An Approach to Organizational Intelligence Management (A Framework for Analyzing Organizational Intelligence Within the Construction Process)

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ABSTRACT

The construction industry is inherently multidisciplinary and has adopted many intellectual and technical business improvements from other industries in an effort to optimize productivity. In construction, management inactivity is the root cause of 30% of non-productive time. This has created an opportunity and need for standardized and structured repeatable procedures for new managerial strategies.

A theoretical framework for Organizational Intelligence (OI), which encompasses the procedural ability of an organization to efficiently process, support, measure and reason through management issues, is proposed. The elements of organizational intelligence are divided into three types of intellectual capital: Human Capital, Organizational Capital, and Relational Capital. The performance of an organizational activity depends on the quality of these capitals that are available within an organization. An organization's Human Capital (HC) is the human resources within the organization that can be deployed to acquire and apply its knowledge to perform, respond, or control designated work with available organizational assets. Organizational Capital (OC) refers to the assets available to the organization to support the performance of organizational activities Relational Capital (RC), which combines human capital and organizational capital to perform, is needed specific organizational activities.

In addition, the research uses human cognitive abilities as the basis of a fundamental structure from which to form new organizational cognitive abilities that are capable of presenting management processes as critical value creations. Organizational cognitive ability is suggested to define appropriate organizational resources in order to integrate and determine a rational selection of applicable technologies and improvements. This ability can develop knowledge with interconnected variables, namely intellectual capital, managerial process, and performance, all of which support organizational intelligence.

From the theoretical framework for OI, a prototype (Intelligibility Learning Model), which determines the role of relationships in an organization's operation and use of resources, is formulated. A case based research then applies the prototype to a managerial process in the construction industry. The case research demonstrates that the Intelligibility Learning Model (ILM) could be use effectively by industry decision makers to improve performance of organizational activities. The identification and application of a theoretical framework constitutes the foundation of a new managerial theory, Organizational Intelligence Management. It thus provides a fundamental foundation that explains how the construction processes, knowledge, skills, and resources used for managerial activities function. This theory contributes and establishes a better understanding of management, from organizational resources through to final production.

DEDICATION

TO MY FATHER, DONG-SIK JUNG, IN HEAVEN

MAY HIS SOUL REST IN PEACE!!

***Intelligence* is such a word: we use it so often that we have come to believe in its existence, as a genuine tangible, measurable entity, rather than as a convenient way of labeling some phenomena that may (but may well not) exist.**

(Howard Gardner, 1983)

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CHAPTER 1: RESEARCH STATEMENT

The construction industry is inherently multidisciplinary, with representatives from many fields, including architects, contractors, owners, and government agencies working closely together to initiate a project and see it through to completion. Inevitably, managerial issues will arise during the course of such an endeavor and the Architecture, Engineering, and Construction (AEC) industry has adopted a wide array of useful, meaningful, and accessible information tools and management strategies in support of construction operations. However, the industry still struggles as a result of a lack of accurate, reliable and timely management processes, which creates inefficiencies, cost overruns, and inter-party disputes that all too often characterize the construction managerial process. The fact that many players in the construction process consider each project a customized one-off activity, designed and built by different parties who assemble short-term supply chains then go their separate ways, reaffirms the opportunity and need for standardized, and repeatable information exchange procedures (Mills, Jung, & Thabet, 2004). There is thus an urgent need for a set of standardized and repeatable structured procedures and this is addressed by the new management concept known as Organization Intelligence Management.

Typically, in a standard construction project the owner communicates with the designer, who in turn communicates with the consultants and then the constructor, who passes on instructions to field trades, workers and suppliers. The work that is produced is inspected and the results relayed back to the constructor, who may be required to correct any defects. For instance, 54,000 parts spread across 30 subsystems may be assembled by as many as 17 subcontractors in the construction of light, wood-framed houses (O'Brien, 1999). These interrelated trades in the common construction process, kept informed and updated in order to perform their roles successfully. The dynamic nature of this management activity between all the parties involved frequently results in an inability to predict necessary actions, which reduces the overall performance of the organization. This fragmentation of management adversely affects the overall performance by increasing problematic and productivity-reducing activities such as untimely changes, non-productive labor tasks due to wrong or absent information, disputed change orders, accidents, double handling of material, incorrect material availability, rework, and so on.

Although the construction industry is increasingly adopting productivity-improving techniques that rely on Information Technology (IT) Tools and management theories for success, it is still struggling with inefficiencies and reduced productivity compared to other industries, as shown in Table 1-1.

	Productive	Non-Productive
Manufacturing	84 %	16 %
Construction	50 %	50 %

Table 1-1: Workforce's Non-Productive Time

(Adopted from Adrian, 2000)

Problems due to the complexity of the building process and management issues among the multiple players are just some of the problems that construction industries must overcome. Approximately one-third of construction non-productive times can be traced back to the lack of management actions (Adrian, 2001). However, other non-productive times are directly and indirectly related to management actions, because in the final analysis management actions control every construction process.

To minimize fragmentation among the processes that comprise a construction project, the construction industry has begun to apply techniques such as Information/Communication Technology (ICT), Total Quality Management (TQM) and Knowledge Management (KM). These approaches improve human interaction and management activities in the area of materials procurement, labor allocation, equipment scheduling, and workforce productivity, which should lead to both higher productivity and better quality. However, these efforts have not been as successful in the construction industry as in other industries[1] . Construction is a special type of production, and a theory of construction deals thus both with the concepts and principles of general, and with their application to construction (Koskela and Vrijhoef, 2001). As yet, there is no fundamental theory that explains how the construction processes, knowledge, skills, and resources widely used for

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[1] "Labor productivity index for US construction industry and all non-farm industries from 1964 through 2003", Data sources: U.S. Bureau of Labor Statistics U.S. Department of Commerce

managerial activities function and how they contribute and relate to productivity based on intrinsic attributes such as principal, structure, and requirements. Theories of construction should be established and contributed to the understanding of construction management from organizational resources to the final construction production.

This research, therefore, investigates the use of intelligence in construction processes in order to identify appropriate management standards for construction management that can then be used to develop a theoretical basis for Organizational Intelligence (OI) in the construction industry. The first step in this process calls for an exploration of how intelligence is embodied in the processes and resources or assets within the organization. These assets are considered to be the organization's intellectual capital in this research. Emulating human intelligence, human cognitive abilities are used as the fundamental structure for this effort to define and formulate new organizational cognitive abilities that are capable of characterizing management processes and suggesting how organizational cognitive abilities can be used to describe a specific construction act and serve as a critical value selector in determining appropriate capitals with which to perform specific management tasks

The concept of OI encompasses the procedural ability of a business organization to efficiently process, exchange, measure and reason to support efficient and effective decision-making in its activities, specifically planning, organizing, leading, and controlling the organization's operations. In this work OI is viewed as the combination of knowledge and skills that results from the integration of organization assets, i.e. intellectual capital, to achieve organizational goals. OI is thus made up of the three components of intellectual capital: Human Capital (HC), Organizational Capital (OC), and Relational Capital (RC). Organizational Intelligence optimizes these elements and applies them to managerial processes in order to clarify and intensify the organization’s performance requirements. This performance optimization is based on understanding and integrating human and organizational intelligence in accordance with the three capitals and specific organizational activity. This optimization is called Organizational Intelligence Management (OIM) in this dissertation.

By applying organizational intelligence to a hypothetical example of a specific construction process, this research explores how organizational intelligence management can be utilized as an innovative management strategy with which to manage an organization’s intellectual capitals. This research presents a conceptual framework for organizational intelligence that is supported by a firm theoretical foundation that enhances our understanding of organizational activity and the subsequent integration of the three types of capital into organizational intelligence management.

1.1. BACKGROUND

According to Beta-Rubicon’s definition (2006), information/communication technology (ICT) encompasses all the software applications, operational technology, enhanced techniques, and other methods used to create, store, exchange, and use information in its various forms e.g., business data, voice conversations, still images, motion imagery, multimedia, and other informational forms. Based on this definition, it thus represents intelligence in every industry. This author’s position is that ICT is a component or part of organizational or managerial intelligence.

Intelligence was originally used to refer solely to human intelligence, but the post-industrial information society is altering this. The term ‘intelligence’ is now found in many industries and takes many forms, with perhaps the best known being the ‘artificial intelligence’ used when referring to computers and feedback theory. Of particular interest for this research, the term ‘intelligent building systems’ is becoming commonplace in the construction industry. The concept of construction intelligence is a recent development that merges IT tools with intelligent on-site performance (Mills, Jung & Thabet, 2004). This concept has also been recognized by industry and academic researchers and is incorporated into the Capital Technology Roadmap produced by the industry consortium FIATECH (2005).

ICT in organizations is regarded as a dramatic breakthrough that is expected to increase organizational productivity or performance and to support management functions. The field of management has continued to develop quality assurance applications and both ICT and quality theories have been applied to construction management alongside knowledge management (KM), which governs the process of creating value through an organization’s intelligence. Examples of these applications are knowledge-based systems, human resource management and process improvement.

The need for an effective managerial strategy that incorporates ICT and KM is obvious in construction. There is a growing awareness in the construction industry that intellectual management and leadership processes in construction need to be addressed as a comprehensive, integrated strategy that includes ICT and quality management and takes into account organizational resources as a part of formal knowledge management functions.

1.2. RELEVANCE OF ORGANIZATIONAL INTELLIGENCE IN CONSTRUCTION

In general, all sectors of the construction industry share a common ground in their approach to increasing productivity or performance. However, the discussion has been limited to current improvement of construction processes or adoption of technologies only, with no consideration of the resources or assets that are already available within the organization. Management of construction processes is usually assumed to consist of several fundamental components, such as system, function, application, object, etc, not all of which apply to every process. Although a construction project may be a success, the construction organization typically does not create explicit knowledge from its intangible assets for use on subsequent projects. Moreover, the success of a project is highly dependent on the successful management interactions between players. A working structure must specifically address intellectual abilities and how to manage, maintain, and grow intelligence within an organization's typical managerial processes. Therefore, modeling construction processes in terms of intellectual capital with related factors is important to the construction industry.

Unlike other industries' structures, a construction project typically involves many parties and requires efficient managerial leadership between them. In addition to ICT, many theories of strategic management, for example TQM and KM, are likely to be implemented as intelligent applications that enhance efficient performance. The construction companies involved in a project will be of different sizes and abilities, but the intelligent applications needed for a project cannot take this into account and every construction organization must perform managerial processes routinely, regardless of their size or ability. Intelligent applications that are believed to contribute to performance improvements are not typically customized to suit different organizations' requirements. It is, for instance, questionable how many construction companies can afford to use or invest in Industry Foundation Classes (IFCs) and aecXML[2] schemas related to the managerial process.

In addition, to date individual intelligent applications have been studied in isolation, and so the combined effects of applications that might have an effect on the construction organization have not been identified. It is clear that a critical methodology is required to analyze an organization's status and to identify which intelligent applications or other organizational assets are beneficial to the organization. If the organization fails to take into account organizational differentiations and

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[2] Common schema definitions for AEC/O commodity data based on the standard XML formatting language

applications, an organization will lose its ability to manage and control projects effectively. Thus, research to adapt Organizational Intelligence Management (OIM) for the management of intelligent applications to suit the specific needs of the construction industry is needed.

1.3. PROBLEM STATEMENT

Traditionally, many industries including construction have used the word "productivity" to mean two metrics - time and cost - and this productivity is fundamentally a comparison of units of output to input or dollars to labor-hours of effort.[3] Classical project management is framed by a control philosophy that focuses on time and cost. However, these measurements are not adequate for all organizational processes, especially managerial activities. In addition, all phases of construction involve collaborative activities, which may involve assembly work and work that occurs prior to and after the assembly processes. The evaluation of productivity in construction is thus not solely dependent on time and cost but is also based on other complicated performance dimensions that depend on the use of organizational resources, such as individual human intelligence, corporate knowledge management, business strategy, and so forth. To improve low productivity within a complex system like the construction industry it is therefore necessary to define and analyze each organizational process using reliable criteria.

The construction industry struggles with fragmentation and inaccuracies among people, information, and management (Mills, Lewendowski, and Wakefield, 2002). The lack of management is the root cause of non-productive time, which has created an opportunity and need for standardized and structured repeatable procedures for new management personnel and decision makers. Table 1-2 shows the causes of non-productive time in general construction crafts work. These non-productive times are not only caused by the craftsmen concerned, but also involve other managerial operations such as waiting for resources (16%), waiting for instructions (6%), late or inaccurate information (5%), and so on.

Generally, construction activities divide into two main areas, production management operations and project management operations. The function of production management in construction is to manage the temporary production system dedicated to delivering the product,

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[3] Productivity = Units or Dollars of Output (adjusted for inflation) ÷ Input (labor-hours of Effort)

which may be a residential, commercial or manufacturing facility, while maximizing value and minimizing waste (Ballard & Howell, 2004). The function of project management is to support production operations to ensure the effective and efficient performance of construction processes. Project management therefore includes the managerial processes of planning, organizing, leading, and controlling resources, such as materials, labor, and equipment, to ensure the efficient and successful completion of production.

Non-Productive Time (Craftsman)	
Waiting for Resources	14%
Waiting for Instructions	6%
Multiple Material Handling	6%
Late Starts & Early Quits	6%
Late or Inaccurate Information	5%
Accidents	3%
Waste or Theft	3%
Punch List Work	3%
Redo Work	2%
Substance Abuse	2%

Table 1-2: Non-Productive Time in Construction

(Adapted from Adrian, 2000)

To improve management defects that lead to non-productive time in the construction industry, ICT and other managerial theories offer a way to minimize fragmentation and improve the application of construction knowledge or management operation, which in turn enhance performance. However, it is clear that these state-of-the-art techniques are effective only when they are understood and applied correctly and integrated within a firm's operations. For example, there is general agreement within the industry that the use of an extranet that links construction parties reduces the distribution times for documents. However, it is difficult to quantify the contribution of an extranet to the improvement of performance or productivity in construction projects or even to determine whether extranet technology is suitable for all construction firms or projects. Although several studies have investigated the effectiveness of using IT tools (Williamson and Woo, 2003; Rivard et al., 2004), there is currently no standard method for measuring changes in organizational performance resulting from information technology and associated managerial strategy usage. These technologies and improvements generally contribute to intelligence and performance of management operations within the organization, but the proper usages and applications of these technologies and improvements for a particular management process are still uncertain.

As in other industries, most inefficiencies in construction management can be ascribed to inappropriate decision making based on a lack of managerial knowledge. Many current project personnel simply record and manage construction data, as management personnel barely recognize fundamentals that are part of the integration of organizational resources. Managerial processes must integrate optimally organizational resources to enhance future performance. To correct management misalignments, the construction industry is increasingly accepting technological tools and managerial strategies to maximize construction performance. However, critical methods have not yet been applied to the analysis of misalignment, the identification of significant factors, and the construction of appropriate decision making models, all of which affect the performance of processes in the construction industry. For instance, a company's rank, as measured by the industry, is often considered a common indicator of its performance, this is generally based solely on its revenue. Although valuing work in terms of profit is an important measurement criterion, it is inadequate as a measure of performance or intelligence. Reliable methods are therefore required in order to analyze deficiencies, to minimize investing errors, and to increase the probability that the construction firm will be able to provide the intelligence needed to improve performance.

Multiple ICT tools and managerial strategies designed specifically for the construction industry are available with which to improve the performance of construction processes (e.g., knowledge management, project management information systems, video conferencing, etc), but there are still unresolved issues concerning how best to use them. This research will focus on examining three major issues associated with the establishment of organizational intelligence, including the problems and challenges associated with each:

- A need to define and identify methods for the application of organizational resources to support organizational activities.
- A lack of knowledge concerning how to understand, integrate and optimize organizational resources to mitigate human and management fragmentation in organizational activities.
- A demand for a comprehensive methodology and valuation system that will enable decision makers to identify, document, and value organizational needs and processes.

As yet, little research has been done in this area and the adoption of improvements cannot be clearly justified in terms of the increased value of investments and the improved performance that such techniques should yield to the project and organization. Now, however, as with any organization that desires to understand and improve the effectiveness of its organizational activities, the construction industry is actively seeking ways to enhance its performance.

In order to compare human and organization intelligence, it is first necessary to understand what the terms mean. The study of human intelligence is well established and there has been a great deal of research designed to measure an individual's ability to solve problems in the specific areas of verbal, mathematics, spatial, memory, and reasoning (Flanagan et al., 2000). In contrast, there is as yet no widely accepted definition for organizational intelligence, which is generally taken to include such things as individual employee intelligence, corporate knowledge management, decision support systems, business strategy and its deployment across functions and levels, and so forth. In a typical organization it is questionable whether it has the appropriate ability to perform an organizational activity correctly due to the absence of intellectual measuring standards, although this ability, known as "Organizational Intelligence (OI)," can indeed be measured. The difference between intelligence in human beings and in organizations is that human intelligence is an innate ability that has been passed on from previous generations, while organizational intelligence can be defined as the combined knowledge and skills of the organization's resources. Both types of intelligence can be improved by education, experience, use of tools, and so on. However, if organizational intelligence comes from the resources available within the organization, it therefore follows that this can be managed through their integration and optimization or by adopting intellectual applications from outside sources.

The ability to perform organizational activities depends on the use of appropriate resources. Organizational resources may be abundant, but there is a lack of studies that establish their value for specific organizational activities. Organizational resources include not only items with a physical existence, but also intellectual property such as knowledge, reputation, policy, culture and so on. Organizational resources that have a long-term physical existence are called tangible assets, and organizational resources such as corporate knowledge are called intangible assets, The study of intelligence in organizations can be used as a basis for the development of a conceptual and systematic analysis of an organizational activity and hence the construction of a new managerial knowledge-based approach that can be used to allocate both tangible and intangible assets, or resources, to achieve better performance.

1.4. RESEARCH OBJECTIVES

Specifically, the purpose of this research is to develop the theoretical basis for a new methodology for modeling and achieving organizational intelligence. This approach will study and incorporate capital management theory and human intelligence theory and will use case studies in support of the study of organizational processes in order to formulate a new managerial theory. This research is designed to achieve several main objectives:

1. Define OI in terms of the combined knowledge and skills within the organization.
2. Suggest organizational cognitive ability that parallels and mimics human intelligence
3. Create a framework and prototype to incorporate the basic structure and description of intellectual capital into the model of organizational activities
4. Identify all the knowledge elements related to OI that contribute to organizational performance
5. Develop learning models that describe the managerial process that integrate all of the knowledge elements for effective and efficient performance

1.5. RESEARCH CONTRIBUTION

The primary contribution of this research is **the development and validation of a theoretical framework for Organizational Intelligence (OI) that will provide a firm foundation for the development of new knowledge to facilitate organizational management.** Using the theoretical framework developed from an in-depth review of the literature on intelligence and economics, a prototype (Intelligibility Learning Model) has been formulated and applied to a construction management procedure, namely the submittal process. The details and sequence of this contribution are as follows:

1. A new approach to organizational intelligence based on a review of the literature on intelligence (i.e., human intelligence) and economics (i.e., capital management theory), is utilized in this study. Information garnered from the review is used to identify current research into intelligence, especially human intelligence and how it is related to and is differentiated from intelligence in organizations.
2. The information gathered in the review provides a theoretical framework, hereafter designated Organizational Intelligence (OI). The organizational intelligence framework encompasses the combined knowledge and skills regarding the organization's assets that that organization can call on to support specific organizational activities. In the formulation of OI, a number of new concepts were defined and/or redefined for this body of work – organizational intelligence management, organizational cognitive ability, and intellectual capital (i.e. human, organizational and relational capital). These concepts crystallize the operating principals involved in organizational activities.
3. From the OI framework a prototype, hereafter referred to as the Intelligibility Learning Model (ILM), was formulated. The ILM defines the role of relationships in organizational activities and how the organization's resources are utilized. The prototype developed within this dissertation provides the backbone for learning modeling as well as the foundation for a new theory of Organizational Intelligence Management (OIM). The learning model allows the analysis of an organizational activity by breaking it up into a series of sequential tasks. It covers all the knowledge elements (e.g., ability, interdependence, transformation, etc.) that can contribute to effective and efficient organizational performance. Current managerial processes in the

construction industry are separated into sequential tasks with stages, and the representation of these sequential tasks is demonstrated through flow charts (see Chapter 5). The use of flow charts for current managerial processes makes it possible for decision makers to address both common and critical aspects and to shed new light on standard and alternative activities

4. A case based research approach is utilized to apply the prototype, the Intelligibility Learning Model, to a common managerial process in the construction industry. The ILM provides comprehensive information for more effective and efficient performance through three sequential tasks as follows:
    a) Defining a procedural analysis in order to standardize organizational activities.
    b) Defining appropriate organizational resources in order to determine applicable technologies and improvements.
    c) Defining important factors in order to optimize organizational activities
5. The identification and application of the OI framework constitutes the foundation of a new theory, Organizational Intelligence Management (OIM), that can be used to further develop new managerial strategies. This theory is a culmination of this research and is its major contribution to the field. It will enable managerial personnel in industrial settings to better understand organizational issues and make appropriate decisions to improve performance.

