$. Computed correlation coefficient for CoPs was slightly higher than that for internal orientation. Student's T tests again provided no evidence that one strategy was more closely correlated to networking than another. Results are shown in the following Table 23.

Table 23: Results of Hypothesis Testing

Hypothesis	Independent Variable	Dependent Variable	Pearson r	P value	T	Conclusion
H1	Networking	Individual Innovative Outcomes	0.345	.003	3.075	Reject Ho
	Situatedness		0.200	0,091	--	--
	Acquisition		-0.015	0.904	--	--
H2	Internally oriented (IO)	Group Outcomes	0.502	0.000	4.856	t = 0.5765 < CV, No evidence for difference
	Community of Practice (CoP)		0.404	0.000	3.695	
	Collaboration with Experts		0.228	0.054	--	--
H3	Networking : Collab. w/ experts		0.219	0.065	--	--
	Networking : Internal Orientation		0.367	0.002	3.301	t = 0.0703 < CV, No evidence for difference
	Networking : CoPs		0.431	0.000	3.996	

Critical Value (CV) = 2.385 for $\alpha = 0.01$

5.7 Expected and Unexpected Results and Possible Causes

Although the survey was able to distinguish a predominant individual learning behavior, it was unable to distinguish strategies to the degree that analysis could yield significant results for connections between individual and group strategies. It was also unable to determine the most strongly correlated group strategy to group learning outcomes, though it did reveal dominant approaches. The results for individual learning confirmed that the apparent predominant method among individuals is networking. The results for acquisition were somewhat disconcerting, meaning possibly that individuals seek explicit information through formal means the least often or simply that acquisition at the individual level is the least correlated to outcomes. As mentioned in Chapter 2, learning disabilities will affect perception of causality as well as other aspects of the knowledge.

Group results, while unexpected, are not entirely surprising. The power of an individual's recall of group level activities may not be as strong as that for an individual's own experience. There are aspects of complex assignments for which a single person may not grasp all the elements. The emergence of the two dominant factors representing internal orientation and communities of practice may provide a clue at how groups accommodate the two knowledge types or "brands" in an AEC (knowledge for success and technical expertise).

Sections 3.3, 4.2. in addition, 4.3 discuss risks and problems that can affect the outcome of the research. The problems and issues experienced in this research can be summarized in terms of format of the methodology and the questions themselves. The following list provides a summary of issues, criticisms and suggested alternative approaches to resolving issues that arose in the research:

- As mentioned previously, recall for group outcomes is likely to be less accurate or incomplete. Cross referencing with interviews or group surveys may have provided more accuracy for group outcomes, such as the hybrid approach suggested by Edmondson and McManus (2007).
- Measurement scale (frequencies of use – Section 4.3.3) was too short or otherwise not able to distinguish differences in frequencies of behavior. A seven point scle may have been better able to distinguish differences. A forced ranking may have been more effective at eliciting responses concerning relative frequency of use of one method over another, but carries more risk of introducing a bias.
- Chapter 2 mentions that enablers and disablers would not be the subject of direct inquiry, though they were used to define directions taken in some of the questions. This does not appear to be a positive direction in question development. Such is the case of questions 4 and 8 in the survey instrument that attempt to distinguish characteristics of short term as opposed to long term learning strategies in exploitive and explorative approaches. Questions should be directed at the methods themselves, *not* to motivation or intent.

- Questions in several instances, loaded across variables, causing cross correlation that proved difficult to overcome for hypothesis testing. The non-exclusive aspects of these methods were the likely issue. Focus should have been on selecting exclusive items rather than just on items that may be easily recognizable for any one method or strategy. Developing an interrelationship diagram for items may have been more effective at identifying potential correlation.
- The number of questions may have been too few. This resulted in loss of a variable (group adaptation) that was necessary for comparing adaptive to innovative learning.
- There is a question as to whether frequency of use of a particular method is the desired indicator of effectiveness of learning methods. This assumes that the more often something works, the more often it is used. However, the literature (Cyert and March, 1963, 1992) describes innovative learning as being more distant and sometimes uncertain. This could imply that some learning strategies may be less frequent, but potentially more impactful, especially in change management. This leads to the possibility that the wrong tools (questions) were used to discover these relationships or respondents were not cognizant of causality in their own learning strategies. Berings (2006) suggests using comparison and contrast of responses from differing experience or position levels to address inter-rater reliability.

- The amount of variability carried in the factored variables was low (see Table 20). It is apparent that more variability exists than is explained by the model. This leads to a question of whether the right questions were asked or if other elements not considered in the model held greater influence. Enablers and disablers may offer a clue into what strategies may or may not be more effective.

5.8 Other Findings

Other results were received from questions regarding respondents' perception of the organization's provisions for learning (Questions 45 – 49). All questions loaded to a single factor that was tested as a variable against both individual and group learning strategies to determine if a relationship may exist between these perceptions and frequency of strategies. Table 24 displays these results.

Table 24: Correlation of Perceived Learning at Firm to Strategies / Outcomes

Variable	Variable	Pearson r	P	T *	Conclusion
Perception of Learning in the Firm	Networking	0.241	0.044	2.077	No evidence
	Situatedness	0.183	0.130	1.557	No evidence
	Acquisition	0.344	0.004	3.113	Significantly correlated to perception of learning at firm
	CoPs	0.106	0.381	0.892	No evidence
	Internal Orientation	0.216	0.072	1.851	No evidence
	Collaboration with Experts	0.228	0.058	1.959	No evidence

* CV for significance = 2.385 ($\alpha = 0.01$)

The results provide evidence that a weak correlation exists between attitudes toward how learning issupported at the firm, and frequency of use of strategies. Interestingly, acquisition by individuals did not test to the significance levels of the other two individual learning strategies. Experience, which is an indicator of differences between respondents, did not show significant ($\alpha = 0.10$) correlation to the learning methods.

CHAPTER 6: CONCLUSIONS

6.1 Content

These conclusions examine impacts to the following items:

- Research Questions.
- Research Objectives.
- Implications for Practitioners.
- Implications for Academic Research.
- Conclusion.

6.2 Research Questions Conclusion

The original research question is,

"How do expertise and group learning contribute together for effective organizational learning in an AEC?"

The sub-questions that arise are:

1. *How do individual actions contribute to organizational learning and performance?*

Organizational learning starts with the individual. The research confirmed that experiential learning in an AEC is apparently influenced by networking and that individuals look for opportunities through specialization through common interest or linking themselves to company goals and objectives through participation. These

groups provide a forum for exchange and communication that is affected more by reliance on internal resources than external.

2. *Can internal differentiation and competition between project and non-project learning be overcome by learning strategies?*

The research did not fully define the exact processes by which project (groups) and non-project (individuals) differences can be overcome. Networking is apparently tied to either use of communities of practice that share domain specific knowledge and a distributed membership, or through groups that are focused on how to be successful in the firm (presumably through gains in performance) and rely on institutional knowledge. Strategies that emphasize collaboration with outside experts are not as prevalent. How these two former lines of approach are reconciled should be investigated further.

3. *Are explorative behaviors important to the AEC?*

The research indicates through the redefined variables in individual and group learning strategies, that explorative approaches are more prevalent at individual levels. This runs counter to the literature that promotes collective innovation. Learning outcomes as measured in this research could not fully discern adaptive from innovative learning at the group level, so differences could not be measured. Differences between adaptive and innovative outcomes at the individual level were found not significant. However, the apparent correlation of networking (individuals)

to communities of practice or internally oriented strategies (groups) is an indicator of how innovation may be transmitted by way of domain specific forums or those emphasizing a mix of informal and formal dialogue and communication, and that externally oriented in strategies in AEC firms are not prevalent.

6.3 Research Objectives Conclusions

The research objectives were as follows:

1. *Develop a conceptual model of how actions by individuals and groups lead to learning.*

A conceptual model was based on a comprehensive learning model of individuals, groups and the organization itself. The model was revised to provide focus on individual and group contributions through specific strategies and directions to overall learning.

2. *Translate to a research model using known definitions and concepts in the literature.*

The research model used known concepts from several areas of literature in knowledge management, organizational leaning, and experiences of previous studies in AEC behavior. The model was simplified to enable collection of data on strategies and directions only, although enablers and disablers are known to exist and affect organizational learning. The interest of the researcher was to investigate the interaction of individual strategies and directions with those of groups in promoting innovative knowledge through the individual / group structure.