1.6. JUSTIFICATION

The formal definition of an organization is that it is a social entity that is goal-directed and deliberately structured. It is a social entity because it is made up of two or more people, while being goal-directed means it is designed to achieve some outcome. Deliberately structured indicates that tasks are divided up and responsibility for their performance is assigned to organizational resources (Daft and Marcic, 2001). Hence, all organizations including the construction industry must carry out organizational activities successfully by utilizing the available resources, and the effective and efficient performance of these organizational activities is based on the integration and optimization of organizational resources. The activity of integration and optimization is referred to as organizational intelligence and is directly connected with the level of outcome achieving.

It is clear that better organizational resource management practices and the application of an appropriate decision-making model could increase efficiency in integration and optimization and thus improve the organization's performance. Currently, many technologies and business improvements are available that could contribute to these goals and many research studies have looked at the deployment of information technologies and the adoption of business improvements to the construction sites and processes, arguing that this constitutes intelligence. However, this provides a very limited view of intelligence that fails to take into account the contributions due to organizational activities and resources. There is as yet no structured approach to identifying the optimal integration of organizational resources that will lead to a more effective and efficient performance for specific organizational activities. Therefore, this research investigates the origin of organizational intelligence and the attributes of organizations that contribute to its formation. The definitions provided here of organization, intelligence, capital, and performance, the concepts that make up this knowledge, and a mapping of their relationship and use are a first vital step towards building a new managerial theory for organizational intelligence.

1.7. HYPOTHESES

The proposed research will test several hypotheses for an organizational knowledge framework drawn from the study of human intelligence and organizational assets as follows:

1. Organizational intelligence is the combination of knowledge and skills that can be used to perform organizational activities using both tangible and intangible assets within the organization.
2. Three intellectual capitals, Human Capital (HC), Organizational Capital (OC), and Relational Capital (RC), are composed of both tangible and intangible assets.
3. Organizational Intelligence (OI) can emulate human intelligence, especially human cognitive ability.
4. Within a given organization, any activities are processed and supported by its Intellectual Capitals.
5. The integration of HC, OC, and RC into the organization's activities is directly connected with OI and organizational performance.

1.8. RESEARCH METHODOLOGY

There is no widely accepted definition of OI. Thus, it is not immediately obvious how best to apply the notion of intelligence to an organization. It is therefore vital to create a definition for OI. The approach adopted for this research examines a way to use intellectual capital to support organizational processes. Additionally, this research suggests the use of a new concept, organizational cognitive ability, which is concerned with all levels of tasks in organizations, to explore organizational resource effectiveness. The study of OI in construction management takes a collaborative approach to establish common notions from existing studies about human intelligence, cognitive ability, construction processes, performance, and intellectual capital. This research consists of the following primary tasks:

1. Emulation
    a. Conduct a literature review to establish a foundation for OI
        - Review the concept of Intelligence in humans, businesses, machines, and organizations
        - Review existing theories and applications of intellectual capital
    b. Determine organizational cognitive abilities
        - Determine how the cognitive ability of an organization is used by extracting and analyzing the intelligence literature
        - Define organizational cognitive ability in terms of its support for organizational activities
2. Categorization
    a. Identify and apply intellectual capital in terms of the elements that form and affect an organizational activity
        - Determine which elements are components of intellectual capital (e.g., education, experience, policy, culture, system, etc)
    b. Observe the phenomena related to intellectual capital and organizational activities
        - Determine which relationships and interactions among the different capitals affect an organizational activity
3. Analysis

    a. Analyze organizational activities by breaking them down into sequential steps/tasks
        - Review organizational activities, especially managerial processes, in construction
        - Determine the order in which the tasks should be accomplished to serve as the basis for a procedural analysis and hence the prototype

4. Creation
    a. Create a learning model prototype
        - Develop perspectives that determine the principals of organizational activities and resources
        - Determine the structures and components that govern each perspective
5. Validation
    a. Validate the proposed prototype with case studies (both illustrative and exploratory)
        - Deconstruct a specific managerial process into sequential tasks with interviews (illustrative case study)
        - Develop questionnaires for a pilot study using information gathered from the illustrative case study and the prototype
        - Execute the exploratory study with construction professionals
        - Develop a comprehensive set of knowledge elements using the learning model
6. Implementation
    a. Develop the concept of OI as a knowledge management approach that presents a systematic strategy for the analysis of managerial tasks
        - Propose the learning model prototype as a standard managerial knowledge process that reveals various elements on completion of OIM

1.9. SCOPE AND LIMITATION OF RESEARCH

This research adapts and extends the study of intelligence and capital management theory and develops a theoretical framework for organizational intelligence. Based on this theoretical framework, a new prototype is formulated and applied to a real-world managerial process in order to validate the new theory, Organization Intelligence Management, and facilitate the development of new and more effective managerial strategies.

This research conducts a procedural analysis to determine the comprehensive knowledge elements needed for the effective integration and optimization of organizational resources in common organizational activities, especially managerial processes. A learning model prototype known as the Intelligibility Learning Model (ILM) is then created and used to present a series of managerial processes as a function of OIM. The learning model prototype provides a fully comprehensive set of information that can be used to analyze organizational activities intelligently, including sequential task analysis, professional and organizational requirements, performance factors, and similar functions. Figure 1-1 illustrates the basic scope of this dissertation. First, this research conducts a literature review that reveals the current status of research in the fields of human intelligence and intellectual capital. It then goes on to define organizational intelligence as the combined knowledge and skills of organizational resources and create a prototype that supports the theory of organizational intelligence. Finally, the new theory of OI that is developed is validated using case based studies that apply the prototype to the type of managerial processes commonly found in construction.

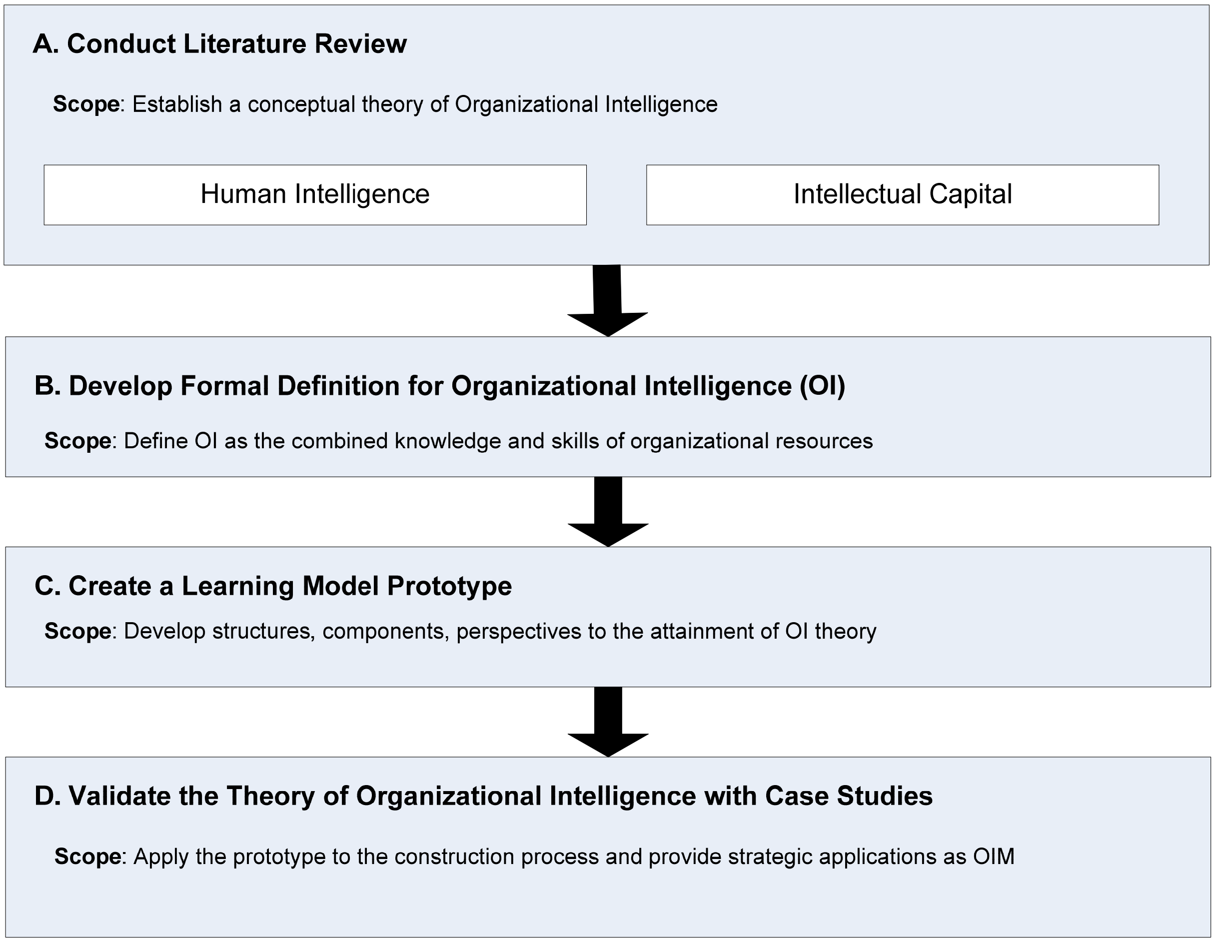


Figure 1-1: The Basic Scope of the Research

The proposed research will be limited in scope by the following constraints:

- This research will only address managerial processes in general construction contracting.
- The research will identify organizational cognitive ability from a managerial process that suggests organizational resources for effective and efficient performance.
- The research will investigate and analyze a selected construction managerial process in order to illustrate how to use intellectual capital based on the procedural analysis of the theoretical model used as a mechanism to define and enhance OI.
- The research analyzes and characterizes particular processes as normalized industrial standard procedures.

- The research determines the latent factors that affect the performance of managerial processes.
- The research explores and suggests, but does not quantify, possible elements that can be utilized as indicators of organizational intelligence

1.10. DISSERTATION ORGANIZATION

This dissertation is organized into seven chapters, described in turn below. There is also an Appendix, given as Chapter 8, which provides more detailed information about the pilot study.

Chapter 1 – Research Statement: Provides background information related to this research; describes the general concepts involved and problems in the area of study and defines the objectives, scope, hypothesis, and methodology. Chapter 1 also lists the study's limitations and discusses its potential contribution to the construction industry.

Chapter 2 – Literature Review: Summarizes the current research literature on intelligence in three areas relevant to this study. This chapter describes the psychological background of human intelligence generally and then goes on to discuss business and machine intelligence and concludes by looking at the notion of intellectual capital in economics.

Chapter 3 – Development of Organizational Intelligence: Defines organizational intelligence and describes the structures and elements of organizational intelligence management, focusing on how this new theory is developed from the conceptual to the application level. Chapter 3 also defines related terms that make up the main theory of OI, including organizational cognitive ability and intellectual capital, and suggests elements that contribute to each term.

Chapter 4 – A Framework of Learning Model Prototype: Describes the structure of the Intelligibility Learning Model (ILM), as well as the mechanism of each variable in the ILM prototype and how it applies to a particular process, with six perspectives.

Chapter 5 – The Application of the Intelligibility Learning Model within the Construction Process: Presents the learning process for the proposed ILM using an example of a project management operation. This chapter first defines the abilities that are required in order to perform the managerial activity in the organization. Then particular methods that are used in the organization are compared to show how the required abilities apply to each of the four perspectives.

Chapter 6 – Organizational Intelligence Management with Intelligibility Learning Model: Presents a systematic factor-based strategy for OIM through the pilot study utilizing the ILM. The analysis of the pilot study facilitates the understanding and integration of organizational assets and describes the opportunities offered by OIM for managing both organizational activities and assets.

Chapter 7 – Conclusions and Recommendations: Summarizes the research hypotheses and findings, including the study's contribution to the body of knowledge as a new theory. In addition to summarizing the study's findings and drawing conclusions, the direction of future research and recommendations for future development in the area of organizational intelligence management are discussed.

Appendix - Includes the Intelligibility Learning Model and its application to the production management operation, the survey form used in the pilot study, and results from the pilot study data gathered from the three construction professionals who participated. The analysis of the production management in terms of a series of sequential tasks is used as a basis for recommendations regarding the development of future ILM applications.

CHAPTER 2: LITERATURE REVIEW

The search of the relevant literature in this chapter will be used to develop a firm theoretical knowledge base upon which to build the new Management of Organizational Intelligence model. The following areas are examined:

1. Human intelligence with cognitive ability
2. Other intelligence studies
3. Intellectual capital in the organization

The literature on human intelligence will be discussed first because it is fundamental to the whole endeavor. The term "intelligence", whose use was originally limited to considering ability differences in human beings, has evolved over the years to include a broader spectrum of applications and here will be extended further to cover its analog in organizations.

The defined variables in tests of human intelligence or mental ability for human Intelligence Quotient (IQ) models are measures of an individual's problem solving ability and potential verbal, mathematical, spatial, memory and reasoning skills. A great deal of effort has been devoted to studies in this area and substantial progress has been achieved, considerably advancing our understanding and measurement of human intelligence since the early part of the last century. This research into human intelligence has enabled other industries to implement human-like control procedures in fields such as automation and decision-making, resulting in innovations that are now part of our everyday lives such as artificial intelligence, machine intelligence and business intelligence.

This chapter explores typical architectures and measuring components in three intelligence areas, namely human, machine, and business relationships between organizational resources, by studying the related research literature. The information in this chapter is important as it provides a vital source of possible ideas and principals that can be developed into the foundation for a new theory of organizational intelligence.

2.1. WHAT IS ‘INTELLIGENCE’?

When it comes to defining intelligence opinions are divided into two major camps. First, according to a report from a task force established by the Board of Scientific Affairs of the American Psychological Association (Neisser et al., 1996), the definition of intelligence should take into account both ‘Known and Unknown’ factors:

Individuals differ from one another in their ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, to overcome obstacles by taking thought. Although these individual differences can be substantial, they are never entirely consistent: a given person’s intellectual performance will vary on different occasions, in different domains, as judged by different criteria. Concepts of "intelligence" are attempts to clarify and organize this complex set of phenomena.

The second definition comes from an editorial in the journal *Intelligence* and was agreed by 52 intelligence researchers (Gottfredson, 1997):

a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings—"catching on", "making sense" of things, or "figuring out" what to do.

These definitions of intelligence are focused on human intelligence, but in fact the concept of intelligence may take different meanings in different areas, for example in business, machine, and military intelligence. Most modern industries are information intensive structures, so in this area the definition of intelligence can be considered to consist of information gathering. Hence, intelligence is the process and the result is a capability that can be measured in the form of an intelligence quotient based on the results of the application of this capability to processes. In addition to analyzing the information that has been gathered, intelligence answers questions or gives advance warnings that facilitate planning or decision-making for future development.

2.2. HUMAN INTELLIGENCE QUOTIENT (IQ)

People believe that children and adults vary in their intelligence even though it is hard to specify precisely what intelligence really means. Measuring supposed differences in intelligence has thus become the task of science. The early history of IQ testing can be found in Darwin’s theory of evolution by natural selection. Two of the basic premises of that theory are that there is variation among members of any species, and that this variation is inherited, with differences between parents in one generation being transmitted to their offspring in the next (Mackintosh, 1998).

Based on Darwin’s theory, Galton suggested the possibility that there may be inherited differences among people in important characteristics such as mental ability or intelligence, and he is known for his pioneering studies of human intelligence. He started with physical measures, such as head size, to test intelligence but soon realized that head size alone was an imperfect indicator of ability. Other measures tested were reaction time and sensory acuity, but he was unable to find correlations from each measure (Galton, 1869, as cited in Plucker, 2003).

In 1905, the intelligent quotient was proposed by the French psychologists, Alfred Binet and his assistant Theodore Simons, and this still forms the basis for much current IQ testing (Binet, 1905). Binet had been charged by a governmental commission with the task of finding a quick and reliable method of identifying children who would be unable to profit in a normal manner from the instruction given in ordinary French schools in 1904. This test was thus devised specifically to distinguish between mentally subnormal children and normal children. The basic insight was the decision to measure intelligence with respect to age, and they found that the mentally handicapped children’s performances could be equated with those of much younger normal children. With this methodology they therefore created a set of questions for age-linked items that reflected the average knowledge and capabilities of specific age groups.

The scale proposed by Binet and Simon was made up of thirty tests (Binet, 1905):

- Le Regard
- Prehension Provoked by Tactile Stimulus
- Prehension Provoked by a Visual Perception
- Recognition of Food
- Quest of Food Complicated by a Slight Mechanical Difficulty
- Execution of Simple
- Verbal Knowledge of Objects
- Verbal Knowledge of Pictures
- Naming of Designated Objects
- Immediate Comparison of Two Lines of Unequal Lengths
- Repetition of Three Figures
- Comparison of Two Weights
- Suggestibility
- Verbal Definition of Known Objects
- Repetition of Sentences of Fifteen Words
- Comparison of Known Objects from Memory
- Exercise of Memory on Pictures
- Drawing Design from Memory
- Immediate Repetition of Figures
- Resemblances of Several Known Objects Given form Memory
- Comparison of Lengths
- Five Weights to be Placed in Order
- Gap in weights
- Exercise upon Rhymes
- Verbal Gaps to be Filled
- Synthesis of Three Words in One Sentence
- Reversal of the Hands of a Clock
- Paper Cutting
- Commands of Simple Gestures
- Definitions of Abstract Terms

For instance, the test of ‘Synthesis of Three Words in One Sentence’ in the twenty-sixth exercise is a test in spontaneity, facility of invention and combination, and aptitude for constructing sentences. The procedure used is as follows (Binet, 1905):

“Three words are proposed: Paris, river, fortune. Ask that a sentence be made using those three words. It is necessary to be very clear, and to explain to those who may not chance to know what a sentence is. Many subjects remain powerless before this difficulty, which is beyond their capacity. Others can make a sentence with a given word but they cannot attain to the putting of three words in a single sentence".