3. *Test the model by conducting a survey that demonstrates support of lack of support for hypotheses derived from the questions and based on understanding of the literature and developed ideas of the phenomena.*

The model was tested by a survey that found only partial evidence for support of the theory of how individuals and groups interact through various strategies. Questions did not separate the strategies to the degree required to define the pathways most frequently taken to develop innovative knowledge. However, tests of hypotheses were able to provide guidance and additional information on possible future directions for research.

4. *Analyze the results and develop recommendations for professional application and academic research.*

Results of the research have led to lessons learned in survey development, recommendations for the engineering manager and recommendations for future academic study. Lessons learned in survey development are presented in Section 5.7.

6.4 Implications for Practitioners

An underlying reason for this research is to address a perceived issue, namely performance related to learning at AEC firms. In Chapter 1, issues with fragmented learning, sub-optimization of design, and errors in causality were presented as resulting from learning "disabilities" or failure to recognize learning. The findings that follow serve to create an awareness of how these issues and steps taken to mitigate them:

- Individuals in an AEC operate through networking or situated strategies more than acquisition strategies. However, acquisition is more strongly correlated to the perceived learning support of the firm than other methods. Assuming a causal relationship with outcomes, firms should re-examine learning programs to determine the relevance of their formal methods.
- Networking by individuals is more strongly correlated to internally oriented group behaviors and communities of practice, but differences in those correlations could not be distinguished in this research. Individual strategies indicate a tendency toward exploration or "combining knowledge" with others. Groups tend to look to themselves for knowledge, which is the "combination" to which Nonaka (1994) refers in the knowledge spiral. An example of an organization taking advantage of this would be the establishment of informal CoPs to promote networking and providing the necessary sustainment for them (Brown and Duguid, 1991).
- Evidence was shown for higher correlation of internally oriented group behaviors and behaviors that use a distributed membership and specialize, to learning outcomes. Differences between the two correlations of these strategies to outcomes could not be distinguished. The absence of a dominant strategy to engage in collaboration with external experts and the use of institutional knowledge is indicative of the tendency of AECs to "keep information inside". Another possible outcome of this finding is evidence for a "dual strategy", or balance that technical professionals must maintain for knowledge of success in the firm (internally oriented) and technical competence (CoP). Firms should be

aware of this duality in their training and succession planning (members as institutional knowledge banks). Consideration must be given for "passing along" of knowledge through explicit (written) means.

- The nature of the business to resist external collaboration may explain low results for collaboration with outside experts in groups. The environment is highly competitive. However, renewal of knowledge stocks may be accomplished by other means, suc as professional society participation and inter-organizational forums.

6.5 Implications for Academic Research

One of the difficulties for those immersed in research is the recognition of peripheral issues during execution of a defined program, which provide potentially equal and rich areas for additional research and discovery. The subject of organizational learning and knowledge management is no different. Implications for additional study should include the following areas:

- Tendencies for learning "what is needed" were evident through responses to questions, though learning outcomes for innovation were significant. This could be the result of mislabeling the questions by the researcher or lack of recognition on the part of the respondent. Additional research is needed on the subject of what constitutes adaptation and innovation in AEC firms, especially firms that must operate across client disciplines ranging from private developers to institutions to governmental entities.

- Acquisition in this study was limited to more traditional and limited sources. The rising prominence of "webinars" and electronic forms of formal learning should also be included in any investigation into effectiveness of acquisition.
- Given the "dual nature" of learning strategies for individuals through CoPs or internally oriented groups, the attributes for each strategy need further decoding. Study of knowledge brands, with a focus on the "generalist" as opposed to the "specialist" nature of each, may reveal more knowledge about reative dominance of each type. A research model based on knowledge brands and learning strategies may provide more insight.
- Do competition, costs, and resource constraints prevent distribution of "subject matter experts" into truly matrixed groups?
- Future study should examine learning at the organizational level and performance outcomes themselves. Innovation may be getting into groups, but are groups doing anything with it? Does the group filter it and how?
- Does a set of effective learning outcomes depend on frequency of use? This study assumes that frequency of use is the correct form. However, in innovative learning, where results are less immediate and potentially interruptive, frequency of use may not be a prevalent characteristic. Linear relationships may also give way to learning curves, making linear correlation a less likely tool for comparison.

6.6 Conclusion

Miller and Salkind (2002) ask a series of questions (Section 2.8) that are answered in the previous research questions and objectives statements. The remaining questions are whether the research can lead to contribution to methodology by discovery or refinement of practical tools, and how integration of the study can be integrated into a planned program that produces results more meaningful than those prior. First, an explanation is offered of how the research contributes to the body of knowledge in knowledge management.

The contribution of the research to the body of knowledge in knowledge management can be summarized in three ways. First, the research demonstrates dominance of methods that vary according to type of knowledge (content) likely to be shared. Second, the dominant types of strategies employed, are identified according to relative frequency with learning outcomes. This enables us to strengthen those pathways and further investigate why other methods are not as frequently employed or not associated as strongly with outcomes. Third, the research identifies carriers of the knowledge within AEC firms as its own members and more senior staff, to the neglect (benign or otherwise) of outside experts, whether from outside the group or outside the firm. This is a potential gap in learning that needs to be addressed by learning within the organization itself, whether between departments, project teams, or operating divisions.

Expectations are that while the study did not contribute any new tools to research methodology, it did confirm the validity of the present tools in guiding and providing a reliable platform for scientific inquiry. Item and question development is one area in which suggestions are made for refinement of tools. Support is also provided for the process of factor analysis as confirmatory in the sense that preconceived theory is upheld,and exploratory in the sense that that some "sense-making" is necessary to describe an unexpected or unpredicted result that helps to explain the complexity of the system being studied.

The use of prior research in the literature enabled further investigation into interaction of individuals and groups in organizational learning. While no one dominant group strategy was identified, results have narrowed the field to a pair of strategies that also may suggest a link to the knowledge brands they represent, namely that for organizational success and that encompassing technical expertise.

Finally, future application to academics is evident through the questions that arise from the research itself. What defines adaptation and innovation in an AEC environment? And where should be it fostered - among individual participants, or among groups? The variables that developed from the survey suggest more innovative behavior among individuals than groups, but should this be the case? Or is more research needed (using differing methodologies) when investigating group behaviors?

The usefulness the study as a work that can be integrated into a larger body of work is partly dependent on its repeatability, dissemination and communication by the researcher. It also rests upon those who are inspired to carry the work or some portion of it through future studies listed above, or in combination with other related topics. Its potential usefulness to practitioners is heavily dependent on its perceived relevance and dissemination into the profession in general.

APPENDIX A: PILOT SAMPLE & FINAL SURVEY

Pilot Survey for Learning in the AEC.

Please answer the following questions, as you perceive your own experience and the results you get, then as a member of the group of which you regularly take part in day-to-day activities. The group may be a project team, department, or other localized group that functions as a part of the firm in which you work.

Please answer the questions as best as you recall in actual experience. The results are to be kept confidential and no one will know the identity of individual respondents.

Please answer questions as Never (N), Infrequently (I), Sometimes (S), Often (O), or Very Often (VO).

#	Questions- Individual Learning	N	I	S	O	VO
1	I learn new things by formal classes and training.					
2	I learn new capabilities by taking time out from regular assignments for classes/training.					
3	I learn new things in my discipline by conducting independent research.					
4	I learn new things to increase my future worth to the firm.					
5	I learn by constant practice at the edge of my capabilities.					
6	I learn at my own work pace.					
7	I learn through taking on progressively more challenging work.					
8	I learn as a means of increasing my immediate value to the firm.					
9	I learn new things by participating in a network that includes multiple disciplines.					
10	I learn new things by connecting my expertise to the wider company goals.					
11	I learn through knowing what others in our network have to offer.					
12	I learn new things to increase my value to others in the network as source.					
13	I learn by exchanging ideas with others during project execution or “in the field”.					
14	I learn through unexpected challenges that arise during assignments.					