A criterion of 75% passing was used to determine each test's placement. Thus, if 75% or more of six-year-olds passed a given test, it was placed at the six-year-old level. An especially useful aspect of the 1905 scale was that it provided for the possibility of expressing a child's level of intelligence in relation to the age group whose performance he or she matched. A six-year old child, for example, who performed as well as the average eight-year old, would have a "mental level" of eight. The mental level represented the averaging out of successes and failures that matched the given age norm (Minton, 1998).

The quotient of the age could be obtained and compared the chronological age to produce the decimal IQ using the following equation:

$$IQ = (\text{Mental Age} / \text{Chronological Age})$$

The primary aim of such tests is to determine a child's present mental status so that a decision can be made about the appropriate curriculum placement, either in special education or in regular classroom instruction.

Lewis Terman a psychologist at Stanford modified the test in 1916, adding new items like "fill-in-the-word" and fable integration (Terman, 1916, as cited in Gould, 1981), and removing several of Binet and Simon's original items. He also multiplied Binet's percent form by 100 to eliminate decimals. This simplification of the results of the test into one easy number contributed to the reification of intelligence, and it is now referred to as the 'Stanford-Binet Intelligence Scales' and used as an essential part of human intelligence measurement. In the spring of 1917, the Stanford-Binet Scales were modified yet again for the army. Approximately 1.75 million men were tested, and on this basis recommendations were made with respect to job placements or immediate discharge from the army (Minton, 1998).

The version of the Stanford-Binet Intelligence Scales Assessment that is currently most widely used has been edited by Roid in2003 (Roid and Barram, 2004) based on the five-factor hierarchical cognitive model shown in Figure 2-1, and it is known as SB5 or SBIS-V. The five cognitive factors of the SB5 were selected based on research on school achievement and on expert ratings of the importance of these factors in the assessment of reasoning, especially in giftedness assessment (Roid and Barram, 2004). The verbal and nonverbal domains include five subtests each. The verbal subtests require facility with words and printed material.

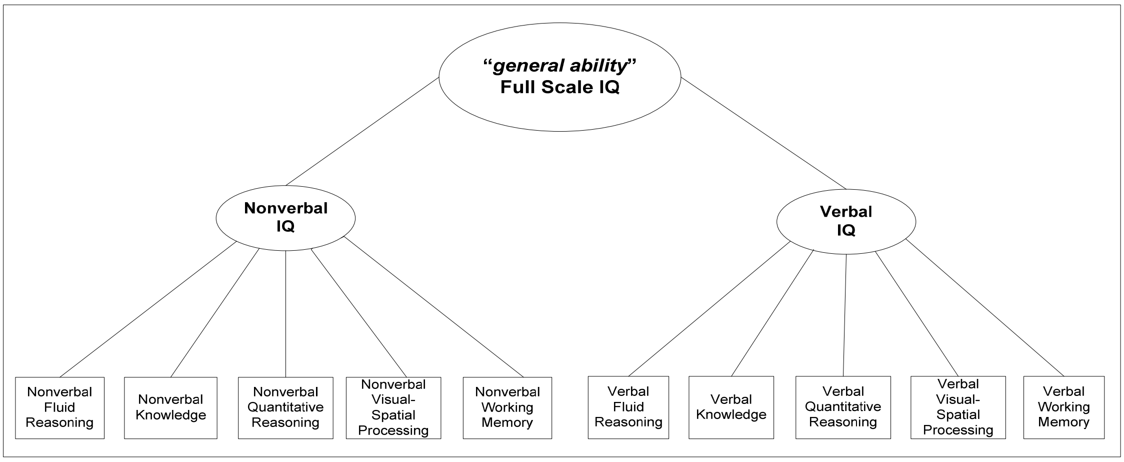


Figure 2-1: The Hierarchical Structure of the SB5 Scoring System

(Adapted from Roid and Barram, 2004)

The nonverbal subtests require a small degree of receptive language and allow for pointing responses, the movement of puzzle-like pieces, and manipulation of toys to indicate correct answers. A description of subtests is provided in Table 2-1. Normative scores usually include scaled scores ranging from 1 to 19 for subtests, and standard scores ranging from 40 to 160 (average 100) approximately for factors and IQ composites.

Another important step in measuring human intelligence was achieved by David Wechsler (Flanagan et al., 2000). His definition of intelligence as "the global capacity to act purposefully, to think rationally, and to deal effectively with his environment" included the idea that intelligence is not a single capacity but a multifaceted aggregate. He developed the Wechsler Adult Intelligence Scale in 1939. The science of intellectual assessment proposed by Wechsler was based on four factor indices, namely verbal comprehension, perceptual organization, working memory, and processing speed, and subtests from each of these indexes are shown in Table 2-2. Wechsler Scales are used to generate peer comparison scores based on percentile rank, and the range of standard scores for total composites is from 40 to 160, approximately.

Subtests		Description
Nonverbal	Fluid Reasoning	Object Series/Matrices (a point scale used for routing). Includes new sequential reasoning items and classic matrices.
	Knowledge	Procedural Knowledge (a new type of item involving gestures), followed by Picture Absurdities (a classical subtest in the Stanford-Binet tradition).
	Quantitative Reasoning	Nonverbal Quantitative Reasoning items, tapping number concepts, problem solving, and figure-geometric/measurement-estimation problems.
	Visual-Spatial Reasoning	Form Board, followed by the new Form Patterns (making designs from an expanded set of form-board pieces).
	Working Memory	Delayed Response (e.g., hiding an object under cup) at low levels followed by Block Span.
Verbal	Fluid Reasoning	Early reasoning items (e.g., picture reasoning) followed by classic Verbal Absurdities and Verbal Analogies.
	Knowledge	Vocabulary (a point scale used for routing), Includes toys, identification of body parts, Child Card, and classic word definitions.
	Quantitative Reasoning	Verbal Quantitative Reasoning items, tapping number concepts, problem solving, and figure-geometric/measurement-estimation problems.
	Visual-Spatial Reasoning	Innovative new Position and Direction (verbal-spatial problems requiring explanation of directions, identifying spatial relations in pictures, understanding complex statements of spatial orientation).
	Working Memory	Classic Memory for Sentences followed by an innovative Last Word procedure (requiring memory of the last world of series of questions)

Table 2-1: Subtests of the SB5

(Source: Roid and Barram, 2004)

Verbal Comprehension (VC)	Perceptual Organization (PO)
Information Similarities Vocabulary Comprehension	Picture Comprehension Block Design Matrix Reasoning
Working Memory (WM)	**Processing Speed (PS)**
Arithmetic Digit Span Letter-Number Sequencing	Digit Symbol-Coding Symbol Search

Table 2-2: Wechsler Factor Indexes and Organizational Subtests

(Source: Flanagan et al., 2000)

2.3. HUMAN COGNITIVE ABILITIES

An ability is defined as “the quality of being able to do something: physical, mental, financial, or legal power to accomplish something” according to the *American Heritage Dictionary* (2000). Using a psychological perspective, English and English (1958, p. 1) defined ability as “[the] actual power to perform an act, physical or mental, whether or not attained by training and education,” and they distinguish between two major types of abilities with the following definition:

“**General Ability** is concerned with all sorts of tasks, but especially those of a cognitive or intellectual sort. Syn. *Intelligence*.
Special Ability has to do with a defined kind of task. Each special ability should, when possible, be so defined as not to overlap with other special abilities.” (1958, p. 1)

Although the term “ability” can be used to characterize or modify attributes of human individuals such as musical ability, athletic ability, or cognitive ability, cognitive ability is generally concerned with all levels of tasks in human beings. “Task is defined as any activity in which a person engages, given an appropriate setting, in order to achieve a specifiable class of objectives, final results, or terminal states of affairs" (Carroll, 1993, p. 8).

The study of cognitive abilities is an important part of the quest to develop a test of mental ability. Cognitive abilities can be interpreted in the developmental period of mental testing as being oriented toward the measurement of a common concept of intelligence. Defining cognitive abilities in terms of a single measure originated from Charles Spearman's assertion that: "mental abilities of nearly all kinds are positively linked in the sense that if we are good at one thing, we are also likely to be good at others" (Spearman, 1904, as cited in Flanagan, et al., 2000). He proposed the concept 'general intelligence,' which is now known as the psychometric '*g*.' According to Spearman, intelligence consists of two kinds of factors: a single general factor and the g factor (or g) that would explain all observed correlations.

Based on factor analysis in mental abilities, the *Gf-Gc* theory has been developed as a foundation for the development and interpretation of intelligence batteries. R. B. Cattell (1941) first postulated *Gf-Gc* theory as consisting two major types of cognitive abilities: Fluid Intelligence and Crystallized Intelligence. This is now known as the Cattell-Horn theory of fluid and crystallized intelligence (Plucker, 2003). The *Gf-Gc* theory has been used to understand and create order within the domain of human cognitive abilities and has been extended into the ten cognitive abilities shown in Table 2-3. The broad abilities, in the form of the ten cognitive abilities, represent "basic constitutional and longstanding characteristics of individuals that can govern or influence a great variety of behaviors in a given domain" and they vary in their emphasis on process, content, and manner of response (Carroll, 1993).

Ability	**Definition**
Fluid Intelligence (*Gf*)	Mental operations with a relatively novel task: forming and recognizing concepts, drawing inferences, comprehending implications, problem solving, extrapolating.
Crystallized Intelligence (*Gc*)	The breadth and depth of person's acquired knowledge of a culture and the effective application of this knowledge.
Quantitative Knowledge (*Gq*)	An individual's store of acquired quantitative declarative and procedural knowledge
Reading/Writing Ability (*Grw*)	An acquired knowledge about basic reading and writing skills required for the comprehension of written language and the expression of thought via writing.
Short-Term Memory (*Gsm*)	The ability to apprehend and hold information in immediate awareness and then use it within few seconds.
Visual Processing (*Gv*)	The ability to generate, perceive, analyze, synthesis, store, retrieve, manipulate, transform, and think with visual patterns and stimuli.
Auditory Processing (*Ga*)	Cognitive abilities that depend on sound as input and on the functioning of our hearing apparatus and reflect the degree to control the perception of auditory stimuli inputs.
Long-Term Storage and Retrieval (*Glr*)	The ability to store information in and fluently retrieve new or previously acquired information
Processing Speed (*Gs*)	The ability to fluently and automatically perform cognitive tasks.
Decision/Reaction Time (*Gt*)	An individual's quickness in reacting (reaction time) and making decision (decision speed)

Table 2-3: The Definitions of *Gf*-*Gc* Broad and Narrow Abilities

(Source: Flanagan et al., 2000)

2.4. THE LINKAGE BETWEEN HUMAN COGNITIVE ABILITIES AND IQ TESTS

The domain of human cognitive abilities can be used to determine which subtests from each factor index in a particular intelligence quotient scales test is best suited to evaluating that aspect of human intelligence. For instance, picture completion, a subtest of perceptual organization in the Wechsler Scales test, can be used to estimate the abilities in Crystallized Intelligence (*Gc*) and Visual Processing (*Gv*). The following figures display the linkage between the domains of cognitive abilities and intelligence quotient test areas independent of whether the area of IQ tests in SB5, WAIS-III, and WJ-III is represented by the factorial nature of cognitive abilities. The human cognitive ability domains in Figures 2-2 to 2-4 were developed by Flanagan et al. (2000) to assess the coverage of human intelligence tests and identify each test area. Then, each test area is linked with the appropriate human cognitive ability for the three tests: the Stanford-Binet V test (Figure 2-2), the WAIS-III test (Figure 2-3), and the WJ-III test (Figure 2-4). The graphical connections developed for this research are based on the validation of Flanagan et al.'s study (2000, Figure 2-3) and applied to the other figures (Figures 2-2 and 2-4).

The Stanford-Binet V test is constructed on a five-factor hierarchical cognitive model (Roid, 2003) and based on the important research of Carroll (1993). The linkage in Figure 2-2 indicates that the components of this test are designated to represent all the human cognitive ability domains except *Grw* (Reading and Writing Ability) and *Ga* (Auditory Processing). Therefore, two human cognitive abilities, *Grw* (Reading and Writing Ability) and *Ga* (Auditory Processing), are not connected with any test area because this test is not designed to cover these abilities.

The development of Wechsler's test was not based on theory (except perhaps Spearman's *g*, or general intelligence theory) but instead on practical clinical perspectives (Kafuman et al., 1993). WAIS-III subtests originated from the existing source of subtests; subtests of verbal comprehension, for instance, are mostly developed from Stanford-Binet's subtests. Flanagan et al. (2000) tried to validate the structural relationship between WAIS-III and the domain of human cognitive abilities, as shown in Figure 2-3. The WAIS-III IQ test is designed to test six human cognitive abilities, omitting *Grw* (Reading and Writing Ability), *Ga* (Auditory Processing), *Glr* (Long-Term Storage and Retrieval), and *Gt* (Decision/Reaction Time).

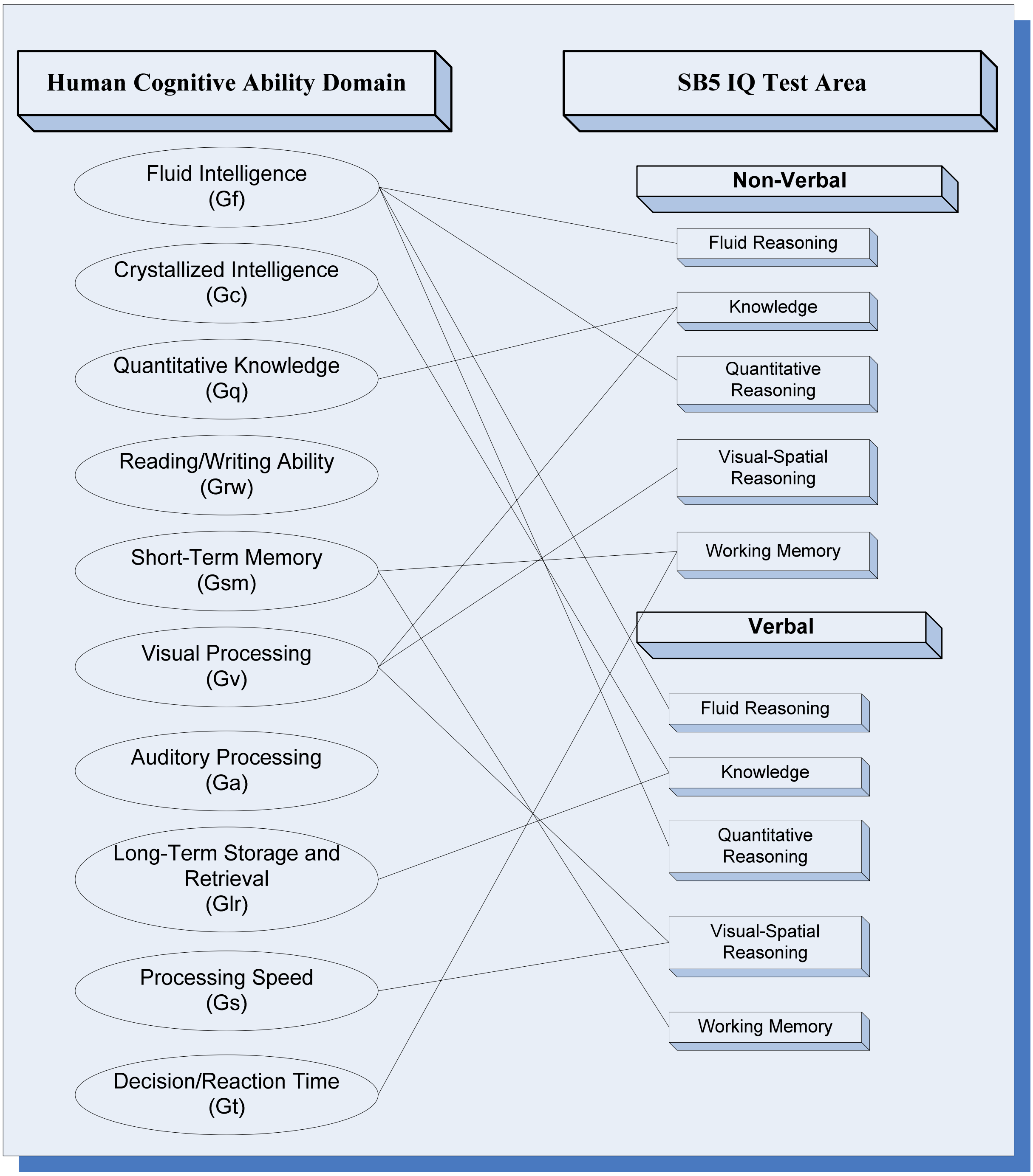


Figure 2-2: The Linkage between Cognitive Ability Domain and SB V IQ Test

(Sources: Flanagan et al., 2000 and Roid et al, 2004)

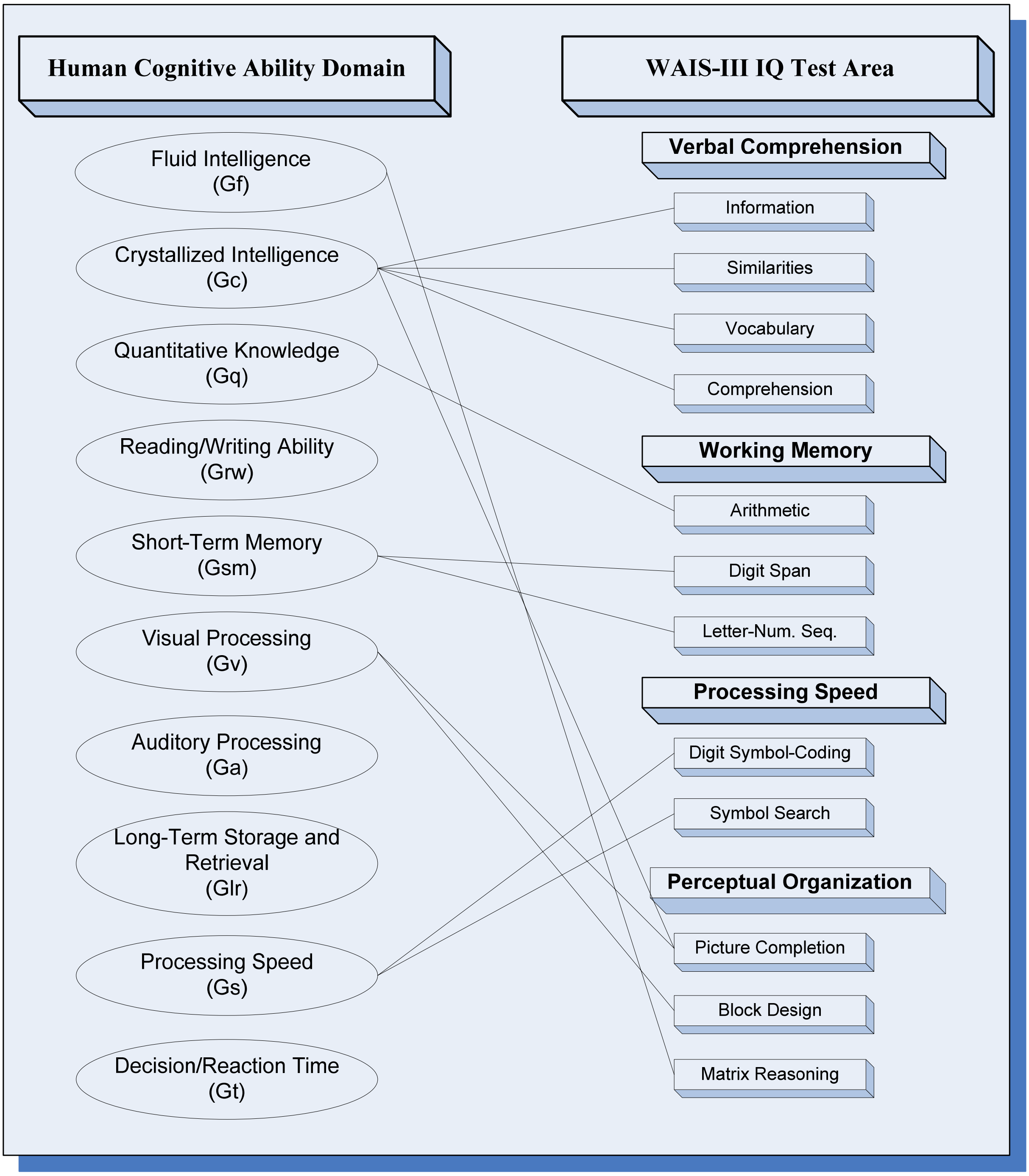


Figure 2-3: The Linkage between Ability Domain and WAIS-III IQ Test

(Source: Flanagan et al., 2000)

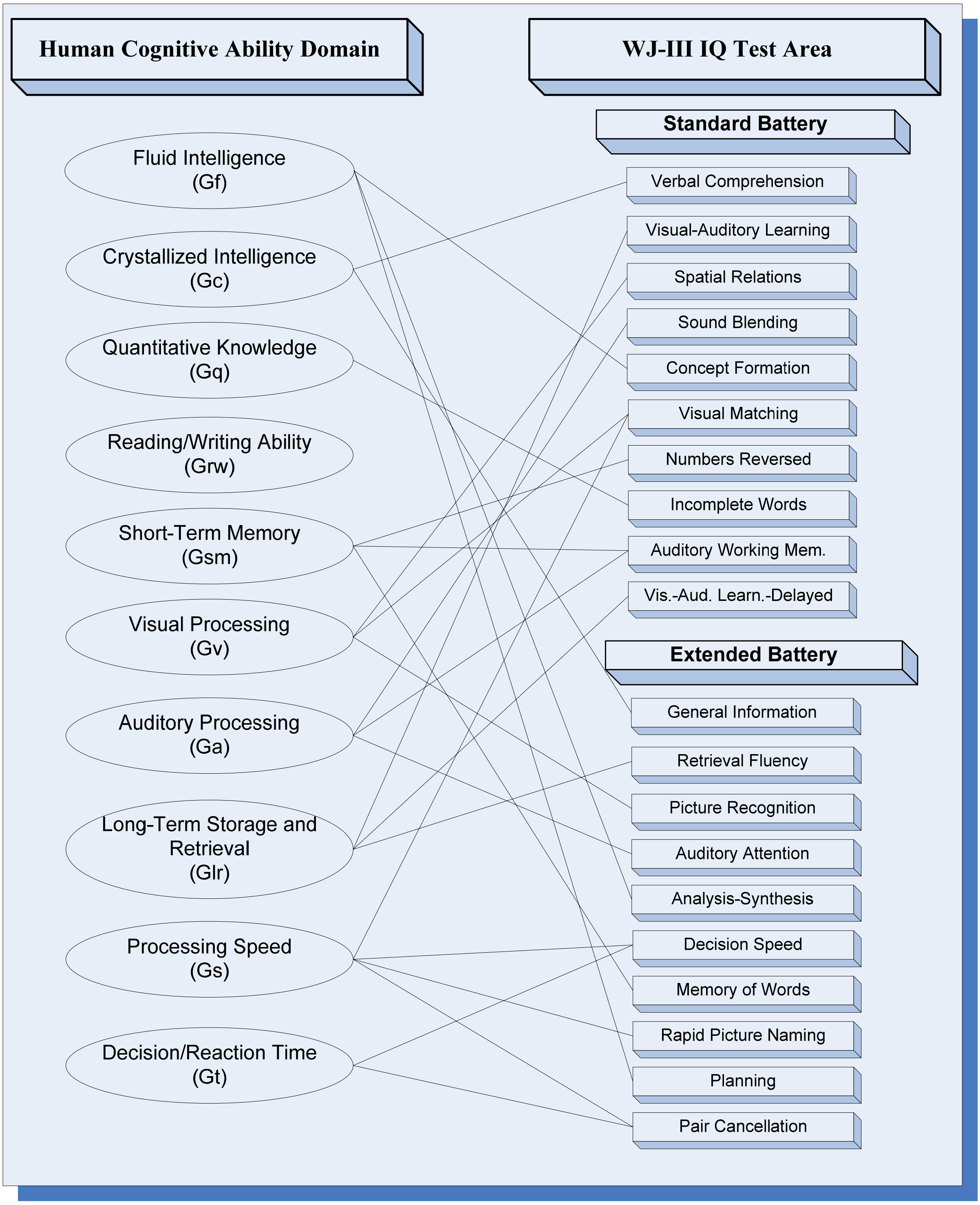


Figure 2-4: The Linkage between Ability Domain and WJ-III IQ Test

(Sources: Flanagan et al., 2000 and Woodcock et al., 2001)

The *Gf-Gc* model is the most widely accepted theory of intellectual factors, characterizing human cognitive abilities in terms of fluid and crystallized intelligence. It has been expanded and developed to incorporate broad abilities, as mentioned earlier, and is now referred to as the Cattell-Horn-Carroll (CHC) theory (Woodcock and Mather, 1989).

The WJ-III Tests of Cognitive Abilities are based on the Cattell-Horn-Carroll (CHC) theory of cognitive ability, which combines Cattell and Horn's *Gf-Gc* theory and Carroll's three–stratum theory (Woodcock, McGrew and Mather, 2001). These tests are designed to measure general and specific cognitive functions and are used for educational, clinical or research purposes to determine specific strengths and weakness in place of common IQ tests. Figure 2-4 shows the linkage, and WJ-III subtest reflects the complexity of cognitive abilities. The WJ-III IQ test shown in Figure 2-4 covers most human cognitive abilities, omitting only *Grw* (Reading and Writing Ability). The standard battery consists of tests 1 through 10, and the extended battery tests are 11 through 20. Depending on the purpose and extent of the assessment, examiners can either use the Standard Battery alone, or in conjunction with the Extended Battery.

Table 2-4 shows a comparison between cognitive abilities and subtests in the three IQ tests based on the figures above.

Although the two most widely used standardized tests of intelligence are the Wechsler scales and the Stanford-Binet, the study of intelligence has proved to be a continuously evolving, dynamic field, with the breadth of the field expanding rapidly over the past 25 – 30 years (Plucker, 2003). Measures have now been developed to measure items such as multiple intelligence, social intelligence, and emotional intelligence for human beings. Table 2-5 shows a list of the more commonly used intelligence quotient measures.

Human Cognitive Abilities Intelligence Quotient Tests			Fluid Intelligence	Crystallized Intelligence	Quantitative Knowledge	Reading/Writing Ability	Short-Term Memory	Visual Processing	Auditory Processing	Long-Term Storage and Retrieval	Processing Speed	Decision/Reaction Time
SBV	Non-Verbal	Fluid Reasoning	●									
		Knowledge			●			●				
		Quantitative Reasoning	●									
		Visual-Spatial Reasoning						●				
		Working Memory					●					●
	Verbal	Fluid Reasoning	●									
		Knowledge		●						●		
		Quantitative Reasoning	●									
		Visual-Spatial Reasoning						●			●	
		Working Memory					●					
WAIS-III	Verbal Comprehension	Information		●								
		Similarities		●								
		Vocabulary		●								
		Completion		●								
	Working Memory	Arithmetic			●							
		Digit Span					●					
		Letter-Num. Sequence					●					
	Processing Speed	Digit Symbol-Coding									●	
		Symbol Search									●	
	Perceptual Organization	Picture Completion			●			●				
		Block Design						●				
		Matrix Reasoning	●									
WJ-III	Standard Battery	Verbal Comprehension		●								
		Visual-Auditory Learning						●	●	●		
		Spatial Relations										
		Sound Blending										
		Concept Formation	●									
		Visual Matching						●			●	
		Numbers Reversed					●					
		Incomplete Words			●							
		Auditory Working Mem.					●		●			
		Vis.-Aud. Learn.-Delayed								●		
	Extended Battery	General Information		●								
		Retrieval Fluency								●		
		Picture Recognition						●				
		Auditory Attention							●			
		Analysis-Synthesis	●									
		Decision Speed									●	●
		Memory of Words					●					
		Rapid Picture Naming									●	
		Planning	●									
		Pair Cancellation									●	●

Table 2-4: IQ Tests of Cognitive Domains

Test	Age Range	Description
Stanford-Binet Intelligence Scale, Fifth Edition (SBIS-V)	2 – 90+	An update of the SB-IV. In addition to providing a Full Scale score, it assesses Fluid Reasoning, Knowledge, Quantitative Reasoning, Visual-Spatial Processing, and Working Memory as well as the ability to compare verbal and nonverbal performance.
Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV)	6 – 16-11	An update of the WISC-III, this test yields a Full Scale score and scores for Verbal Comprehension, Working Memory, Perceptual Reasoning, and Processing speed.
Woodcock-Johnson III Tests of Cognitive Abilities	2 – 90+	This test gives a measure of general intellectual ability, as well as looking at working memory and executive function skills.
Cognitive Assessment System (CAS)	5 - 17	Based on the "PASS" theory, this test measures 'P'lanning, 'A'ttention, 'S'imultaneous, and 'S'uccessive cognitive processes.
Wechsler Adult Intelligence Scale (WAIS)	16 - 89	An IQ test for older children and adults, the WAIS provides a Verbal, Performance, and Full Scale score, as well as scores for verbal comprehension, perceptual organization, working memory, and processing speed.
Comprehensive Test of Nonverbal Intelligence (CTONI)	6 – 18-11	Designed to assess children who may be disadvantaged by traditional tests that put a premium on language skills, the CTONI is made up of six subtests that measure different nonverbal intellectual abilities.
Universal Nonverbal Intelligence Test (UNIT)	5 - 17	Designed to assess children who may be disadvantaged by traditional tests that put a premium on language skills, this test is entirely nonverbal in administration and response style.
Kaufman Assessment Battery for Children (KABC)	2-6 to 12-5	This test measures simultaneous and sequential processing skills, and has subscales that measure academic achievement.

Table 2-5: The Description of Modern IQ Tests

(Source: Plucker, 2003)

2.5. MACHINE INTELLIGENCE

Since the advent of the first electronic computer in 1941, the technology has been available to implement machine intelligence, although the concept of a thinking machine was first discussed as early as 2500 B.C. in ancient Egypt. The term "artificial intelligence" (AI) was first used at the Dartmouth Conference in 1956 to suggest a link between human intelligence and machines. John McCarthy, who is regarded as the father of AI, is credited with introducing it (Plucker, 2003).

One of the first theories developed in AI was feedback theory (Wiener, 1941 as cited in Mindell, 2004). The most familiar example of feedback theory is the thermostat, which controls the temperature of a designated space by monitoring the actual temperature inside a building, comparing it to the desired temperature, and responding by turning the heat on or off as necessary to maintain that desired temperature. Wiener theorized that all intelligent behavior was the result of feedback mechanisms based on feedback loops, and this discovery has played a key role in the development of AI.

The notion of “intelligent control” was first proposed by Fu in the 1960s. Machine intelligence was needed to accomplish human-like control in automation (Fu, 1970). Since then, various intelligent methodologies have been developed for automatic control systems, and the concept of intelligence has been extended to include models of artificial intelligence such as fuzzy logic, neural networks, and genetic algorithms. This trend began to be applied to electronic products in the 1990s and has now been implemented in the design of household appliances, electronics, and other type of consumer products. For instance, fuzzy logic based washing machines are capable of selecting appropriate settings to optimize performance. In cameras, auto focusing comes close to the results that can be achieved by professional photographers in picture-taking ability. These kinds of products have become popular as they appear to be intelligent, as manifested by their apparent ability to be able to sense, reason, and/or act in an intelligent manner. However, this tendency highlights the need to establish precisely what is meant by an intelligent product, rather than simply labeling it with the much abused term intelligent.

Zadeh (1994) is credited with coining the term “Machine Intelligence Quotient” (MIQ) to describe the measurement of intelligence of man-made systems equipped with machine intelligence. MIQ can be considered as a measurement that is enhanced by some type of human intelligence quotient. The goal of machine intelligence is to mimic human abilities or characteristics based on computer science, biology, ecology, philology, mathematics, and so forth in order to solve problems.

2.6. BUSINESS INTELLIGENCE

Each person has a different view and definition for business intelligence (BI), according to their role within the enterprise. Generally, business intelligence is a broad category of business processes, application software and other technologies that is used for gathering, storing, analyzing, and providing access to data to help users make better decisions. BI enables users to convert raw data into information that is useful for making decisions that will contribute to achieving the organization’s desired goals.

The data used by businesses come from both inside and outside the organization. Inside data is easy to collect and make useful by applying management information systems. Such data would include sales volume, personnel actions, and expenditures. Data that originates from outside the organization deals with the present or future environments in which business is to be conducted. These data include items such as competitor site location, competitor pricing, market demand, labor availability, and government regulations. All the collected data are stored and analyzed in order to derive useful information that is used by the organization's decision-makers. If this activity cycle of collecting, storing, and deriving, is performed efficiently, the business can be called intelligent.

The corrective action of business intelligence can be described in various ways according to Abukari and Jog (2003, page 15), who give the following examples:

- BI is about having the right information available to the right decision makers at the right time to help organizations make better decisions faster.
- BI is an effective way to link systems that traditionally do not communicate well, to ensure that the mountains of data in different legacy systems are converted into accessible information.
- BI is a decision support system that employs a rational approach to management. It uses a fact-based approach to decision making to ensure that an organization achieves a comprehensive advantage.

This can be summed up by saying that business information is processed information that is of interest to management and concerns the present or future environment in which the business is operating (Greene, 1966).

As part of the business intelligence endeavor, many applications and tools have been developed to ease the work, especially when the intelligence task involves gathering and analyzing large amounts of unstructured data. This is important for applications such as those in the following examples:

- Online Analytical Processing (OLAP)
- Data Mining
- Management Information System
- Date Warehouses
- Business Performance Management
- Decision Support System

- Visualization
- Operational Data Scores

Although many tools and applications for intelligence are commercially available currently, every business needs to identify its strengths and areas of improvement. To facilitate this process, the use of the Business Intelligence Quotient (BIQ) has been suggested to distinguish between business intelligence and other aspects of data processing or productive application development because the difference lies in the way BI enables managers to identify changes in business opportunities or challenges that will benefit the company, rather than merely meet business needs.

2.7. THE EVALUATION COMPONENTS FOR HUMAN, MACHINE AND BUSINESS INTELLIGENCE

Albus (1991) insisted that intelligence should span a wide range of capabilities, from those that are well understood to those that are beyond comprehension. It should embody both biological and machine abilities, and these should span an intellectual range from that of an insect to that of an Einstein, from that of a thermostat to that of the most sophisticated computer system that could ever be built. However, it is not easy to identify the precise intellectual range that will be needed by common creatures to sustain life or achieve a specific level of performance. It is important to establish that the system has a reasonable range for the degree or level of intelligence because the system may act differently in an uncertain environment, and appropriate action is that which increases the probability of success.

There are degrees, or levels, of intelligence in individual creatures, and these are determined by various factors. The premise in measuring human intelligence is that an individual has different levels of ability and potential to solve problems, and mental areas can be determined in terms of a single general factor, such as verbal, mathematical, spatial, and memory. Intelligence would consist of two kinds of factors: a single factor and the G factor that explains all the observed correlations between single factors. Spearman proposed the idea that intelligent behavior is generated by a single, unitary quality within the human mind or brain and derived this theoretical entity, which he called the *general factor***,** or simply *g***,** through a new statistical technique that analyzed the correlations among a set of variables. This technique, known as factor analysis, demonstrated that scores on all mental tests are positively correlated, offering compelling evidence that all intelligent behavior is derived from a single metaphorical pool of mental energy (Plucker, 2003). After performing various tasks based on a single factor, one is assigned a number, which is assumed to be a valid indicator of a one's intellectual capabilities.

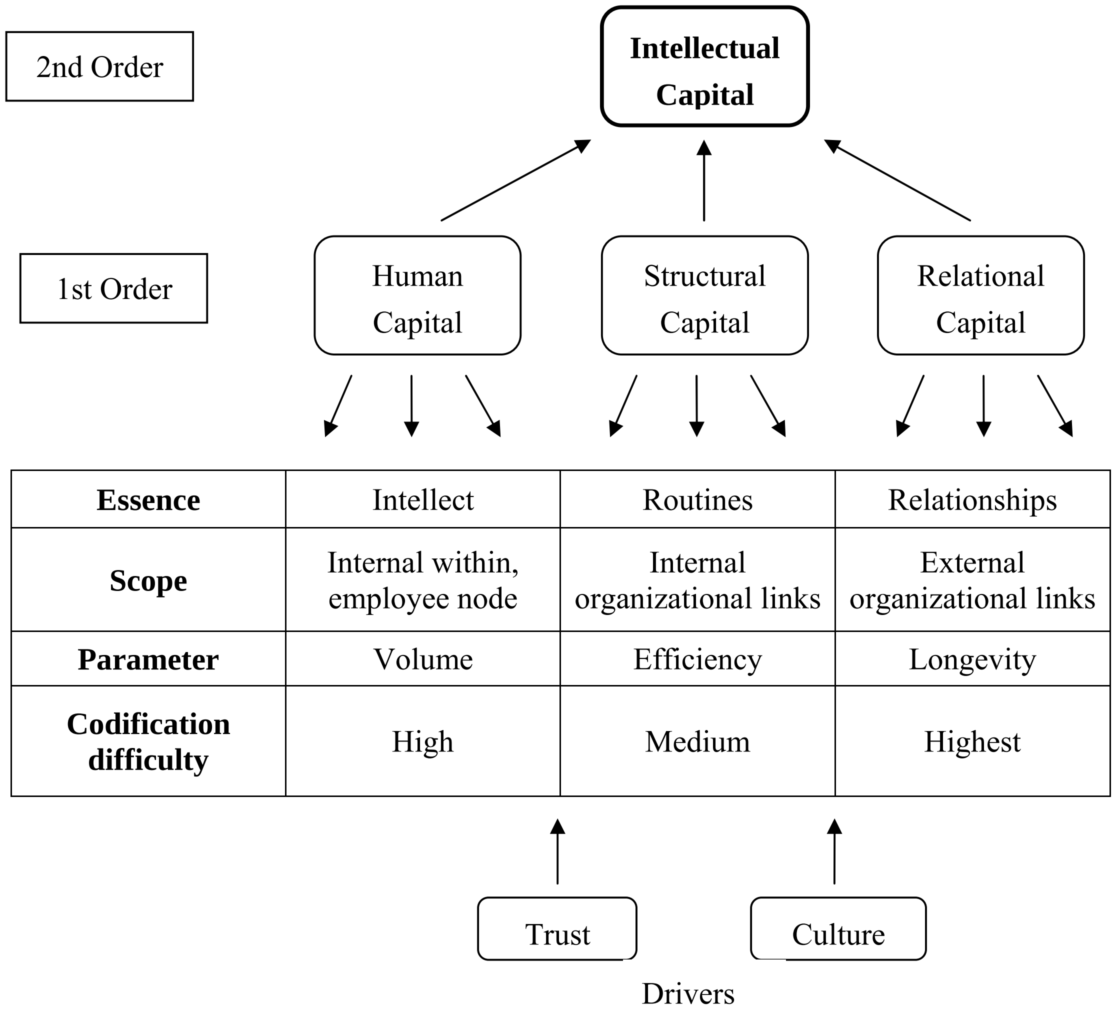
Although the machine intelligence quotient (MIQ) is enhanced by incorporating elements of the human intelligence quotient (HIQ), the components of MIQ differ from HIQ. The machine is a man-made creature that mimics human behavior. Machine intelligence, therefore, can be applied for human benefit in several attributes such as safety, reliability, high efficiency, and economical maintenance. The capability of human-machine interactions is an additional feature and key aspect of evaluation components for MIQ such as autonomy, controllability, human-machine interaction, and bio-inspired behavioral.