		N	I	S	O	VO
15	I learn by moving between settings (e.g. office and the field).					
16	I learn by becoming skilled at gathering data relevant to the problem.					
17	I am satisfied with the knowledge I have brought to the firm.					
18	My learning has had significant beneficial impact to my immediate or past assignments.					
19	My knowledge has had significant beneficial impact to my group's or the firm's projects.					
20	My knowledge has been useful to discovering root causes for solving problems.					
21	Changes to the firm's basic processes have been proposed or instituted as a result of my findings.					
22	My knowledge is documented and available for use by others in the firm.					
	Questions – Group Learning					
23	We learn new things through common interest in our subject discipline.					
24	We learn as individuals or small groups doing independent research.					
25	We learn many aspects within a single discipline that may not be the domain of any one individual.					
26	We learn new things through members who are distributed through different project or work teams.					
27	We learn by emphasizing efficiency through improving existing processes and tools.					
28	We learn by sharing/communicating informally or having discussions.					
29	We learn by staying within well defined discipline boundaries.					
30	We learn through improving the effectiveness of our solutions.					
31	We learn new things by drawing on resources outside the group.					
32	We learn by converting or codifying knowledge of others to formal knowledge (e.g. written process) for others to use.					
33	We learn new connections by recognizing the type of expertise needed for a specific need.					
34	We learn new things by going outside the firm for expertise.					
35	We learn by sharing experiences and having dialogue with each other.					

		N	I	S	O	VO
36	We learn through senior members who share their "institutional" knowledge.					
37	We learn through combining our dissimilar but complimentary technical disciplines.					
38	We learn primarily through others inside the firm.					
39	We are satisfied with the outcomes our knowledge has achieved for our assignments					
40	What we learn assists the firm to accomplish its immediate goals.					
41	Our knowledge has a significant beneficial impact to the firm.					
42	Our knowledge has resulted in reexamination or changes to the firm's goals or assumptions.					
43	We have transferred or translated our knowledge for other groups in the firm to use.					
44	Our group provides explicit (written) knowledge that has changed the firm's processes or operations.					
	Demographics					
45	The firm provides training and support for allowance of learning and managed risk.					
46	The firm promotes balanced development of new competencies and improvement of existing competencies.					
47	The firm rewards individuals for learning and applying lessons learned.					
48	The firm rewards teams and groups for collective learning and performance.					
49	The firm seeks opportunity to change its offerings or procedures to remain competitive.					
50	My total length of service in the profession is _____ years.					
51	My length of service within my present firm is _____ __years.					
52	My length of service in my present position is _____ years (if applicable).					
53	I spend approximately _____ % of my time in training, teaching or coaching others.					
54	My present title is: _____.					

Survey for Learning in the AEC-Final.

You are invited to take part in a survey that will include many engineers and architects. Your contact information was furnished by permission of your firm for possible interest in taking this survey. You may take this survey or you may contact the principal investigator, the faculty advisor, or the office of Compliance for research at UCF for more information. This survey is for those persons engaged in the practice of design, design management, or construction management of facilities and on-going projects involving multiple technical disciplines. You must be 18 years of age or older to participate. The person doing this research is Robert D. Beaver P.E. of the College of Engineering, Department of Industrial Engineering and Management Systems (IEMS). The researcher is a graduate student and is directed by Dr. Tim Kotnour, a UCF faculty advisor in the Department of IEMS.

Study title: The title of this study is "Contributions of Individual and Group Strategies to Organizational Learning in Architecture, Engineering and Construction Firms".

Purpose of the research study: The purpose is to determine what strategies are used by individuals and groups to attain learning that helps organizations distinguish between adaptive learning and learning that assists in promoting innovative behaviors.

What you will be asked to do in the study: You will be asked to complete a survey of 53 questions. You will select responses by multiple choice that best describe your experiences in learning and your perception of how effective that learning has been to you and the groups with which you work.

Voluntary participation: Your participation in this survey is voluntary. You have the right to stop at any time, if you desire, and you do not have to answer any question that you do not want to answer.

Time required: The survey is estimated at about 20 minutes. You will be able to gauge your progress on a scale bar at the top of each page.

Risks: There are no expected risks for taking part in this study.

Benefits: There is no compensation to you or your firm for participating in the survey, and no penalty for not participating. The results of the study may lead to indirect benefits to you or your firm, for future learning, through the researcher making available aggregate results of this study.

Confidentiality: The study is anonymous, and that no one will know who took the survey. The name of any firm will not be used in any report, so people will not know how you or anyone at any one firm answered as an aggregate. The provider of the survey engine will keep all respondent emails confidential.

Study contact for questions about the study or to report a problem: Robert D. Beaver P.E., or Dr. Tim Kotnour

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901.

Waiver of Documentation: There are no forms to sign or return to the researcher or the institution. Your participation in the survey will constitute your agreement to participate. If these terms are acceptable, you may proceed to the next page. Thank you!

Please answer the following questions as to frequency with which you engage in this activity (Never, Infrequently, Sometimes, Often, Very Often). Note: Answer boxes left out of this sample for brevity

#	Individual Learning – think about what methods you use to learn individually in your position.
1	I learn new things by formal classes and training.
2	I learn new capabilities by taking time out from regular assignments for training.
3	I learn new things through consulting academic or professional journals.
4	I learn new things to increase my future worth to the firm.
5	I learn through performing my regular work processes.
6	I learn through focusing on my depth of specialization in my given subject area.
7	I learn through taking on progressively more challenging work.
8	I learn as a means of increasing my immediate value to the firm.
9	I learn new things by participating in a network that includes multiple disciplines.
10	I learn new things by connecting my expertise to the wider goals of the company.
11	I learn through knowing what others in our network have to offer in the way of knowledge and expertise.
12	I learn new things to be a valued part of a multidiscipline network.
13	I learn by exchanging ideas with others during project execution or “in the field”.
14	I learn through unexpected challenges that arise during assignments.
15	I learn by moving between settings (e.g. office and the field).
16	I learn by becoming skilled at gathering data relevant to the problem.

What are the outcomes or things you learn as an individual? Please answer the following as to actual experience, based on methods you employ.	
17	I am satisfied with the knowledge I have brought to the firm.
18	My learning has had significant beneficial impact to my immediate or past assignments.
19	I am recognized as a source of knowledge in my discipline.
20	My knowledge has been useful to discovering root causes for solving problems.
21	My knowledge has been useful toward redefining how we do things or the types of things we do.
22	My knowledge has been used to reveal new connections between my discipline and other disciplines for the firm's benefit.
Group Learning – Think about your experience in learning as a part of a group or tem. Recall the methods you use and answer the following statements.	
23	We learn new things through common interest in our subject discipline.
24	We learn as individuals or small groups doing independent research.
25	We learn many aspects within a single discipline to become known as subject matter experts in the field.
26	We learn new things through members who are distributed through different project or work teams.
27	We learn by increasing the efficiency of our work processes..
28	We learn by sharing/communicating informally (e.g. having hallway discussions).
29	We learn within our respective technical areas by performing our work within a functional (organized by discipline) classification.
30	We learn through improving solutions that are more effective than previous versions.
31	We learn new things by drawing on resources outside the group.
32	We learn from combining knowledge from all disciplines and placing it in a database (e.g. drafting a new procedure or technical report) for future use.
33	We learn new connections to others by recognizing the type of expertise needed for a specific need.
34	We learn new things by going outside the firm for expertise.
35	We learn by sharing experiences and having dialogue (e.g. meetings and forums) within our group.
36	We learn through senior members who share their "institutional" knowledge with the team.
37	We learn through depending on each discipline member in our group to translate knowledge for each other's use.
38	We learn primarily through others inside our group.