Business intelligence (BI) is an architecture and collection of integrated operational and decision-support applications and databases that provide the business community with easy access to business data (Moss and Atre, 2003). BI also encompasses latent factors that promote the desired goals of the organization. The evaluation components of business intelligence quotient can include many factors such as leadership, benchmarks, market demand, feedback, business and strategic plan, and e-commerce, but the key aspect of BI is that the enhanced access to data enables managers to make better decisions.

2.8. INTELLECTUAL CAPITAL

Intellectual capital is a vital organizational resource (Choo and Bontis, 2002). Any organization consists of tangible and intangible assets. Choo and Bontis describe tangible assets as those that typically are found on the balance sheet of a company, such as cash, buildings, and machinery. They define intangible assets as people and their expertise, business processes and market assets such as customer loyalty, repeat business, reputation, and so forth (Choo and Bontis, 2002). Those assets can be an essential source of competitive knowledge and can be considered intellectual capital. Bontis (1998) demonstrates that intellectual capital is positively and significantly associated with organizational performance. Intellectual capital supports and requires the performance of managerial processes to further the constitution of organizational intelligence. Although there is no widely accepted definition of intellectual capital (Cabrita and Vaz, 2006), intellectual capital is essentially related to "knowledge that can be converted into value" (Edvinsson and Sullivan, 1996 as cited in Bontis, 1998).

Because of the various perspectives, a survey of the literature presents a great number of classification schemes for intellectual capital. Mentions of intellectual capital initially started appearing in the popular press in the early 1990s (Stewart, 1991; 1994). Stewart (1997) defines intellectual capital as the intellectual material that has been formalized, captured, and leveraged to create wealth by producing a higher valued asset (Choo and Bontis, 2002). Intellectual capital has also been defined as encompassing (a) human capital, (b) structural capital, and (c) relational capital by many researchers such as Bontis (1996), Roos and von Krogh (1998), and Stewart (1991, 1994, 1997) as cited in Bontis (1998). These sub-phenomena encompass the intelligence found in human beings, organizational routines, and network relationships (Choo and Bontis, 2002). This classification of different types of intellectual capital has led to various perspectives and the consequent conceptualization of intellectual capital shown in Figure 2-5. The three subdomains are made up of: (1) human capital - tacit knowledge embedded in the minds of the employees, (2) structural capital – organizational routines of the business, and (3) relational capital – knowledge embedded in the relationships established with the outside environment (Bontis, 1996 and Edvinsson and Sullivan, 1996 as cited in Bontis, 1998).



Essence	Intellect	Routines	Relationships
Scope	Internal within, employee node	Internal organizational links	External organizational links
Parameter	Volume	Efficiency	Longevity
Codification difficulty	High	Medium	Highest

Figure 2-5: Conceptualization of Intellectual Capital

(Source from Choo and Bontis, 2002)

Resources and capabilities related to people are often viewed in the managerial context as Human Capital (HC), and HC has always been at the center of organizational performance. Human capital tends to be defined as part of a firm's intellectual capital (IC) or intangible resources (Johanson, 2005). Human capital is defined on an individual level as the combination of four factors: (1) genetic inheritance, (2) education, (3) experience, and (4) attitude towards life and business (Hudson, 1993).

Structural capital represents the organization’s capabilities to meet its internal and external challenges and includes infrastructure, information systems, routines, procedures, and organizational cultures (Cabrita and Vaz, 2006). This structural capital is closely related to human capital in terms of the overall business performance. An individual can have a high level of intellect, but if the organization has poor systems and procedures by which to track their actions, the overall intellectual capital will not reach its fullest potential (Choo and Bontis, 2002), and vice versa.

Relational capital is the knowledge embedded in the relationships with any stakeholder that influences the organization’s life (Cabrita and Vaz, 2006). Knowledge of market channels and of customer and supplier relationships, as well as a sound understanding of governmental or industry association impacts, is the main theme of relational capital (Choo and Bontis, 2002).

This chapter has reviewed the literature in order to facilitate the development of a new theoretical approach to define Organizational Intelligence Management an interdisciplinary study building on existing theories. The next chapter will describe how the new theory of organizational intelligence is developed.

CHAPTER 3: DEVELOPMENT OF ORGANIZATIONAL INTELLIGENCE

Construction management is a dynamic organism that adapts to change and evolves to higher levels of functioning and decision making, all of which are functions of human intelligence. Hence, it should be possible for construction management to represent and manifest a form of intelligence that parallels human intelligence. Unlike human intelligence, however, organizational intelligence incorporates the knowledge and skills of the combined abilities of organizational resources/assets.

3.1. CONCEPTUALIZATION OF ORGANIZATION INTELLIGENCE

Organizational Intelligence (OI) is the procedural ability of an organization to efficiently process, exchange, measure and reason about management. OI is the combined knowledge and skills of both the tangible and intangible assets that are available for collaborative problem-solving and decision making within the organization. It is based on the combined ability of three organizational assets that combine to make up OI, namely Human Capital (HC), Organizational Capital (OC), and Relational Capital (RC) in this dissertation. Organizational Intelligence Management (OIM) is the management of these organizational assets to understand, integrate and optimize specific organizational activities and, ultimately, to enhance the organization's OI.

3.1.1. Definitions

To conceptualize Organizational Intelligence, definitions are required to undertake the basis of this research work as follows:

Intellectual Capital (**IC**) describes the tangible and intangible resources/assets within the organization that can to contribute to organizational intelligence and is divided into three domains: human capital, organizational capital, and relational capital.

Human Capital (**HC**) refers to the human resources within the organization that can be deployed to acquire and apply its knowledge to perform, respond, or control designated work with the available organizational assets.

Organizational Capital (**OC**) is the available assets, excluding HC, that are available to support the performance of organizational activities. It includes both tangible and intangible assets such as system, policy, culture, and so on. Information/Communication Technology (ICT) is an example of tangible assets. Intangible assets indicate intellectual property with the organization such as attitude, culture, leadership, and policy.

Relational Capital (**RC**) is a special phenomenon that combines human capital and organizational capital to perform a specific organizational activity. For instance, the use of a computer for estimating in the construction company integrates HC and OC. The specific organizational activity is estimating, HC is an estimator, and OC is a computer. RC requires items such as education, experience, appropriate policy, and software that are from both HC and OC.

Organizational Cognitive Ability is an analogue of human cognitive ability. This is the organization-based skills and organizational processes that are needed to perform organizational tasks. The organization aims to provide organizational cognitive ability appropriately for a specific task.

Organizational Intelligence is the combined knowledge and skills regarding both tangible and intangible assets that the organization can deploy to achieve its goals.

Organizational Intelligence Management is characterized by an understanding of organizational assets, especially IC, and activities and how these can be integrated most effectively to provide comprehensive information to decision makers, including managerial personnel, seeking solutions for a myriad of organizational issues.

Performance is a measure of the results of the combined knowledge and skills of organizational assets, or resources. The performance efficiency depends on the OIM that an organization can use to provide appropriate intellectual capital to support organizational activities.

Some of the definitions developed within this dissertation are the first given in the literature and are an important part of the effort to understand and verify principals and foundations for a new theory of OI. Using these newly defined components, the development of OI starts from the emulation of human intelligence, especially human cognitive ability.

3.2. COGNITIVE ABILITY PERSPECTIVE - EMULATION

A better understanding of human cognitive ability and how it can be mapped to organizational cognition contributes to the development of new intellectual approaches in comparing and examining current organizational practices and processes for the optimal use of intellectual capital during an organizational activity, especially a managerial process. The initial step in formulating the new Management of Organizational Intelligence (OI) theory is to develop a model of organizational cognitive ability, which can then be used to map organizational cognitive ability to the managerial process for characterization.

Figures 3-1(A) and 3-1(B) show the parallels between human cognitive ability and organizational cognitive ability; (1) Decision/Reaction Time *(OIt)*, (2) Processing Speed *(OIs)*, (3) Quantitative Knowledge *(OIq)*, (4) Reading/Writing/Recording Ability *(OIrwr)*, (5) Visual Processing *(OIv)*, and (6) Working Memory and Retrieval *(OImr)*, are all modeled from human cognitive abilities. Human cognitive ability is a gift that is a basic part of human nature. Human cognitive ability is a constitutional and longstanding characteristic and is concerned with all levels of human tasks (Carroll, 1993). The study of cognitive ability in psychology is based on two abilities, fluid intelligence and crystallized intelligence. Fluid intelligence describes the reasoning for doing something, and crystallized intelligence is the ability to retrieve necessary knowledge from memory. Eight additional human cognitive abilities are shown in Figure 3-1 (A).

In organizing a knowledge framework for OI management, this research combines the human cognitive abilities of Short-term Memory *(Gsm)* and Long-term Storage and Retrieval *(Glr)* to form Working Memory and Retrieval *(OImr),* as shown in Figure 3-1 with arrows. The managerial process is the planned activity within defined phases and is not depended on Short-term Memory *(Gsm)*. Human Auditory Processing *(Ga)* has been incorporated into Reading/Writing/Recoding Ability *(OIrwr)* because organizational activities generally do not include auditory processing.

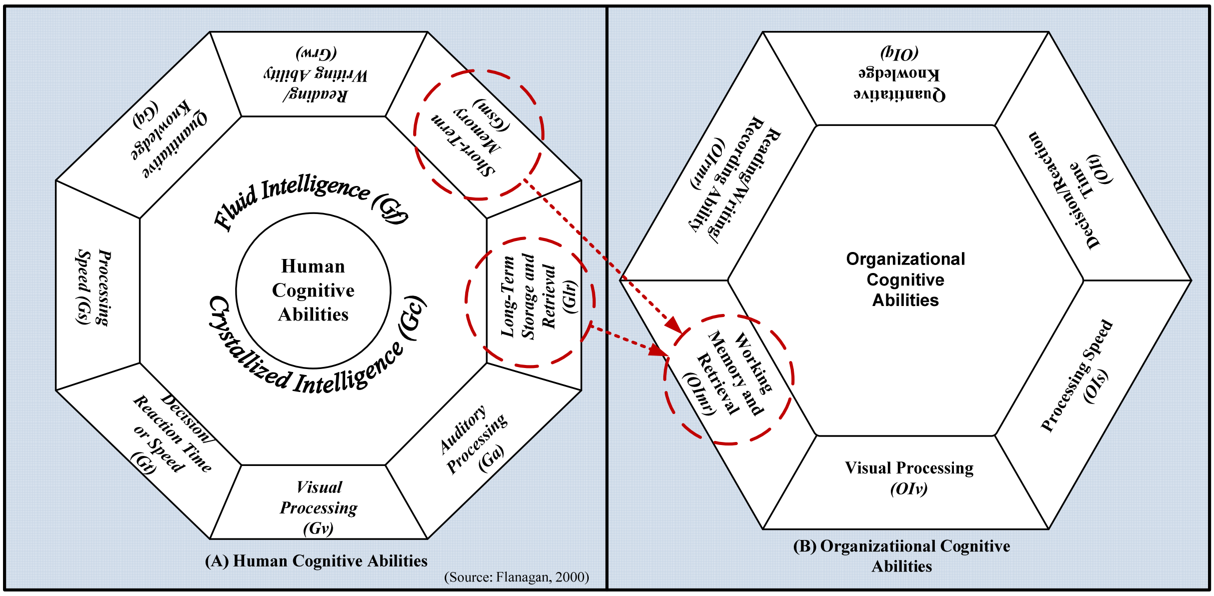


Figure 3-1: Parallel Cognitive Abilities (Human/Organization)

This research suggests that a set of six organizational cognitive abilities provides a mutually exclusive and collectively exhaustive set of cognitive abilities for OI. A detailed definition of these six organizational cognitive abilities is described as follows:

1. **Decision/Reaction Time** ***(OIt)*** reflects how quickly the organization reacts and makes decisions. Decision/Reaction Time *(OIt)* reflects the immediacy with which an organization addresses problems and selects from among a range of alternative solutions. This is a qualitative response that is related to Processing Speed *(OIs)* in organizational activities.

2. **Processing Speed** ***(OIs)*** is the ability to perform tasks fluently including uncommon tasks, to maintain focused collaboration. Faster processing speed is more efficient because it improves the power of the Working Memory and Retrieval *(OImr)* and Decision/Reaction Time *(OIt).*

3. **Quantitative Knowledge** ***(OIq)*** represents the organization's capacity to acquire quantitative, analytical, and procedural knowledge and then solve quantitative organization activities and problems, including numeric calculations such as accounting, estimating, scheduling, and resource allocation.

4. **Reading/Writing/Recording Ability** ***(OIrwr)*** is the basis upon which the organization acquires and exchanges information in unified formats, both within the organization's own structural hierarchy and with outside organizations, encompassing the available usage in the field or office, e.g., field reports, daily logs, submittals, and so on.

5. **Visual Processing** ***(OIv)*** denotes the organization's ability to acquire, generate, analyze, synthesize, store, retrieve, transform, and deliver visual objects or pattern images, and form and store images such as graphical charts, digital photos, visualizations, and animations.

6. **Working Memory and Retrieval** ***(OImr)*** is the ability to apprehend, hold, store, and fluently retrieve new or previously acquired information such as change orders, daily reports, and drawings. Personnel must be able to update, modify, store, and later retrieve documents from the organization's database at need.

The performance of any organizational task requires knowledge and ability, and most tasks require knowledge from multiple sources and integrative abilities. For instance, the successful processing of a Request for Information (RFI) in construction may depend on at least three organizational cognitive abilities: (1) Processing Speed *(OIs)*; (2) Reading/Writing/Recording Ability (*OIrwr)*; and (3) Visual Processing (*OIv)*. RFIs have been converted from a communication tool to a means of preventing defective design (Zack, 1999). *OIv* can clarify a drawing defect, *OIrwr* can prevent duplication, and *OIs* can prevent unnecessary delay.

To paraphrase Flanagan et al., (2000) within an organizational context, the six organizational "*cognitive abilities represent basic typical and longstanding characteristics of (organizational) intelligence that govern or influence a great variety of functional tasks in a given (organizational) processes.*"

The development of organizational cognitive ability can explain procedural activities in the organization and determine the effective utilization of capitals, whether HC or OC. There are, however, limitations on human cognitive capacity while performing administrative functions (Simon, 1945), and OC can assist and replace HC in various organizational tasks to achieve higher performance. Hence, for some tasks technical improvements can replace human beings. There are many examples of functions where human cognitive abilities that concern tasks and operations within an organization have been replaced or supported by technological innovations. For instance, a calculator for estimating in construction can be replaced with estimating software. However, the benefit of technological innovations that enable estimating software to delivery better productivity and performance to meet the organizational needs is sometimes doubtful. As a consequence, some organizations hesitate to adopt and implement the latest technological solutions. The concept of Organizational Cognitive Ability offers comprehensive information to decision makers seeking potential solutions regarding the adoption of technological innovations.

3.3. KNOWLEDGE CREATION - CATEGORIZATION

The categorization of an organization according to the theory of OI can provide opportunities to create new knowledge value and elements. The current classification of organizational assets is vague for specific organizational activities. In this dissertation, OI defines the combined knowledge and skills of assets within the organization. Organizational assets that contribute to OI are classifiable and manageable entities that can be used to optimize organizational activities.

The transformation from organizational assets into organizational activities can be considered as utilizing intellectual capital within organizational activities. All organizations have a level of intelligence that is analogous to human intelligence, and this intelligence directly impacts organizational performance. To formulate a new theory of OI, this research must first determine the relationship between organizational assets and organizational activities, including managerial processes. The initial theoretical approach for OIM is therefore to comprehend that the organizational assets of human capital, organizational capital, and relational capital are manageable values and elements that contribute directly to the success of various organizational activities. The management of intellectual capital is the management of organizational intelligence. Unlike human intelligence, OI can be created and developed by adopting and building on what this research calls “intellectual capital.” The diagram of human, organizational, and relational capital laid out in Figure 3-2 provides a graphical insight into this classification.

Organizational activities and organizational assets have a mutual relationship. Any organization consists of both tangible and intangible assets. These assets are manifested by specific organizational activities, which in turn are supported by organizational assets. Typically, tangible assets have a physical existence, for example buildings, machinery, or cash, while intangible assets consist of intellectual property such as people, reputation, and policies. The literatures contain many studies on this topic, which present a great number of classification schemes for organizational assets from many different perspectives. Intellectual capital is another organizational resource that is positively and significantly associated with organizational performance (Bontis, 1998). As explained above, organizational performance is defined here as the results of the combined knowledge and skills of organizational assets, or resources. Therefore, this research classifies organizational assets into intellectual capital that is directly connected with organizational performance and thus to OI. To classify intellectual capital items as manageable entities, this research divides them into HC and OC. RC is special phenomenon and is composed of elements of either or both HC and OC. When an organization processes organizational activities, RC is applied to perform organizational activities. This is shown in Figure 3-2, and the categorization of organizational assets with organizational activities creates knowledge value and elements that are utilized to integrate and optimize organizational activities with intellectual capital.