Please answer the following statements as best fits your experience, for the types of learning outcomes your group has achieved.	
39	We are satisfied with the outcomes our knowledge has achieved from our assignments
40	What we learn assists the firm to accomplish its immediate goals.
41	What we have learned in our group has been applied by others in the firm to their benefit.
42	Our knowledge has resulted in reexamination or changes to the firm's goals or assumptions.
43	We have transferred our knowledge and made it understandable for others in the firm to use.
44	Our group provides explicit (written) knowledge that has changed the firm's processes or operations.
Please indicate how you perceive learning is supported or viewed at your firm.	
45	The firm provides training and support for allowance of learning and managed risk.
46	The firm promotes balanced development of new competencies and improvement of existing competencies.
47	The firm rewards individuals for learning and applying lessons learned.
48	The firm rewards teams and groups for collective learning and performance.
49	The firm seeks opportunity to change its offerings or procedures to remain competitive.
Please indicate your own background and experience. Answer according to whether 1-5 years, 6-10 years, 11-15 years, 16-20 years, or more than 20 years.	
50	My total length of experience in my given profession is
51	My length of service at my present firm is
52	My length of service in my present position is
53	My position or job descriptor can be best described as: -Engineer/Architectural Designer -Senior Engineer/Architect -Staff Engineer/Senior Architect -Prject, Dept. or Program Manager -Division Manager -Executive, VP, or President

APPENDIX B: IRB LETTER

APPENDIX C: DATA

Weighted data tables for responses 1- 21. Questions 1 – 19. Unused questions are shown in raw form (integer) only.

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19
1.158	1.38	1.152	4	4	4	0.868	4	0.798	0.777	0.939	1.212	0.468	0.888	1.524	1.576	1.968	2.204	1.04
1.158	1.38	1.536	4	5	4	0.868	4	1.33	1.036	1.252	1.212	0.468	0.888	1.016	1.182	2.624	2.204	1.04
0.772	0.92	0.768	4	5	5	0.651	2	0.266	0.518	1.252	0.606	0.351	0.888	2.032	1.182	2.624	2.204	1.04
0.772	0.92	0.768	5	4	4	0.868	4	1.064	0.777	1.565	1.515	0.351	0.888	1.016	1.182	3.28	2.755	1.3
1.158	1.38	1.536	3	4	4	0.868	3	0.798	1.036	1.252	1.212	0.351	1.184	1.524	1.576	2.624	2.204	1.04
1.544	0.92	0.768	4	4	3	0.868	4	0.798	0.518	0.939	0.606	0.234	1.184	1.016	0.788	2.624	2.204	1.04
1.158	1.38	1.152	4	4	4	0.868	4	1.064	1.295	1.252	1.212	0.351	1.184	1.016	1.182	2.624	2.204	1.04
1.544	0.92	0.768	3	5	2	1.085	5	1.33	1.036	1.565	1.515	0.468	1.48	2.032	1.576	3.28	2.755	0.78
1.158	1.84	1.152	4	4	3	1.085	4	1.064	1.036	1.252	1.212	0.351	1.184	1.524	1.576	2.624	2.204	1.04
1.544	1.84	1.152	4	4	4	1.085	5	1.33	1.295	1.565	1.515	0.585	1.48	2.032	1.576	3.28	2.755	1.04
1.158	1.38	1.152	4	4	4	1.085	5	1.064	1.036	1.252	1.212	0.468	1.48	2.54	1.97	1.968	2.755	1.3
1.158	1.38	1.152	4	4	4	0.868	4	0.798	1.036	1.252	1.212	0.468	1.184	2.032	1.576	2.624	2.204	1.04
1.158	1.38	1.536	3	5	3	0.868	4	0.532	0.518	0.939	0.909	0.468	1.184	1.016	1.576	2.624	2.204	1.3
1.544	1.84	1.152	4	4	3	0.868	4	1.064	0.777	1.252	1.212	0.585	1.184	2.032	1.576	2.624	2.204	1.3
1.544	1.84	1.92	4	4	3	0.868	4	1.064	1.036	1.252	1.212	0.468	1.48	2.54	1.576	3.28	2.755	1.04
1.544	1.38	1.152	4	4	4	0.868	4	0.798	1.036	1.252	1.212	0.351	1.184	1.524	1.576	2.624	2.204	1.04
1.158	2.3	0.768	4	4	3	1.085	4	0.798	0.777	1.252	1.212	0.351	1.48	2.032	1.97	2.624	2.204	0.78
0.772	2.3	1.92	5	4	4	1.085	5	1.33	1.036	1.252	1.515	0.468	1.48	1.524	1.576	2.624	2.755	1.04
0.772	1.38	1.152	4	4	4	1.085	5	1.064	0.777	1.565	1.515	0.468	0.888	1.524	1.576	1.968	2.204	1.04
1.544	1.84	1.536	3	3	3	0.868	3	1.064	0.777	0.939	0.909	0.351	1.184	2.032	1.576	1.968	2.204	1.04
1.158	0.92	0.768	4	5	3	0.651	4	0.532	0.777	0.939	1.515	0.468	1.48	1.016	1.576	2.624	2.204	0.78

Weighted data table, Responses 22 - 45, Questions 1 – 19. Unused questions shown in raw form (integer) only.

1.158	0.92	0.768	4	4	2	1.085	4	1.064	1.036	1.252	1.515	0.351	1.48	2.54	1.576	1.968	2.204	1.04
0.772	0.92	1.152	2	3	2	0.651	3	0.798	0.777	0.939	0.909	0.468	0.888	1.524	1.576	2.624	2.204	1.04
1.544	1.84	1.152	5	5	4	1.085	5	1.064	1.295	1.252	1.212	0.585	1.48	2.54	1.97	3.28	2.755	1.3
0.772	0.92	1.152	4	5	4	0.651	4	1.064	1.036	1.252	1.515	0.585	1.48	2.54	1.97	1.968	2.204	1.04
1.158	1.38	1.536	5	4	4	0.868	5	1.064	1.036	1.252	1.212	0.468	0.888	1.524	1.576	1.968	2.204	1.04
1.158	0.92	1.152	4	4	3	0.651	4	1.064	1.036	1.252	1.212	0.468	1.184	1.524	1.576	1.968	2.204	1.3
0.772	0.92	1.536	4	3	4	0.651	4	0.798	1.036	0.939	1.212	0.468	0.888	1.016	1.182	1.968	2.204	1.04
1.158	0.92	1.536	4	4	2	0.868	4	0.798	0.777	1.565	1.515	0.585	1.184	1.016	1.182	2.624	2.204	0.78
0.772	0.92	0.768	3	3	3	0.868	3	1.064	1.036	0.939	1.212	0.351	1.184	1.524	1.182	3.28	2.755	1.04
0.772	0.92	0.768	5	5	3	1.085	5	0.798	0.777	1.252	0.909	0.585	1.184	1.524	1.182	2.624	2.204	1.04
1.158	1.38	1.536	4	4	3	0.868	4	0.532	1.036	0.939	0.909	0.234	1.184	1.016	1.576	2.624	2.204	0.78
1.158	0.92	1.536	3	5	4	0.868	3	1.064	1.036	0.939	0.909	0.468	1.48	2.54	1.576	1.968	2.755	1.04
1.544	0.92	1.536	2	5	5	0.868	3	1.064	0.777	0.939	1.515	0.585	1.184	2.54	1.576	3.28	2.755	1.04
1.158	0.92	0.768	2	5	4	1.085	2	1.064	0.259	1.252	1.212	0.351	0.888	1.524	1.576	2.624	1.653	1.3
1.544	1.84	0.768	4	4	3	0.868	3	1.064	0.518	0.939	1.212	0.468	1.184	2.032	1.576	1.968	2.204	0.78
1.158	1.38	0.768	4	4	3	0.868	4	0.798	1.036	1.252	1.212	0.585	1.48	2.54	1.576	2.624	2.755	1.04
1.544	1.38	1.152	4	4	3	0.868	4	0.798	0.777	0.939	1.212	0.351	1.184	2.032	1.576	1.968	1.653	1.04
1.158	1.84	1.92	5	4	5	0.651	3	1.064	1.036	0.939	1.212	0.468	1.184	1.524	1.97	2.624	2.755	1.3
1.158	1.38	1.536	5	3	4	1.085	5	1.064	1.036	1.252	1.212	0.468	1.48	1.524	1.182	1.968	2.204	1.3
1.158	1.38	1.152	4	4	3	0.868	4	1.33	0.777	1.565	1.212	0.351	0.888	1.524	1.576	1.968	1.653	0.78
1.158	1.38	1.536	4	4	2	1.085	4	1.33	1.036	0.939	0.909	0.468	1.184	1.016	1.182	1.968	2.204	0.52
1.158	1.38	0.768	4	4	4	0.868	4	1.064	1.036	1.565	1.212	0.468	1.184	2.032	1.576	1.968	2.204	1.04
0.772	1.38	1.536	4	4	4	0.868	4	0.798	0.777	1.252	1.212	0.468	1.48	2.032	1.576	1.968	2.204	0.78
1.158	1.84	1.152	3	4	3	0.651	3	1.064	0.777	1.252	0.909	0.468	1.184	1.524	1.576	2.624	1.653	1.04

Weighted data table, Responses 46 – 72, Questions 1 – 19. Unused questions are shown in raw form (integer) only.

0.772	0.92	0.768	3	5	3	1.085	2	1.064	1.036	1.252	1.515	0.468	1.184	2.032	1.576	2.624	2.204	1.04
0.772	1.38	0.768	4	5	3	1.085	4	0.798	1.295	0.939	1.212	0.351	1.184	1.016	1.97	2.624	2.204	1.04
0.772	0.92	0.768	2	4	3	0.868	2	1.064	0.777	0.939	0.909	0.351	1.184	2.032	1.576	1.968	2.204	1.3
0.772	0.92	0.768	3	4	3	0.868	3	1.064	1.036	1.252	0.909	0.468	1.184	1.524	1.182	1.968	2.204	0.78
0.772	1.38	0.768	4	5	5	1.085	4	0.532	1.295	1.252	1.212	0.468	1.184	1.524	1.576	2.624	2.204	0.78
1.158	1.38	1.92	5	5	5	0.868	4	0.532	0.518	0.313	0.909	0.351	1.48	1.016	1.576	2.624	2.755	1.3
1.158	0.92	0.384	4	5	3	1.085	4	1.33	1.036	0.939	1.212	0.585	1.48	2.54	1.576	2.624	2.204	0.78
1.158	1.38	0.768	4	3	2	0.868	4	0.798	0.777	0.939	1.212	0.468	0.888	1.524	1.97	2.624	2.204	1.3
1.544	1.38	1.536	5	4	4	1.085	5	1.064	0.777	0.939	0.909	0.468	1.184	2.032	1.576	3.28	2.755	1.04
1.544	1.84	1.152	4	4	4	0.868	4	0.798	0.777	1.252	1.212	0.468	1.184	2.54	1.576	2.624	2.755	1.3
1.158	1.38	1.536	4	4	4	0.868	4	1.33	0.777	0.626	1.515	0.351	1.184	2.032	1.576	2.624	2.204	1.3
1.158	1.38	1.152	3	4	3	0.868	3	0.532	0.777	0.939	0.606	0.468	1.184	1.524	1.576	2.624	2.204	0.78
0.772	0.92	0.384	3	5	3	0.868	2	0.532	0.777	0.939	0.606	0.468	1.48	2.032	1.576	1.968	1.653	1.04
1.158	0.92	0.768	3	4	4	1.085	3	0.798	0.777	1.252	1.212	0.468	1.184	1.524	1.97	3.28	2.755	0.78
1.544	1.84	1.152	4	4	3	0.868	4	1.064	1.036	1.252	1.212	0.468	1.184	1.524	1.576	2.624	2.204	1.04
1.158	1.84	1.152	4	4	3	0.651	4	0.798	0.777	0.939	0.909	0.468	1.184	1.016	1.182	1.968	2.204	0.78
1.544	1.84	1.152	4	3	3	0.651	3	0.532	0.777	0.939	0.606	0.351	0.592	1.524	1.182	2.624	1.653	1.04
1.158	0.92	0.768	4	5	2	0.651	5	0.532	0.777	0.626	1.212	0.234	0.888	1.016	0.788	1.312	2.755	0.52
1.158	1.38	0.768	4	5	5	1.085	5	0.798	1.036	1.252	1.515	0.585	1.48	2.032	1.182	2.624	2.204	1.3
1.158	1.84	1.152	4	4	4	0.868	4	1.064	0.777	0.939	1.212	0.468	0.888	1.524	1.182	1.968	2.204	0.52
1.158	1.38	0.768	3	5	3	0.868	2	1.064	1.295	1.252	1.212	0.468	1.184	2.032	1.182	2.624	2.204	1.04
1.158	1.38	1.152	4	4	4	0.868	4	1.064	0.777	1.252	1.212	0.468	1.184	1.524	1.182	3.28	2.755	1.3
1.158	1.38	0.768	3	4	3	0.651	3	0.798	0.518	0.939	0.606	0.351	1.184	1.016	0.788	2.624	2.204	1.04
1.544	2.3	1.536	4	3	4	1.085	4	0.798	0.777	1.252	1.212	0.351	0.888	1.524	1.576	2.624	1.653	1.3
1.93	0.92	1.152	5	4	4	1.085	4	1.064	0.777	1.252	0.909	0.351	1.48	1.016	1.182	2.624	2.204	0.78
1.93	2.3	0.768	3	2	1	0.434	1	1.064	0.518	0.626	0.606	0.234	0.592	2.54	1.576	1.312	1.102	0.52
1.158	0.92	1.536	3	4	3	1.085	3	0.798	0.777	1.252	0.909	0.468	1.184	1.524	1.182	1.968	2.755	1.04

Weighted data table, responses 1 – 21. Questions 20 – 38. Questions not used are shown in raw form (integer) only.

Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38
1.224	1.544	1.077	1.332	3	1.206	0.796	1.444	1.11	0.42	0.828	1.892	3	0.765	1.569	1.116	1.032	0.328	3
0.918	1.158	1.077	0.999	3	1.608	0.597	1.444	1.11	0.63	0.621	1.892	3	1.02	2.092	0.837	0.774	0.492	4
0.918	1.158	1.077	0.999	2	0.804	0.398	0.722	1.11	0.84	0.414	1.419	2	0.51	1.046	0.837	0.774	0.656	5
1.53	1.544	1.077	0.999	4	1.608	0.398	0.722	1.11	0.63	0.621	1.419	2	0.765	1.046	0.558	1.29	0.328	2
1.224	1.544	1.436	1.332	4	1.608	0.796	1.444	1.48	0.84	0.621	1.419	4	0.765	2.092	1.116	0.774	0.656	4
1.224	1.544	1.077	0.666	2	1.206	0.597	1.083	1.11	0.42	0.828	1.419	2	0.51	1.569	0.837	0.774	0.492	3
1.224	1.544	1.795	1.332	4	1.608	0.995	1.444	1.85	0.84	0.828	1.892	3	1.02	1.569	1.395	1.29	0.656	3
1.224	1.544	1.436	1.332	4	1.608	0.796	1.444	1.85	0.84	0.621	1.892	2	1.02	1.046	1.116	0.774	0.656	4
1.53	1.544	1.436	0.999	3	1.206	0.597	1.083	1.48	0.63	0.828	1.892	2	0.765	1.569	1.116	1.032	0.656	4
1.224	1.544	1.436	1.332	4	1.608	0.796	1.444	1.85	1.05	0.828	1.419	4	1.275	1.569	1.395	1.29	0.82	5
1.224	1.544	1.077	1.332	4	2.01	0.796	1.444	1.48	1.05	1.035	2.365	4	1.02	2.092	1.395	1.29	0.82	4
1.224	1.544	1.436	1.332	4	1.608	0.796	1.444	1.48	0.63	0.828	1.419	3	1.02	1.569	1.116	1.032	0.492	3
1.224	1.158	0.718	0.999	2	1.206	0.796	0.722	1.11	0.42	0.621	0.946	4	0.765	1.046	0.837	1.032	0.492	4
1.224	1.158	1.077	1.332	3	1.206	0.597	1.444	1.48	0.63	0.828	1.892	3	1.02	1.569	0.837	0.774	0.656	3
1.224	1.544	1.077	1.332	3	2.01	0.995	1.083	1.85	1.05	0.828	1.892	3	0.765	1.569	0.837	1.29	0.656	4
1.224	1.544	1.077	0.999	3	1.206	0.597	1.444	1.48	0.63	0.828	1.419	2	0.765	1.569	1.116	1.032	0.492	3
0.918	0.386	0.359	0.999	2	0.402	0.398	1.444	1.85	0.84	0.828	1.419	3	0.765	1.569	0.837	1.032	0.492	3
1.53	1.93	1.436	1.332	4	1.206	0.597	1.083	1.85	0.63	1.035	2.365	3	0.765	1.046	1.395	0.774	0.656	3
0.918	1.158	1.077	1.332	3	0.804	0.597	1.083	1.48	0.63	0.621	2.365	2	1.275	2.092	1.116	0.774	0.656	3
1.224	1.158	1.077	0.999	3	1.206	0.597	1.083	1.48	0.63	0.828	1.892	3	0.765	1.569	1.116	1.032	0.656	3
1.224	1.158	1.077	1.332	4	1.608	0.597	1.444	1.85	1.05	0.621	2.365	2	0.765	1.046	1.395	1.29	0.656	5

Weighted data table, Responses 22- 45. Questions 20 – 38. Questions not used shown in raw form (integer) only.