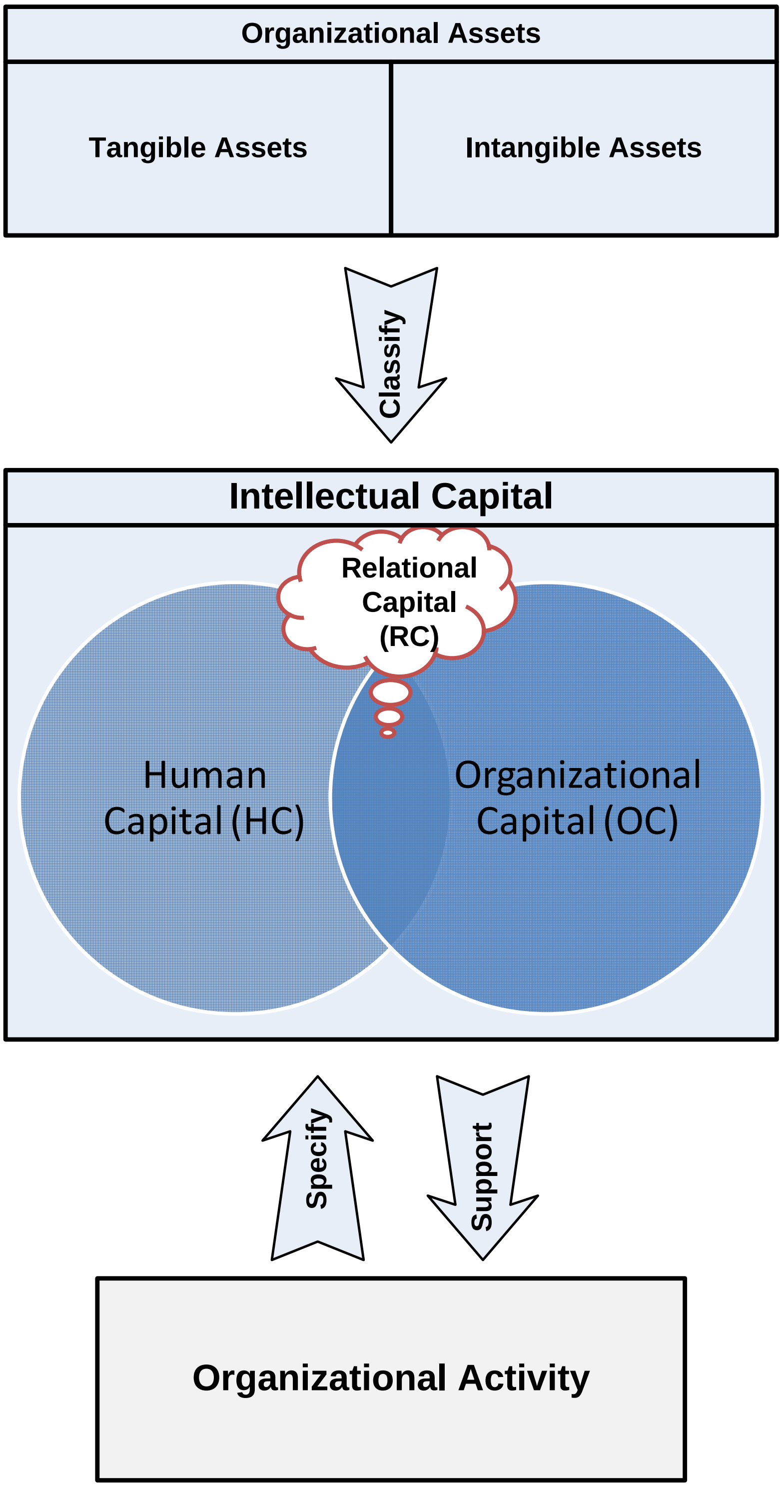


Figure 3-2: Knowledge Value Creation from Organizational Assets to Organizational Activity

The new theory of OI in this dissertation integrates the components necessary to characterize collaboration in the learning process and to achieve effective and efficient performance in various organizational activities. Any managerial process in any organization is performed by a combination of organizational assets, and the performance of this managerial process is a direct result of the efficient usage of these organizational assets. A better understanding of intellectual capital will enhance performance in construction management by qualifying the efficacy of organizational assets for organizational activities. Therefore, it is first necessary to categorize related components that support managerial tasks during managerial operations.

Organizational resources are either tangible or intangible assets within an organization. These include policy, culture, facility, ethics, equipment, personnel, and so forth. Organizational activities, especially managerial processes, are influenced by these factors and although humans necessarily take a significant role in performing processes, the role of humans in organizational activities is often substituted and simplified by various technological and business improvements. The required factors from organizational activities continue to change according to the adoption of improvements, and it is difficult to determine which factors are needed from the vague categorization, tangible and intangible assets, within the organization. In this research, therefore, organizational assets are classified in terms of two important capitals: HC and OC. RC is manifested by the combination of HC and OC and precisely how these are combined depends on the specific organizational activity involved.

3.3.1. Human Capital

Human Capital (HC) is typically made up of the abilities of the personnel within the organization. This capital is a combination of four factors: (1) genetic inheritance, (2) education, (3) experience, and (4) attitude (Hudson, 1993). Genetic inheritance is an important factor to describe human's permanent interest in economical analysis and various studies, but will not be used here as this research is adopting an approach to organizational intelligence management that is based on organizational activities, especially managerial processes. The remaining three of these factors, namely education, experience, and attitude, are closely related and applicable as managerial process factors that contribute to the performance of managerial processes.

3.3.2. Organizational Capital

Organizational capital (OC) is more complicated than human capital and is based on systems, policy, ethics, culture, strategy, and other factors. However, OC factors are institutionalized as the organization's systems, or methods, that are used to perform an internal managerial process in the organization. Table 3-1 shows the basic factors from HC and OC that support and perform general organizational processes. These illustrated factors must be applied differently depending on the requirements of the specific organizational activity, especially for managerial processes. This research will clarify and determine which factors contribute to the achievement of higher performance for organizational activities.

Human Capital	Organizational Capital
Education Experience Motivation/Attitude	Policy Culture Equipment (Tools/Technologies) Ethics etc

Table 3-1: Basic factors of Human and Organizational Capital

3.3.3. Relational Capital

Relational Capital (RC) does not exist in isolation but is automatically manifested whenever an organizational process is performed by combined or transferred capitals such as HC to HC, HC to OC, and OC to OC. Every organizational activity is processed with a combination of different capitals. For example, a project engineer plans a retaining wall project using Project Management (PM) software. The project engineer’s project-management capabilities are part of the organization's HC, while the ICT hardware and software are part of its OC. RC is specifically required for the planning process as education, experience, and training are all elements of HC.

RC can be considered as two relational capitals: within-task RC and cross-task RC. Within-task RC is required by a process that combines HC and OC, while cross-task RC is required by the transfer of capitals from one process to another, such as HC to HC, HC to OC, OC to HC, and OC to OC. In total, four different types of cross-task RC can occur. **Whenever HC integrates with OC, they generate RC in order to effectively and efficiently perform organizational activity.** The integration of HC and OC generate RC, which is the combined ability, OI, that this research explores. RC factors are applied differently, however, depending on the organizational activity that is used in the organization. Possible factors are shown in Table 3-2.

Destination / Initiative	HC	OC	
HC	Leadership Communication Teamwork/fellowship	Provide Motivation Provide Education Experience	RC
OC	Policy (formed or Informal) Culture Procedure Training Ethics	Comparability Interface Policy	

Table 3-2: Required Factors for the Combination of Capitals

3.4. ORGANIZATIONAL ACTIVITY – ANALYSIS

Although many construction management tasks are relatively complex, they can often be analyzed by separating them into discrete processes, stages, or components. In general, a process refers to any action or series of actions by means of which something is operated upon to produce some result (Carroll, 1993).

An understanding of organizational activities, especially managerial processes, is therefore very important in order to specify the intellectual capital for the production of organizational performance. The analysis of organizational activities into discrete processes facilitates the comprehension and judgment that particularize the intellectual capital needed to process a specific task. The procedural analysis of two typical managerial processes, namely a Request for Information (RFI) and a material submittal, in construction is shown in Figure 3-3. The analysis reveals that tasks number 4 (Recording/Transmitting) and 5 (Receiving/Recording) in both analyses are performed repeatedly by the construction professional as part of the managerial processes. Such findings of repeated activities throughout the procedural analysis provide an indication of areas where intellectual capital could be applied more effectively and efficiently.

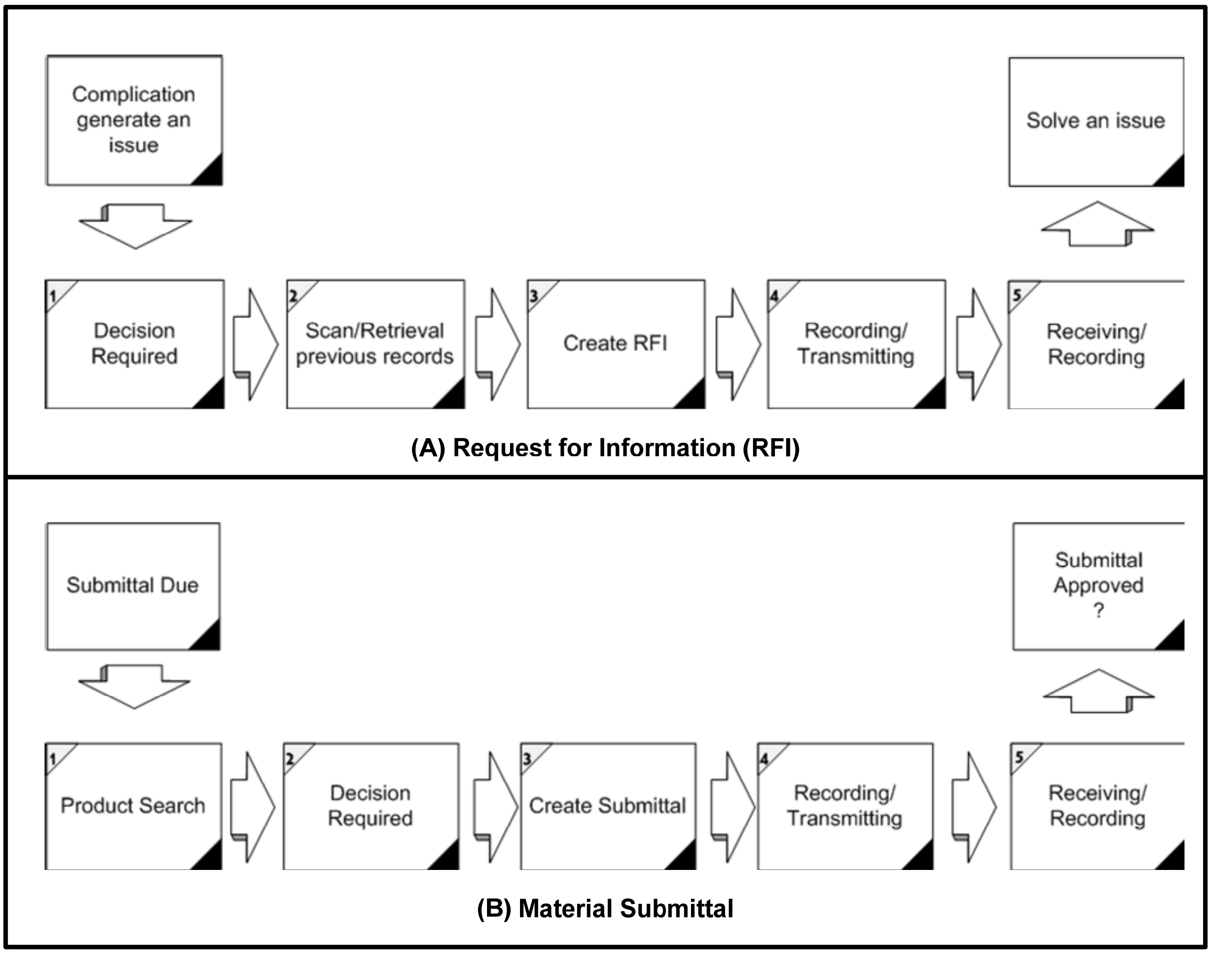


Figure 3-3: Two Examples of Procedural Analysis

3.5. PERFORMANCE

Traditionally, productivity is defined as the amount of output per unit of input. In construction, productivity is typically measured as output per labor-hour or equipment-hour, but it is difficult to measure the effectiveness of the various factors that contribute to OI using these measures. Although organizational assets can and often do replace many redundant and labor intensive human processes, e.g. webcams, video recorders, and RFID, there is as yet no acceptable standard for measuring enhanced performance as a result of utilizing organizational assets for an organizational process.

In engineering psychology and human performance, the measurement of human performance is associated with one of four categories of raw data (Wickens and Hollands, 1999):

1. Measures of speed or time
2. Measures of accuracy or error
3. Measures of workload or capacity demands
4. Measures of preference

When managing organizations, however, performance measures for OI are required in order to provide feedback regarding both tangible and intangible assets and hence enhance managerial performance. Therefore, a set of performance measures should be established to assess the capability of intelligence in organization. Six performance measures that have been suggested to measure OI performance in organizational activities are as follows:

1. Accuracy:	Correctness
2. Time:	Process Quickness
3. Familiarity:	Learning and Control
4. Commonness:	Conflict Free Communication

5. Capacity: Load/Storage Capacity
6. Availability: Usage, Location, and Connectivity on-site

These performance measures will be applied differently based on different organizational task activities. Data, for instance, is comprehensive information that enables managers to make a decision appropriately and quickly, and thus capacity, suggested above as a performance measure, will be applied to the data supply process.

3.6. ASPECTS OF OIM WITH VARIOUS FACTORS FROM INTELLECTUAL CAPITAL

Organizational activity is the most important aspect when assessing the relevance of various factors from intellectual capitals. For example, the managerial processes involved in construction are submittals, shop drawings, change orders, and so on, all of which must be supported from organizational resources ranging from a pen to complicated software. Many technologies and improvements are considered to be innovative tools in organizations. When an organization performs an organizational activity, there will be integration of human capital and organizational capital. Based on this integration of activity and capital, the factors from the two capitals, HC and OC, manifested in RC will be involved to ensure efficient and effective performance. In other words, relational capital is manifested through a specific organizational activity. This research seeks to determine which manifested factors are required from a particular managerial process and whether an organization provides or correctly applies these factors to support a particular process. The relationships between organizational activity, the three capitals, and performance are illustrated in Figure 3-4. Managerial processes in construction have barely changed over the years because many players have specialized into performing different tasks for a construction project. Tools and technologies for a managerial process can be changed in various ways but all of these depend to some extent on the willingness and financial investment by the organization's decision makers. However, it is difficult to define a direction that will guarantee organizational success or viability based on these various factors. It is clear that performance depends on intellectual capital, but the efficiency of performance will be different based on the capital factors provided by the organization. Factors that comprise Relational Capital (RC) are shown on the outside layer in Figure 3-4. These factors are determined by an integration of the organizational activity and the organization's applied capitals, HC and OC.

This research has singled out three factors related to Human Capital (HC): education, experience, and motivation. These factors are the basic attributes of the qualified personnel who are members of the organization. A construction company, for instance, will recruit a field engineer whose qualifications generally consist of education, experience, and motivation. The requirements of factors in HC are consequently more specialized than the relatively straightforward description of an organizational process.

Figure 3-4: The Facets of Integrated Capitals and Organizational Activity

Consider the case of a construction company using e-forms for the RFI process. Here, the organization must provide an internet connection, a computer, policy, and suitable software. These support elements are OC requirements. HC requirements are for a field engineer who is able to use the OC to perform the e-forms RFI process. Here, the combination of HC and OC means they are defined as RC factors in this research. Identifying the role of various factors in a particular managerial process is the critical foundation of OI. In this research, various factors will be determined through modeling a managerial process using a learning model prototype. The prototype that is developed for specific managerial processes in construction will be sufficiently versatile to find additional applications for organizations and organizational activities beyond the construction industry.

CHAPTER 4: A FRAMEWORK OF LEARNING MODEL PROTOTYPE

This chapter explains how this research's main objective was accomplished, namely the development of a learning model that describes organizational activities, especially managerial processes. The framework includes all the knowledge elements needed for effective and efficient performance according to the theory of OI developed in the previous chapters. A learning model prototype supports the recognition of organizational activities and requirements for effective and efficient performance. The structure of the prototype is created by identifying procedural steps, capital usages with factors, and performance measures, as well as the relationship and interactions between them.

4.1. ORGANIZATIONAL INTELLIGENCE FRAMEWORK

Organizational intelligence is hypothesized to learn from 1) human intelligence and 2) intellectual capital and develops as a result of contributions from 1) organizational cognitive ability, 2) intellectual capital (i.e. human, organizational, and relational capital), and 3) performance. These variables are not isolated elements but interact to support achieving higher levels of OI. The knowledge framework in Figure 4-1 presents the elements of OI that this dissertation has defined and described in the previous chapters. To better understand the framework in this dissertation, the relationships between these elements can be described as follows:

- Intellectual capital

An organization's intellectual capital is divided into three domains, human, organizational, and relational capital. How these capitals are applied varies depending on the requirements of the specific organizational activity to be performed, and appropriate relational capital is generated with which to perform the activity.

- Organization Activity (Process)

An organization's activities, especially organizational processes, are performed by intellectual capital and this is divided into three domains, namely human, organizational, and relational capital. A specific organizational activity will require appropriate intellectual capital in order to perform that activity, and once again relational capital is generated as part of this endeavor.

- Organizational Cognitive Ability

Organizational Cognitive Ability (OCA) is developed that emulates human intelligence, especially human cognitive ability that is a basic constitutional and longstanding characteristic and is concerned with all levels of human tasks (Carroll, 1993). The characterization of organizational cognitive abilities for a particular activity provides the underlying typical and longstanding characteristics that represent the cognitive development of an organization. Based on the definition of OCA given earlier, OCA becomes an informative mediator with which to characterize a specific organizational activity. OCA makes it possible to provide the effective integration and rational selection of appropriate intellectual capital, especially cognitive tasks (i.e., communication and gathering information), in order to optimize the performance of that organizational activity.

- Performance

Performance is a measure of the results of an organizational activity. A specific organizational activity is performed by intellectual capital. The determination of performance attributes for a specific process is important as it allows the measurement of these performance attributes to provide feedback that can then be applied to adjust and develop the way the activity is conducted.

- Organizational Intelligence

OI is the combined knowledge and skills within the organization's assets that can be applied to achieve organizational goals. Specifically, an organizational activity is achieved by the combined knowledge and skills of intellectual capital (i.e. human, organizational, and relational capital). It encompasses the procedural ability of an organization to efficiently process, support, measure, and reason through organizational issues.

- Organizational Intelligence Management

This research has identified the following elements that should be included in the new knowledge framework for OIM: 1) organizational process, 2) intellectual capital, 3) organizational cognitive ability, and 4) performance attribute. The management of these elements is important in order to achieve higher levels of OI. OIM is the planning, organizing, leading, and controlling of organizational activity through intellectual capital, organizational cognitive ability, and performance with defined relationships, as shown in Figure 4-1.

- Organizational Intelligence Quotient (OIQ)

There is no widely accepted definition for either OIQ or OI. However, this research suggests the initial approach that should be used for OIQ, which is a necessary part of the effort to develop a test of the intellectual capital needed for a specific organizational activity and whether or not an organization can provide and support that intellectual capital, particularly the relational capital required for a specific organizational process.

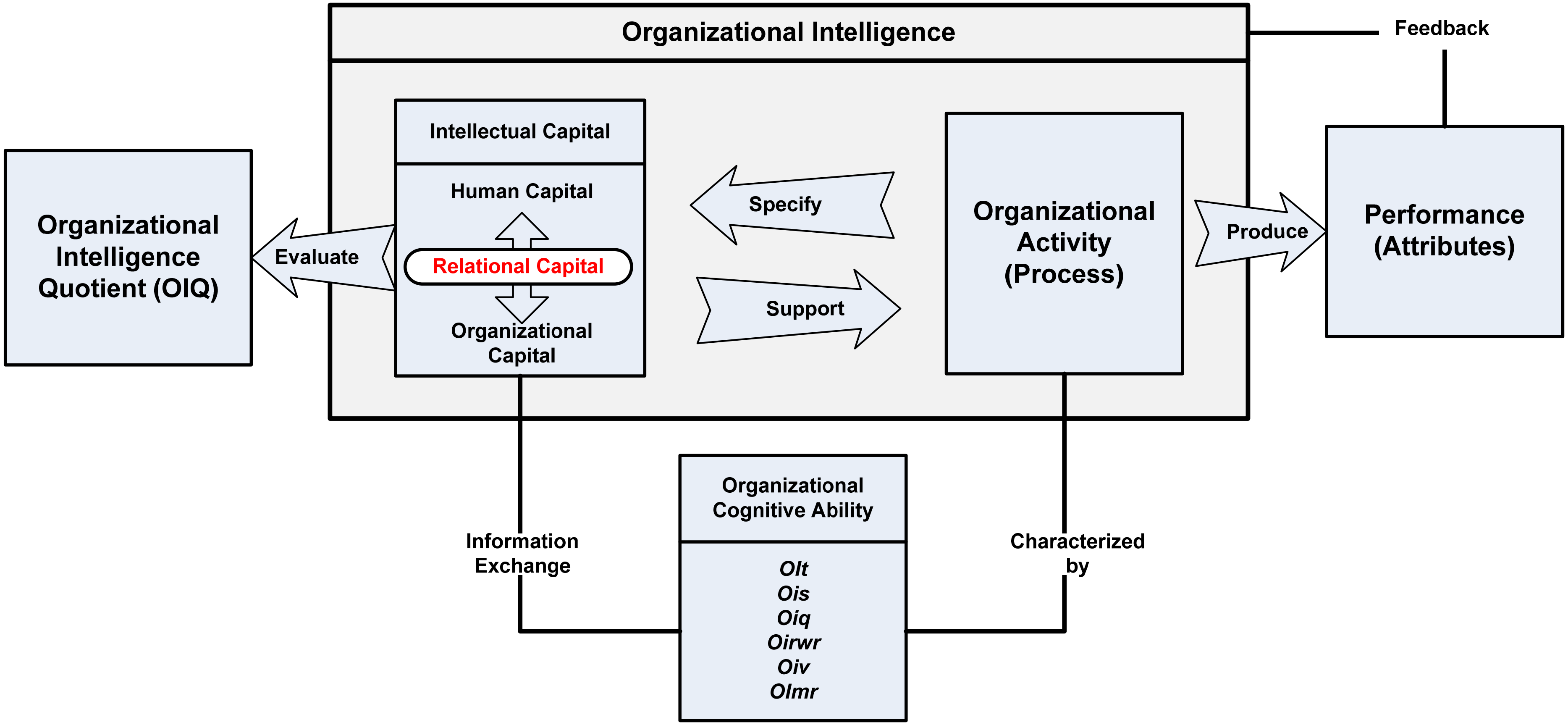


Figure 4-1: The Framework for Organizational Intelligence

The development of a learning model prototype is related to the knowledge framework that has been developed for OI, and it describes several perspectives that can provide guidelines for OIM.