1.224	0.772	1.077	0.999	2	1.206	0.597	1.083	1.11	0.63	0.621	1.419	3	0.765	1.569	0.837	0.774	0.492	3
1.224	1.93	1.077	1.332	4	1.608	0.597	0.722	1.11	0.63	0.621	1.419	2	0.765	1.046	0.837	0.774	0.492	3
1.53	1.93	1.436	0.999	5	1.608	0.796	1.444	1.85	1.05	1.035	1.892	4	1.02	2.615	1.395	1.032	0.656	3
1.224	1.158	0.718	0.999	4	1.608	0.796	0.722	1.48	0.63	0.621	1.892	2	0.765	2.092	0.837	0.774	0.656	4
1.224	1.158	1.077	1.332	3	2.01	0.796	1.083	1.11	0.84	0.828	1.892	3	1.275	1.569	1.116	1.032	0.656	3
1.224	1.544	1.436	1.332	4	1.608	0.597	1.444	1.48	0.63	0.828	1.419	2	1.02	1.569	1.116	0.774	0.328	2
1.224	1.544	1.436	1.332	2	1.608	0.796	1.444	1.48	0.84	0.828	1.892	3	1.02	1.569	1.116	1.032	0.656	3
0.918	0.772	1.077	1.332	2	1.206	0.796	1.444	1.85	0.84	0.621	1.892	2	0.765	1.569	0.558	1.032	0.328	4
1.53	1.544	1.436	0.999	2	1.206	0.597	1.083	1.85	0.84	0.828	1.419	2	0.765	1.569	1.116	1.29	0.656	4
1.224	1.158	0.718	0.999	3	1.608	0.796	1.444	1.85	0.84	0.621	1.419	2	0.765	1.569	0.837	1.032	0.492	4
0.918	1.544	1.077	1.332	4	1.206	0.597	1.444	1.11	0.63	0.828	1.419	2	1.02	1.569	0.837	1.032	0.656	4
1.53	1.544	1.795	1.332	4	1.206	0.597	1.444	1.48	0.63	1.035	1.892	3	1.02	1.569	1.116	0.774	0.82	2
1.224	1.158	1.077	1.332	3	1.608	0.597	1.444	1.48	0.63	0.828	2.365	2	0.765	2.092	1.395	1.032	0.492	4
1.224	0.772	0.718	1.332	2	1.608	0.597	0.722	1.11	0.84	0.414	1.419	1	0.765	1.046	0.837	0.516	0.656	3
0.918	1.158	1.436	1.332	2	1.608	0.597	1.083	1.48	0.84	0.828	1.419	4	1.02	1.569	1.116	1.032	0.656	4
1.224	1.158	1.077	1.332	3	1.608	0.995	1.083	1.48	0.63	0.828	1.419	3	0.765	1.569	0.558	1.032	0.492	4
1.224	1.544	1.077	0.999	3	1.206	0.597	1.083	1.11	0.63	0.621	1.419	3	0.765	1.569	1.116	1.032	0.492	3
1.224	1.158	0.718	0.999	3	0.804	0.597	1.083	1.48	0.63	0.621	1.419	3	0.51	1.569	1.116	0.774	0.328	3
1.224	1.93	1.436	0.999	3	1.206	0.796	1.805	1.48	0.84	0.828	1.892	3	0.765	2.615	1.116	1.032	0.492	2
0.918	1.158	1.077	0.999	3	0.804	0.597	1.444	1.48	0.63	0.621	1.419	4	1.02	1.569	1.116	0.774	0.492	2
0.918	1.158	0.718	0.999	3	1.608	0.796	1.444	1.48	0.63	0.621	1.419	2	1.02	1.569	1.116	1.032	0.656	3
1.224	1.544	1.077	0.999	3	1.206	0.796	1.444	1.48	0.84	0.621	1.892	2	0.765	1.569	1.116	0.774	0.656	3
1.224	1.158	1.077	0.999	2	1.206	0.796	1.444	1.48	0.84	1.035	1.892	4	1.02	1.569	1.116	1.032	0.656	5
0.918	1.158	1.436	1.332	3	1.608	0.597	1.444	1.48	0.84	0.621	1.419	3	0.765	1.046	0.837	0.774	0.492	4

Weighted data table, Responses 46 – 72. Questions 20 – 38. Questions not used shown in raw form (integer) only.

1.224	1.93	1.077	1.332	3	1.608	0.597	1.083	1.11	0.84	0.621	1.419	2	1.02	1.046	0.837	1.032	0.656	4
1.224	1.544	1.436	0.999	4	1.206	0.597	1.083	1.11	0.63	0.621	1.419	3	0.765	1.569	1.116	1.032	0.492	3
1.53	1.93	1.795	0.999	3	0.804	0.796	1.083	1.11	0.42	0.621	1.892	2	0.765	1.569	0.837	0.516	0.492	3
0.918	1.158	1.077	1.332	3	1.206	0.597	1.083	1.11	0.63	0.621	1.419	3	0.765	1.569	1.116	0.774	0.492	4
1.224	1.544	1.436	1.665	4	2.01	0.796	1.444	1.48	1.05	0.828	1.892	3	0.765	1.569	1.116	1.29	0.492	3
1.53	1.93	1.077	1.332	5	1.206	0.796	1.444	1.85	0.84	0.828	1.892	4	1.02	1.046	0.837	1.29	0.656	4
0.918	1.544	1.436	1.332	3	1.608	0.796	1.444	1.48	0.63	0.621	1.419	3	0.765	1.569	1.116	1.032	0.656	3
1.224	1.544	1.077	1.332	2	1.206	0.398	1.083	1.11	0.42	0.828	1.892	3	1.02	2.092	1.395	1.29	0.492	4
0.918	1.158	1.436	0.999	3	1.206	0.597	1.805	1.85	0.84	0.828	0.946	3	0.765	1.569	1.395	1.29	0.656	3
1.224	1.544	1.077	1.332	2	1.608	0.796	1.444	1.85	0.84	0.828	1.892	4	1.02	1.569	1.116	1.032	0.492	3
1.224	1.158	1.077	0.999	3	1.608	0.597	0.722	1.11	0.84	0.621	1.419	3	0.765	1.569	0.837	1.032	0.328	4
0.918	0.772	0.718	0.999	4	1.206	0.796	1.444	1.11	0.84	0.828	2.365	3	0.765	2.092	0.837	1.032	0.656	4
0.918	0.772	0.718	0.999	4	1.206	0.796	1.444	1.85	0.63	0.828	2.365	2	0.765	2.092	1.116	1.29	0.492	3
0.918	1.158	0.718	0.999	3	1.206	0.796	1.083	1.11	1.05	0.828	2.365	3	1.02	1.569	1.116	1.032	0.656	3
1.224	1.544	1.436	1.332	4	1.206	0.796	1.444	1.11	0.84	0.828	1.892	4	1.02	1.569	0.837	0.774	0.328	3
0.918	1.158	0.718	0.999	3	1.206	0.597	1.444	1.48	0.63	0.621	1.419	3	0.765	1.569	1.116	0.774	0.492	3
0.918	1.158	0.718	0.999	3	1.608	0.597	1.083	1.11	0.84	0.621	1.419	3	0.765	1.569	0.558	0.516	0.492	2
0.612	0.772	1.077	0.666	3	0.804	0.597	1.444	0.74	0.84	0.621	0.946	2	0.765	1.046	0.558	0.774	0.492	2
1.224	1.93	1.795	1.332	2	1.608	0.796	1.805	1.85	0.42	1.035	1.892	2	0.765	1.046	1.395	1.29	0.656	4
0.612	0.772	0.718	1.332	3	1.206	0.597	1.083	1.11	0.84	0.828	1.892	3	0.765	1.569	1.116	1.032	0.656	4
1.224	1.544	1.077	1.332	4	1.608	0.796	1.083	1.48	0.84	0.621	1.419	2	0.765	1.046	1.116	1.032	0.656	5
1.224	1.158	1.795	1.332	3	1.608	0.796	1.444	1.48	0.63	0.828	1.419	3	1.02	2.092	0.837	1.032	0.656	3
0.918	1.158	0.718	0.666	3	1.206	0.597	1.444	1.11	0.84	0.621	1.419	2	0.765	1.046	1.116	1.032	0.656	4
1.224	1.158	1.077	0.999	3	1.608	0.597	1.444	1.48	0.84	0.621	1.419	4	1.02	1.046	0.837	1.032	0.656	4
0.918	0.772	0.718	1.332	3	1.608	0.597	0.722	1.11	0.84	0.828	1.419	2	1.02	1.569	0.837	1.29	0.656	4
0.612	0.772	0.718	0.666	4	0.804	0.398	0.722	1.11	0.42	0.414	2.365	3	0.765	2.615	0.558	0.774	0.492	2
1.224	1.544	1.436	1.332	4	1.608	0.796	1.444	1.11	0.63	0.621	1.419	2	0.765	1.569	0.837	1.032	0.656	4

Weighted data table, Responses 1 – 21. Questions 39 – 53. Questions 39 and 40 not used. Questions 50 – 53 are integer form only.

Q39	Q40	Q41	Q42	Q43	Q44	Q45	Q46	Q47	Q48	Q49	Q50	Q51	Q52	Q53
4	4	0.942	0.744	1.059	0.975	0.672	0.687	1.072	0.789	1.028	5	5	5	6
4	4	0.942	0.744	1.059	0.65	1.12	1.145	1.072	1.052	1.285	5	2	2	4
5	4	0.628	0.496	0.706	0.65	0.448	0.458	0.536	0.526	0.514	5	5	2	4
3	4	0.942	0.744	0.706	0.65	0.896	0.687	1.072	0.789	0.771	3	3	3	2
3	4	1.256	0.992	1.412	1.3	0.672	0.916	0.804	0.789	0.771	4	4	1	5
3	4	0.942	0.992	1.059	0.975									
4	5	1.256	0.992	1.059	0.975	0.896	0.916	1.072	1.052	1.028	4	3	2	5
4	4	1.256	0.744	1.059	0.975	0.896	0.916	1.072	1.052	1.285	3	2	1	5
3	4	1.256	0.744	1.412	0.975	0.672	0.916	1.072	0.789	0.771	5	5	1	5
5	5	1.256	0.744	1.765	1.625	1.12	1.145	1.34	1.315	1.285	3	3	2	2
4	3	1.256	0.744	1.412	1.3	0.896	0.916	0.804	0.526	0.771	4	4	4	4
4	4	1.256	0.744	1.412	0.975	0.896	0.916	0.804	0.526	0.771	5	5	5	6
4	4	0.942	0.496	0.706	0.65	0.672	0.916	1.072	0.789	0.514	5	4	3	2
4	5	1.256	0.744	1.412	0.975	0.672	0.916	1.072	0.526	0.514	1	1	1	4
3	4	1.256	1.24	1.412	1.625	0.896	0.916	1.072	1.052	1.028	3	1	1	4
4	4	0.942	0.744	1.059	0.975	1.12	1.145	1.34	1.052	1.028	2	1	1	
4	4	0.942	0.248	0.706	0.65	0.448	0.916	0.268	0.263	0.514	1	1	1	1
4	4	1.256	0.992	1.059	0.65	0.672	0.916	0.804	1.052	1.028	4	3	2	5
3	4	0.942	0.744	1.059	0.65	0.896	0.916	0.804	0.789	1.028	4	3	2	6
3	4	0.942	0.744	1.059	0.975	1.12	0.916	1.072	1.052	1.028	5	4	3	2
4	5	0.942	0.496	1.059	0.975	0.448	0.458	0.268	0.526	0.771	1	1	1	1

Weighted data table, Responses 22- 45. Questions 39 – 53. Questions 39 and 40 not used.
Questions 50 – 53 in integer form only.

3	4	0.942	0.496	1.412	0.65									
4	4	1.256	0.496	1.059	0.975	0.896	0.916	0.804	0.789	1.028	5	4	3	6
4	5	1.256	0.744	1.412	1.3	1.12	0.916	1.34	1.052	1.285	5	2	1	2
3	4	0.628	0.496	0.706	0.65	0.672	0.687	0.536	0.526	0.514	3	1	1	1
4	4	0.942	0.744	1.412	0.975	0.672	0.916	0.804	0.789	1.028	5	5	1	6
3	5	1.256	0.992	1.412	0.975	0.672	0.916	1.072	0.789	0.771	5	1	1	4
3	4	0.942	0.744	1.059	0.65	0.672	0.687	0.536	0.526	0.514	5	3	1	4
4	5	0.942	0.248	0.706	0.325	0.896	0.916	0.268	0.263	0.771	5	3	2	6
4	4	1.256	0.744	1.059	0.975	0.672	0.687	0.804	0.526	0.771	5	2	2	6
4	4	1.256	0.496	1.765	0.65	0.224	0.687	0.804	0.789	0.514	2	1	1	6
4	4	1.256	0.744	1.412	1.3	0.896	0.916	1.072	0.789	1.028	3	3	2	2
3	4	0.942	0.992	1.412	1.3	0.896	0.916	1.34	1.052	1.285	3	3	3	6
2	4	1.256	0.744	1.059	0.975	0.896	0.916	1.34	1.315	1.285	5	1	5	6
4	2	0.942	0.496	0.706	0.325	0.896	0.916	0.536	0.526	0.514	4	4	2	4
3	2	0.942	0.744	1.059	1.3	0.672	0.916	1.072	1.052	0.771	1	1	1	1
4	5	1.256	0.744	0.706	0.65	0.672	0.687	0.536	0.526	1.028	2	2	1	3
3	3	0.942	0.744	1.059	0.975	0.672	0.687	0.804	0.789	0.771	5	1	1	5
4	3	0.628	0.496	0.706	0.65	0.672	0.687	0.804	0.789	0.771	5	1	1	2
3	4	1.256	0.744	1.059	0.65	0.672	0.916	1.072	0.789	1.028	4	2	1	5
4	3	1.256	0.744	1.412	0.975	0.896	0.916	0.804	0.789	1.028	1	1	1	1
4	4	0.942	0.744	0.706	0.65	0.896	0.687	0.804	0.789	1.028	5	1	1	4
5	4	1.256	0.744	1.412	0.65	0.672	0.687	1.072	1.052	1.028	4	3	1	5
3	5	1.256	0.744	1.412	1.3	1.12	0.916	0.804	0.789	0.771	4	1	1	2
4	4	0.942	0.496	1.059	0.975	0.672	0.916	0.804	0.789	0.771	5	5	5	6

Weighted data table, Responses 46 – 72. Questions 39 – 53. Questions 39 and 40 not used. Questions 50 – 53 in integer form only.