4.2. INTELLIGIBILITY LEARNING MODEL (ILM) PROTOTYPE

Key challenges for achieving OI are the need to understand how both organizational assets and activities function and to determine the optimum way to integrate them. To identify these organizational assets and activities, the learning model developed here incorporates an OIM tool in order to allow the prototype to be applied to a range of organizational activities. Organizations can identify the various aspects needed to manage organizational assets and activities. The theory-based design of the ILM provides a firm foundation of definitions and requirements for individual managerial processes in order to provide comprehensive information to the decision makers in the organization. To accomplish the research objectives, i.e. to identify the management of intellectual capital, determine the components of intellectual capital, perform a procedural analysis, and so on, the ILM takes a theoretical approach that:

- Clarifies and analyzes managerial processes as sequential tasks
- Examines the dependency of each task and determines optimal usage of capital
- Determines performance measures for measuring task performance in a managerial process
- Defines various factors that are directly related to OI

The structure of the theoretical prototype of ILM consists of six interconnected perspectives: 1) Procedural Analysis, 2) Ability Intensive, 3) Interdependence, 4) Capital Transformation, 5) Performance Attributes, and 6) Performance Factors. Each of these perspectives provides a set of criteria that can be used to evaluate OI for a managerial process and they are described in more detail in sections 4.2.1 to 4.2.6. The ILM breaks the managerial process down into a series of sequential tasks and displays the factors from each perspective that should be performed by personnel to enable the managerial process to achieve higher levels of OI. Figure 4-2 illustrates the perspectives adopted by the ILM. Based on these perspectives, the ILM creates an OI learning process for a particular process in the organization. Understanding the structure of the ILM is very important because it makes the organization aware of its present status and reveals how best to develop a management process so that it can be achieved more efficiently and effectively by applying the organization's capital assets.

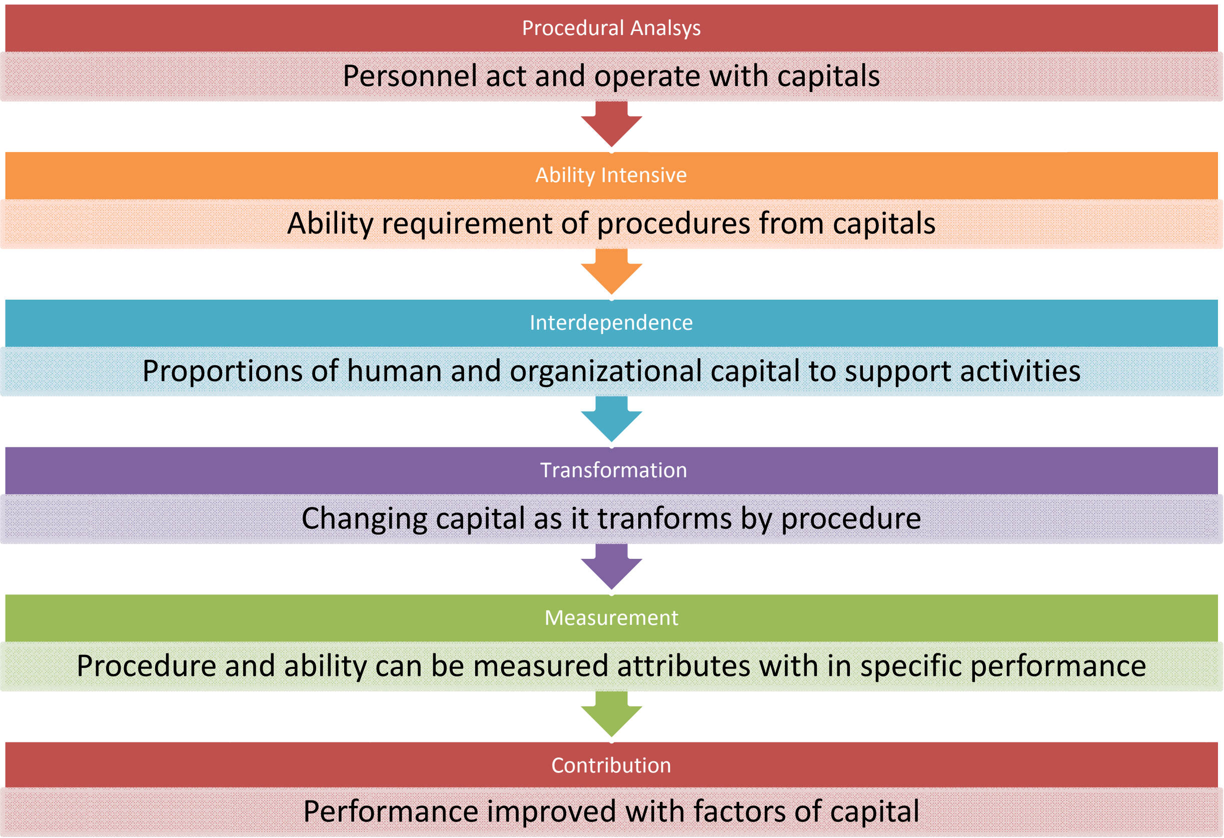


Figure 4-2: The Perspectives of the Intelligibility Learning Model (ILM)

The theoretical design of ILM as a learning process is based on the analysis of managerial processes in terms of a series of sequential tasks, which has never previously been attempted for managerial processes. In this research, a new instance of the ILM, which is based on systematic usage and performance of intellectual capital in the organization, is developed for each specific process. The structure of the specific ILM is created by identifying the relationships and interactions between intellectual capital and factors that use intellectual capital in the managerial process, utilizing the knowledge and skills of the combined abilities of the tangible and intangible assets within a given organization. Factors that are needed in order to perform the managerial process efficiently and effectively are discussed and likely candidates suggested in the previous chapter.

4.2.1. Procedural Analysis Perspective

Intelligence is defined as “an inherited capacity of the individual's which is manifested through his ability to adapt and to reconstruct the factors of his environment in accordance with his group” (Boynton, 1933). By expanding this view to include their organization, decision makers in the organization endow it with an intellectual capacity through its ability to adapt and to reconstruct the factors of the organization's environment in accordance with the organizational activities, especially its managerial processes. Managerial processes in organizational activities are performed by integrating organizational assets. To determine the most efficient and effective way to integrate the assets in the organization, the “Procedural Analysis Perspective” in the ILM analyzes the managerial process as a series of sequential tasks that contribute to the standardization of the managerial process. This analysis is based on a professional’s actions and operations for a particular managerial process.

4.2.2. Ability Intensive Perpective

In the previous chapter, six cognitive abilities were defined in an organization that paralleled human cognitive ability, which is generally considered to be made up of ten abilities beyond the basic level of fluid intelligence and crystallized intelligence. Cognitive ability in human beings is an innate ability inherited from a previous generation, but cognitive ability in an organization is represented by the ability to perform a sequential task and is created by organizational activities. Organizational cognitive ability is therefore the basic typical and longstanding characteristics that stand for a particular process in the organization and is analogous to human cognitive ability. Six organizational cognitive abilities have been defined that can be used to characterize managerial tasks in general based on human cognitive ability. These cognitive abilities are supported by human capital and organizational capital, which were also defined in the previous chapter. Each managerial process requires the performance of a sequential task that combines capitals and is expressed in terms of the organization's cognitive abilities.

For example, if a student is to solve a math problem, they require a minimum of four abilities, which may be used to demonstrate how human cognitive abilities function: 1) long-term storage & retrieval, 2) processing speed, 3) quantitative knowledge, and 4) reading/writing ability, as shown in Figure 4-3. These abilities describe a human’s cerebral activity for a particular activity. If this student is allowed to use a calculator, the cognitive ability “quantitative knowledge” will be de-emphasized. The analog of this within an organizational activity treats the calculator as a technological improvement, and a professional will require additional knowledge and skills such as education and training to use the calculator effectively. Once this additional education has been provided and the new skills mastered, the professional will use less cognitive ability and improve their performance. Ultimately, quantitative ability can be replaced by a technological improvement, in this case a calculator.

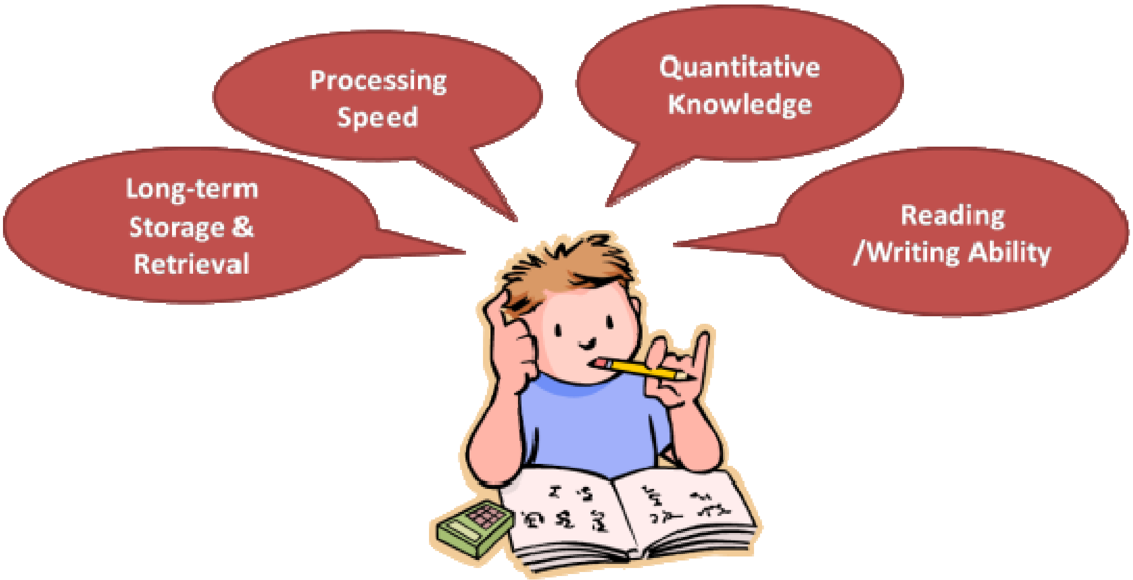


Figure 4-3: The Characterization of Human Activity with Cognitive Abilities

In the same way cognitive abilities are used to characterize human processes, a particular process in the organization can be explained in terms of organizational cognitive abilities, as shown in Figure 4-4. If an estimator, for instance, carries out an estimation, the professional makes use of the following organizational cognitive abilities: 1) working memory & retrieval, 2) processing speed, 3) quantitative knowledge, and 4) reading/writing/recording ability. The success of the estimation is not only dependent on the professional's ability, but also how well the organization supports the required organizational cognitive abilities.

Figure 4-4: The Characterization of Organizational Activity with Cognitive Abilities

This characterization as shown Figure 4-4 makes it possible to describe every process in an organization precisely and effectively and hence determine which abilities will be required for a particular task within the managerial process. In addition to characterizing tasks in terms of the organizational cognitive abilities they utilize, the "Ability Intensive Perspective" in the ILM provides insights into how best to provide the required abilities from the organization's available intellectual capital resources to optimize the performance of the managerial process.

4.2.3. Interdependence Perspective

Technologies and improvements have continued to flow into many industries and have taken over many tasks and roles previously performed by humans. The contributions of human employees in any organization, especially with regard to managerial processes, are very important, but these roles and tasks are evolving rapidly as a result of the introduction of new technologies and other improvements. In this interdependence perspective, the effectiveness of managerial tasks that are traditionally performed by the integration of capitals will be evaluated by the important and appropriate usage of HC and OC. For instance, if an estimator in a construction organization calculates the quantities of raw materials using a calculator this will require more work and effort compared to performing the same task using appropriate estimating software. However, the estimator using the estimation software is simply typing numbers into pre-existing forms, while the estimator using the calculator has a greater dependency on human capital. Thus, the efficient and effective performance of the estimation process not only depends on the ability of the estimator but also on the tools they have available. The performance of human capital can be influenced by various factors. Although a particular task may be mostly performed by managerial personnel, the efficiency and effectiveness of the process may be totally different depending on whether new technologies are used or traditional methods. The proportional indication of interdependency for a managerial task can suggest the optimal integration of HC and/or OC that will produce the most efficient and effective performance.

4.2.4. Capital Transformation Perspective

Each task in a managerial process is performed by some combination of intellectual capital and organizational assets. A procedural task is not performed by an independent capital alone but by the integration and combination of HC and OC. The integration of these capitals invokes Relational Capital (RC), and the connection of two tasks requires the assistance of RC to ensure a smooth progression from one task to the next. The manifested RCs are categorized as either “within-task” or “cross-task”, as explained earlier in section 3.3.3. The capital transformation perspective in the ILM illustrates how primary capital is transformed in this way and suggests how the various factors involved in the sequential tasks can be determined.

4.2.5. Performance Attribute Perspective

Time and cost are traditionally used to measure productivity and assess the overall performance of an organization. The construction industry generally believes that the success of a project depends primarily on time and cost. For example, how many days before the scheduled completion day is a project finished? Or how much profit has been earned from the project? However, these simple calculations can only be performed after the completion of the project. Time and cost are limited measurements that are affected by many complicated and interrelated factors, all of which affect the performance of various organizational activities. Additionally, not every management process can measure its performance accurately using these traditional productivity measurements. Consider the case of a project engineer selecting a supplier for acoustic ceilings as a part of a submittal process. This process of decision making by the project engineer does not depend on time and cost because both measures depend on how the process is done. Instead, the decision depends on the engineer's knowledge of acoustic ceilings, organizational policy, and ethical decision making. Time and cost fail to adequately cover this decision process as performance measures.

Each management process requires different performance measures to assess different organizational activities, but as yet no specialized performance measures have been developed for every organizational activity. Three perspectives in the ILM: 1) the ability intensive perspective, 2) the performance attribute perspective, and 3) the performance factors perspective, can be used in conjunction to determine the appropriate performance measures for each task and produce precise assessments of performance. Possible metrics were suggested in section 3.5.

4.2.6. Performance Factors Perspective

Every task, as well as the transitions between tasks, is processed by the intellectual capital within the organization. HC and OC are basic requirements for operational tasks, and RC is produced as a result of their integration. The precise form taken by the RC is determined by the particular task. Each intellectual capital is composed of different factors that contribute to tasks as described in previous chapters, in order to accomplish the optimal performance. These factors vary according to the sequential task to be performed. The “Performance factors perspective” in the ILM will provide necessary factors from each capital, both within-task and cross-task. These factors represent the RC for each specific task.

4.3. ACHIEVING OIM WITH THE ILM PROTOTYPE

The process of OI management starts with an understanding of organizational activity and organizational assets. Organizational activities are completed by integrations of organizational assets. The performance of organizational activities results directly from the integration of these organizational assets, but the principle of the integration has not yet been examined in terms of specific organizational activities.

Organizational activities are designed to pursue collective goals such as production, management, business relationship, and so on. Managerial processes are one of the main activities that are undertaken in order to maintain the organization’s viability. This can be compared with metabolism in human activity, just as the theory of human intelligence has been developed to explain how individuals differ from one another in abilities such as understanding complex ideas, learning from experiences, and so on. These processes allow organisms to grow and reproduce, maintain their structures, and respond to their environments. Throughout the managerial process, the organization can learn, grow, reproduce, and maintain the organization's goals in order to achieve high performance in organizational activities.

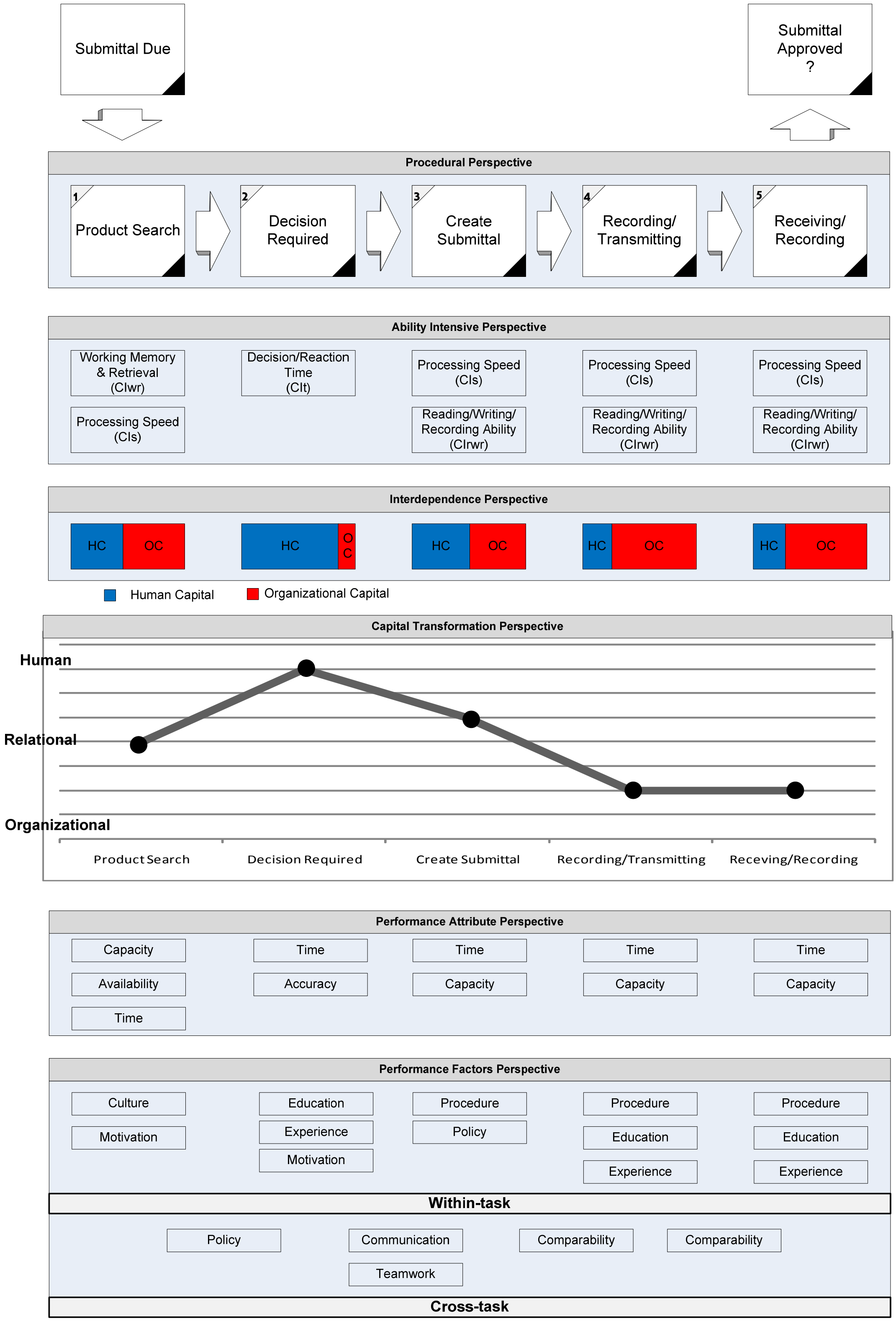
The ILM is designed to integrate and optimize various organizational assets in accordance with organizational activities. Using the ILM will enable decision makers or professionals to appreciate various aspects of their tasks and thus manage their organizational activities more effectively. Figure 4-5 shows how the ILM prototype operates for a typical submittal process, using the six perspectives mentioned above. This prototype provides new ideas and suggests innovative ways to manage organizational activities more intelligently.