4	4	1.256	0.744	0.706	0.65	1.12	0.687	0.804	0.789	0.771	4	5	3	4
4	4	1.256	0.992	1.412	1.3	0.896	0.916	1.072	1.052	1.028	5	5	1	6
3	3	0.942	0.744	1.059	0.975	0.672	0.916	0.804	0.526	1.028	5	3	3	1
3	3	0.942	0.496	1.059	0.975	0.896	0.916	1.072	1.052	1.028	3	3	1	1
4	4	1.256	0.496	1.059	0.975	0.672	0.916	0.804	0.789	0.514	4	2	1	2
3	4	1.256	0.248	1.059	0.975	1.12	1.145	1.34	1.315	1.028	1	1	1	1
3	3	1.256	0.744	1.412	1.3	0.896	1.145	1.34	1.052	1.285	2	2	1	1
5	4	1.256	0.496	1.412	1.3	0.896	1.145	1.072	0.789	1.285	2	2	2	4
4	5	1.256	0.744	1.412	0.975	0.896	0.916	0.804	0.789	0.771	3	1	3	4
4	4	1.256	0.496	1.412	1.3	1.12	1.145	1.072	1.052	1.285	5	5	1	4
3	4	0.942	0.744	1.059	0.975	0.896	0.916	0.804	0.526	0.771	4	3	3	6
3	4	1.256	0.496	1.059	0.65	0.672	0.687	0.536	0.526	0.771	5	4	4	2
3	4	0.942	0.744	1.059	0.65	0.672	0.687	0.536	0.526	0.771	3	3	2	4
4	4	0.942	0.744	1.059	0.975	0.896	0.916	0.536	0.526	0.514	2	1	1	1
3	3	0.942	0.744	1.059	0.975	0.672	0.687	0.804	0.789	0.771	2	1	1	2
4	4	0.942	0.496	1.059	0.975	0.672	0.687	1.072	1.052	1.028	1	1	1	1
3	3	0.942	0.744	0.706	0.65	0.672	0.916	0.804	0.263	0.771	5	1	1	5
4	4	0.942	0.496	1.059	0.65	0.896	0.687	0.536	0.526	0.771	1	1	1	1
3	4	1.256	0.496	1.059	0.65	0.672	0.687	0.804	0.789	0.514	5	1	1	4
3	3	0.942	0.744	1.059	0.975	0.672	0.916	0.804	0.789	0.771	1	1	1	1
4	4	0.628	0.992	1.059	1.3	0.896	0.916	1.072	0.789	1.028	4	4	1	6
3	3	0.942	0.744	1.059	0.975	0.896	0.916	0.804	0.789	1.028	5	5	5	4
3	4	0.942	0.496	1.059	0.65	0.896	0.916	0.804	0.789	0.771	4	3	3	3
4	4	0.942	0.496	1.412	0.325	0.896	0.916	0.804	0.789	1.028	5	5	5	2
4	4	0.942	0.744	1.059	0.65	0.448	0.916	1.072	0.789	1.028	1	1	1	1
2	3	0.628	0.496	0.706	0.65	0.896	0.916	1.34	1.052	1.028	1	1	1	1
5	5	0.942	0.496	0.706	0.975	0.672	0.687	0.804	0.526	0.771	5	5	5	4

APPENDIX D: FACTOR LOADINGS FOR CONSTRUCTS

Factor Loadings and Scores for Individual Learning Construct

Rotated Factor Loadings and Communalities
Equamax Rotation

Variable	Factor1	Factor2	Factor3	Communality
Q1	-0.189	0.165	**0.688**	0.536
Q2	-0.043	0.128	**0.802**	0.661
Q3	0.169	-0.195	**0.622**	0.453
Q7	**0.585**	0.219	-0.046	0.392
Q9	**0.610**	0.093	0.353	0.505
Q10	**0.657**	0.178	-0.016	0.464
Q11	**0.713**	0.020	-0.101	0.519
Q12	**0.746**	0.163	0.011	0.583
Q13	**0.473**	0.447	-0.145	0.444
Q14	0.329	**0.576**	-0.139	0.459
Q15	0.031	**0.851**	0.092	0.733
Q16	0.100	**0.701**	0.201	0.541
Variance	2.6181	1.9432	1.7285	6.2897
% Var	0.218	0.162	0.144	**0.524**

Factor Score Coefficients

Variable	Factor1	Factor2	Factor3
Q1	-0.097	0.091	**0.386**
Q2	-0.020	0.030	**0.460**
Q3	0.135	-0.198	**0.384**
Q7	**0.217**	0.018	-0.024
Q9	**0.266**	-0.092	0.220
Q10	**0.259**	-0.023	-0.001
Q11	**0.313**	-0.126	-0.038
Q12	**0.303**	-0.052	0.018
Q13	**0.117**	0.188	-0.102
Q14	0.026	**0.296**	-0.112
Q15	-0.156	**0.508**	-0.005
Q16	-0.091	**0.394**	0.071

Factor Loadings and Scores for Group Learning Construct

Rotated Factor Loadings and Communalities
Equamax Rotation

Variable	Factor1	Factor2	Factor3	Communality
Q23	0.104	**0.724**	0.085	0.542
Q25	0.027	**0.824**	-0.075	0.686
Q26	0.287	**0.533**	0.117	0.380
Q27	**0.726**	0.023	0.120	0.541
Q28	**0.773**	0.181	0.016	0.630
Q29	0.274	**0.540**	-0.163	0.393
Q30	**0.611**	0.219	0.408	0.587
Q31	0.150	0.133	**0.753**	0.607
Q33	0.065	0.359	**0.414**	0.488
Q34	0.038	-0.148	**0.792**	0.650
Q35	**0.668**	0.135	0.277	0.541
Q36	**0.591**	0.312	-0.055	0.450
Q37	0.277	**0.459**	0.131	0.305
Variance	2.5658	2.5383	1.6957	6.7997
% Var	0.197	0.195	0.130	0.523

Factor Score Coefficients

Variable	Factor1	Factor2	Factor3
Q23	-0.115	**0.333**	0.027
Q25	-0.149	**0.402**	-0.069
Q26	0.018	**0.199**	0.019
Q27	**0.361**	-0.147	-0.048
Q28	**0.370**	-0.077	-0.128
Q29	0.058	**0.210**	-0.165
Q30	**0.207**	-0.030	0.161
Q31	-0.080	0.021	**0.473**
Q33	-0.158	0.255	**0.255**
Q34	-0.086	-0.094	**0.523**
Q35	**0.279**	-0.082	0.065
Q36	**0.258**	0.028	-0.145
Q37	0.026	**0.164**	0.031

Factor Loadings for Individual Learning Outcomes Construct

Rotated Factor Loadings and Communalities
Varimax Rotation

Variable	Factor1	Factor2	Communality
Q17	-0.098	**0.870**	0.766
Q18	-0.223	**0.777**	0.653
Q19	**0.676**	-0.247	0.517
Q20	**0.814**	-0.328	0.770
Q21	**0.868**	-0.112	0.767
Q22	**0.770**	-0.034	0.594
Variance	2.5254	1.5419	4.0673
% Var	0.421	0.257	0.678

Factor Score Coefficients

Variable	Factor1	Factor2
Q17	0.173	**0.656**
Q18	0.090	**0.551**
Q19	**0.260**	-0.022
Q20	**0.306**	-0.051
Q21	**0.386**	0.132
Q22	**0.359**	0.168

Factor Loadings for Group Learning Outcomes Construct

Principal Component Factor Analysis of the Correlation Matrix
Unrotated Factor Loadings and Communalities

Variable	Factor1	Factor2	Communality
Q39	0.157	**0.782**	0.636
Q40	0.383	**0.665**	0.589
Q41	**0.746**	0.188	0.592
Q42	**0.588**	-0.483	0.579
Q43	**0.838**	-0.030	0.704
Q44	**0.772**	-0.270	0.669
Variance	2.3739	1.3961	3.7699
% Var	0.396	0.233	**0.628**

Factor Score Coefficients

Variable	Factor1	Factor2
Q39	0.066	0.560
Q40	0.161	0.477
Q41	0.314	0.135
Q42	0.248	-0.346
Q43	0.353	-0.022
Q44	0.325	-0.193

Factor Loadings for Perception of Learning Allowance by the Firm

Unrotated Factor Loadings and Communalities
70 cases used 2 cases contain missing values

Variable	Factor1	Factor2	Communality
Q45	**0.724**	-0.526	0.801
Q46	**0.739**	-0.463	0.761
Q47	**0.865**	0.330	0.857
Q48	**0.850**	0.402	0.884
Q49	**0.829**	0.116	0.700
Variance	3.2282	0.7756	4.0038
% Var	**0.646**	0.155	0.801

Factor Score Coefficients

Variable	Factor1	Factor2
Q45	**0.224**	-0.679
Q46	**0.229**	-0.597
Q47	**0.268**	0.425
Q48	**0.263**	0.519
Q49	**0.257**	0.149

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