Construction submittals are construction documents that include product data, shop drawings, samples, etc., that have been approved by an Architect/Engineer (A/E) and detail the project specifications that must be met by contractors. Architects and engineers prepare these specifications and verify contractor submittal product data, samples, and shop drawings to validate the correctness of the products to be used in the project. At the beginning of the project, the general contractor prepares a submittal schedule with the specification sections, due dates, and responsible parties for each required submittal. Many submittals are still processed on paper, and contractors need to prepare multiple copies for project participants such as the owner, general contractor, architect, engineer, and consultants. The architect and engineer will indicate approvals, rejections, and conditions on the submittal cover sheets. This often results in hand stamping and hand writing notes onto as many as seven copies.

A typical submittal process may be separated into the five discrete procedures identified in the “Procedural Perspective” in the ILM prototype shown in Figure 4-5 and analyzed earlier, in Chapter 3.4. The organization performs each procedure based on its available capitals, which must have the appropriate organization cognitive abilities to facilitate the procedures. The cognitive abilities needed by the organization for each procedure are listed in the “Ability Intensive Perspective” in Figure 4-5. Based on a procedural analysis of the submittal process requirements, human and organizational capitals are proportioned as shown in the “Interdependence Perspective.” In processing a managerial process, the professional performing the managerial activities is directly and indirectly influenced by the organization's capital, for example whether or not a computer is provided and what the organization's policy is regarding its use. The proportion of human capital and organizational capital in the combination creates an assignable measure of the relational capital associated with each procedure in the process. This proportion from each sequential task indicates the effective integration of HC or OC and precisely how RC is manifested. This generation of RC is referred to as “RC within-task,” and detailed RC within-task factors are illustrated in the “Performance Factors Perspective” in the ILM. According to the proportional scale of human capital and organizational capital assigned to each sequential task, the relative importance of each capital is determined by the construction professional as part of the effort to achieve higher performance. Transitions from task to task also create RC, but here it is “RC cross-task.” The ILM also includes RC cross-task factors in the “Performance Factors Perspective.” The interface for this change of relationship between HC and OC in the procedural process is shown in Figure 4-5 as the “Capital Transformation Perspective.”

For this work, HC is defined as a combination of three factors: 1) education, 2) experience, and 3) motivation or attitude. OC is defined as a combination of intangible and tangible assets. Intangible elements of organizational capital include policy, procedure, and culture, while the tangible elements are the systems and data that can be used for a particular process. For instance, when an organization provides a computer and a product catalog to personnel to enable them to perform a submittal process the computer is considered a system and the product catalog is considered data. HC and OC are the basic inputs necessary to perform a managerial process. The effectiveness of HC and OC can be measured by performance measures such as time or accuracy for a particular process and these performance measures will be determined by several perspectives jointly, as shown in Figure 4-5 and labeled "Performance Attribute Perspective."

Many factors affect the performance of managerial processes. These factors can be determined by the integration and transitions of capitals based on three perspectives: 1) a procedural perspective, 2) an interdependence perspective, and 3) a capital transformation perspective. These factors from HC and OC are described in the "Performance Factors Perspective." These factors are specific to each sequential task and ultimately contribute to higher performance.



- **Procedure:**
  Personnel act and operate with capitals
- **Ability:**
  Ability requirements of procedures from capitals
- **Interdependence:**
  Appropriate usage of human and organizational capital to support an organizational activity
- **Transformation:**
  Changing capital as it is transformed by procedure
- **Measurement:**
  Procedure and ability can be measured attributes with in specific performance
- **Contribution:**
  Performance optimizes with factors of capitals

Figure 4-5: The Intelligibility Learning Model (ILM) Prototype

Additionally, Figure 4-6 indicates the relationship between the knowledge framework of OI (Figure 4-1) and the learning model prototype using dotted lines. The prototype satisfies and describes each element that is proposed in the knowledge framework. Through applying the ILM, decision makers and professionals can recognize which principles of organizational activities and assets can be optimized in order to achieve higher performance. Additionally, decision makers can assess the value of additional investments in capital by examining the potential benefit to organizational activities through the ILM. The following chapter will fine tune the model and apply the ILM prototype to a managerial process in construction through the use of illustrative and exploratory case study methods.

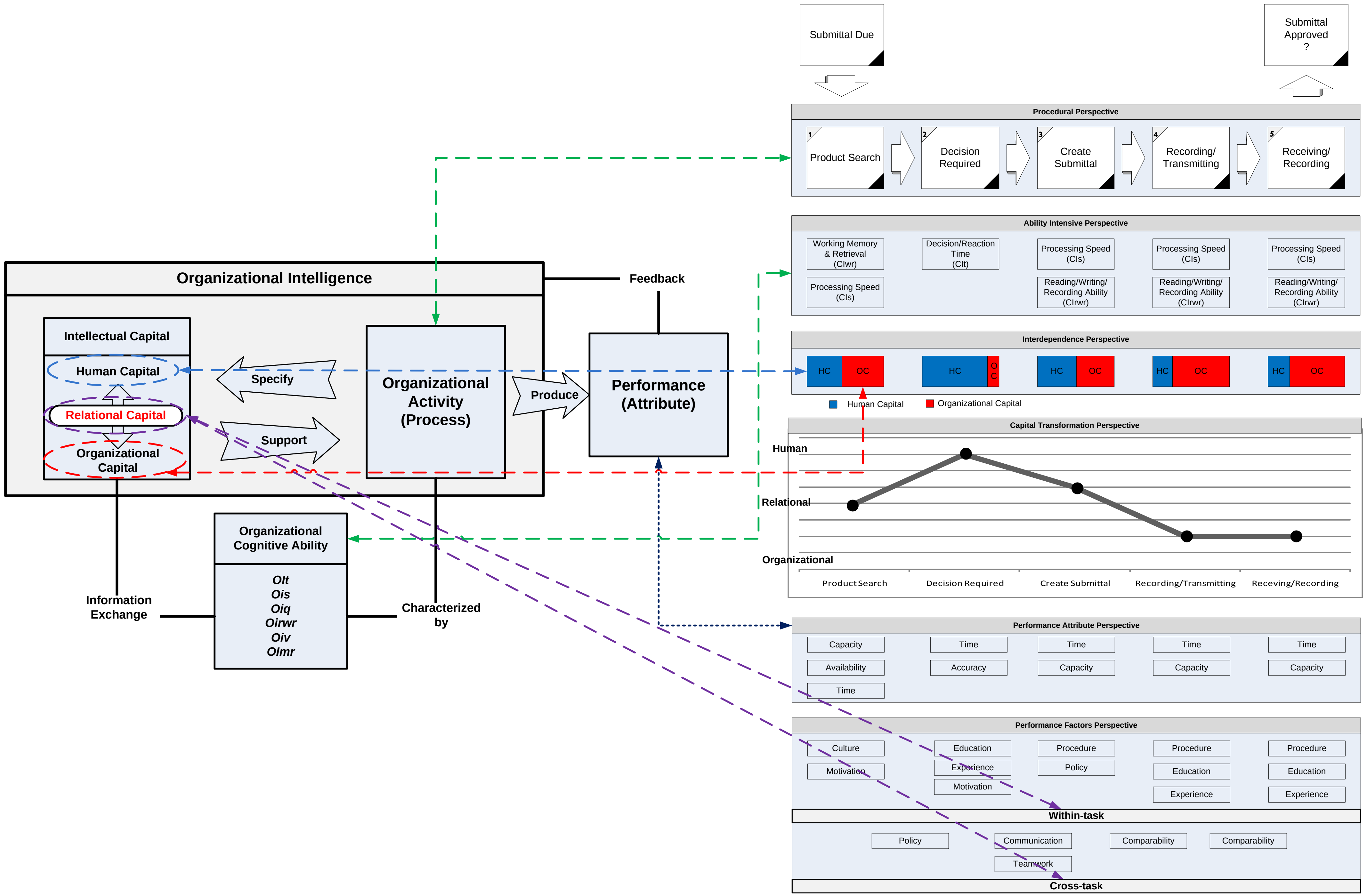


Figure 4-6: Organization Intelligence Framework vs. ILM prototype for OI

CHAPTER 5: THE APPLICATION OF INTELLIGIBILITY LEARNING MODEL WITHIN THE CONSTRUCTION PROCESS

Applying the intelligibility learning model (ILM) prototype to particular managerial processes in construction can help managers recognize the organization's strengths and weaknesses. The ILM can also be used to provide solutions that will optimize the use of organizational assets for a specific activity. Implementation of the prototype ILM is the first step to becoming a successful intelligent organization. A company's organizational intelligence can be created and developed through the Intelligibility Learning Model. This chapter demonstrates the practical application of ILM to the managerial process in construction.

Activities in many construction organizations can be divided into two main areas: 1) production management operation and 2) project management operation. The function of production management in construction is the operation of a temporary production system that is dedicated to delivering a specific product, which can be a residential, commercial or manufacturing development, while maximizing value and minimizing waste (Ballard and Howell, 2004). The function of project management is to support production operations and ensure the effective and efficient performance of construction processes. The learning model prototype will be fully applied to a typical project management operation, in this case a submittal process. The submittal process is a managerial process that is ubiquitous in project management operations and the ILM will be applied to examine its operation using case studies, one of which is illustrative and the other a pilot study. The process of production management operations is examined as a possible application of ILM in this dissertation as shown in Appendix 8-1.

By applying the ILM to the project management and production management operations, the fundamental management mechanisms can be used to develop a foundation for both in Organizational Intelligence. The ILM application to the production management operation has the potential foundation to improve the overall performance of the organization beyond traditional productivity measurements (see Appendix 8-1). Additionally, a theoretical discussion of production management operation in this dissertation becomes an ideal paper of peer review journal for further research.

The illustrative case study was conducted by interviewing three construction professionals. The questionnaires used for the pilot study were developed on the basis of the ILM prototype, Figure 4-5, and the illustrative case study. The illustrative study focused on sequential tasks for the procedural analysis of the selected managerial process, i.e. the submittal process. The interviews were conducted with three professionals who currently perform or previously performed the submittal process in construction organizations. Two are currently working at a different construction organization in the United States, and the other is currently working in South Korea.

Organizational cognitive ability is extracted from human cognitive ability in this research. Since none of the three professionals had any professional experience with cognitive ability, the cognitive expression of construction activities was not stressed in either the interviews or the pilot study. Instead, the interviews focused on the analysis of submittal processes as a procedural perspective in the ILM because the understanding of organizational activities is the first step of OIM.

5.1. CASE BASED STUDIES – CONSTRUCTION MANAGEMENT PROCEDURE

To develop a model for Organizational Intelligence Management based on the prototype of the Intelligibility Learning Model in terms of Organizational Intelligence, this research adopted a case study approach to collect and present detailed information about particular participants, especially those engaged in managerial activities in construction. This research utilized two methods for the case based studies: 1) an illustrative case study and 2) an exploratory, or pilot, case study.

An illustrative case study is primarily a descriptive study and typically utilizes one or two instances of an event that demonstrate how a real world process operates. An exploratory, or pilot, case study is a condensed case study that is performed before implementing a large scale investigation, and its basic function is to help identify suitable questions (Becker et al., 2005).

5.1.1. Methodology

The research utilizes illustrative and exploratory case studies to investigate how OIM can be applied to construction managerial processes in terms of OI. The methodology of OI research for case studies is illustrated by the flow chart shown in Figure 5-1. The top part of the chart represents the input from interviews; the construction professionals also contributed to the procedural analysis of the managerial process for sequential tasks.

To initiate the process, one of the participants was interviewed in order to analyze and create a submittal process that could be broken down into sequential tasks. The initial model developed on the basis of this information was then shown to the other participants and their input incorporated into the model. The other participants also contributed their own experiences, ideas, and beliefs to the model as part of the calibration process, as shown in Figure 5-1. The final version of the model was agreed with all three participants. The initial interview was conducted face to face with the first participant in September, 2008, while the other interviews for the calibration and validation proceeded via telephone, email, and on-line messages due to the geographical distances involved. On the basis of the model that was constructed, questionnaires that included the perspective of the learning model prototype were developed for the pilot study.

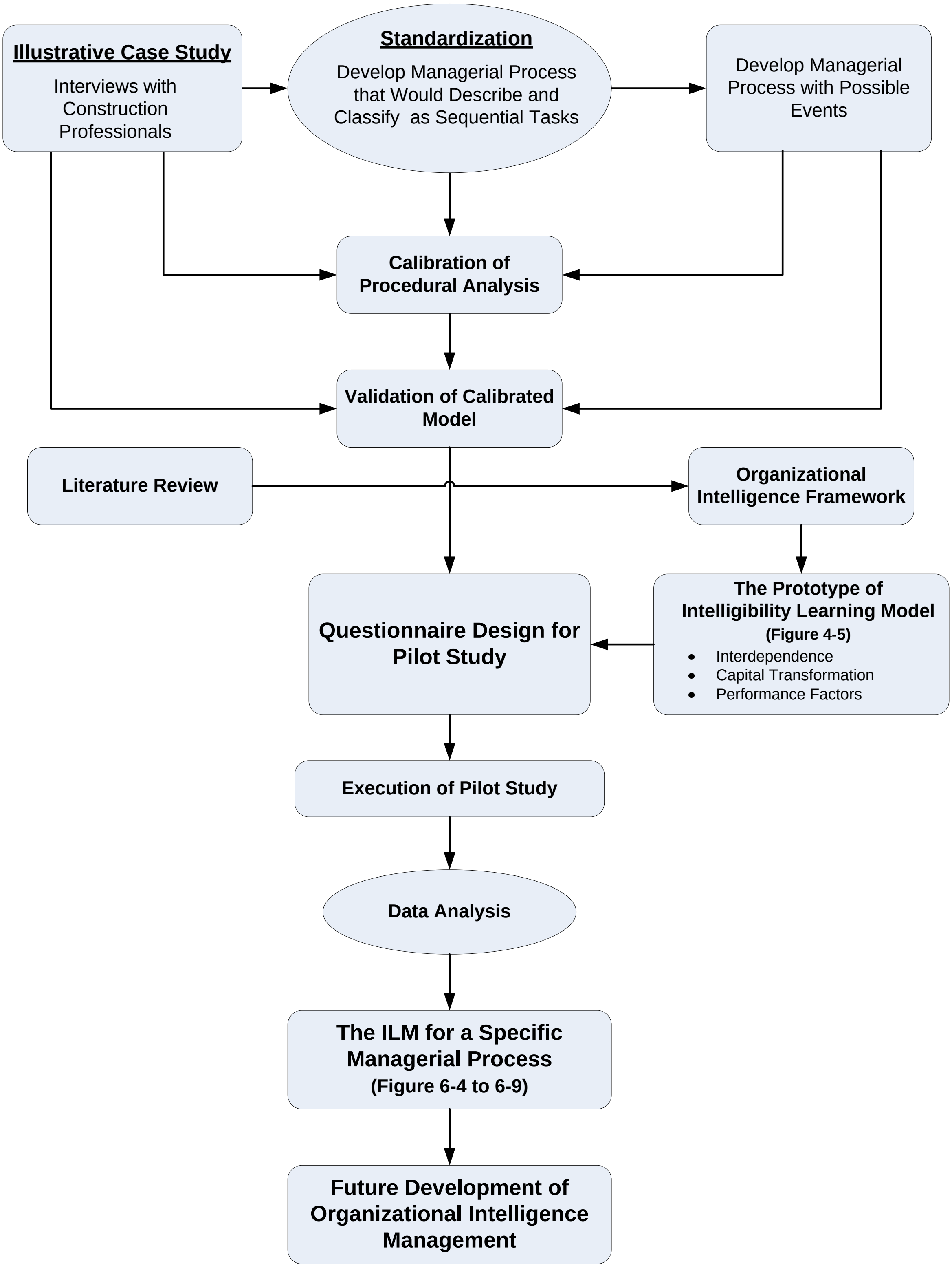


Figure 5-1: Research Methodology for Case Based Studies

5.2. PROJECT MANAGEMENT OPERATION – SUBMITTAL PROCESS

Before starting the actual construction phase of a project, many project management operations must progress through a pre-design phase to project closeout, including bidding, scheduling, estimating, change order, submittal, requests for information, and so forth. The ILM prototype developed for this research was tested using the submittal phase of the construction process.

Submittals are a typical project management operation and are expected to fulfill various project requirements, including product data forms, shop drawings, samples, and so on. Submittals are initiated by various construction parties. The submittals are the contractor's responsibility and a very important part of the process that supplies materials to the site on time. First, a general contractor decides whether a task would best be performed by their own workforce or contracted out to a subcontractor. The general contractor can reflect all submittal-related activities in the project schedule. However, commercially available scheduling software generally utilizes the critical path method, and for most submittal-related activities it is difficult to pinpoint exactly the predecessor of a certain submittal activity with this type of software. Because the project schedule does not normally include submittal activities, most contractors must do this themselves. This is generally called a "submittal schedule" and is based on the project schedule. The project schedule includes only the actual installments activities for a project and system.

On the basis of the interviews with experts, a flow chart of the process of material submittal by general contractors was constructed as shown in Figure 5-2. This model was developed with the aid of the three participants as part of the illustrative case study. The diagram shows how a general contractor's procurement process for material submittals functions, and how it takes into account the way the contractor's work crews will install the materials.

During the submittal process, a professional may have to deal with several issues, which are illustrated with decision nodes in Figure 5-2. The professional must act efficiently and effectively and be able to suggest alternatives if possible in order to prevent delays. Before contacting suppliers, the professional devotes many working hours to understanding and interpreting the contractual requirements from drawings, data sheets, and shop drawings. Based on the interpretation of certain materials, the professional will decide the amount of materials, time for delivery, and administrative requirements. Most contractors have a list of suppliers that they have conducted business with in the past and with whom they have a good working relationship.

Contractors will select and prequalify suppliers from their existing list unless the products are unusual. After the prequalification, contractors send the contractual specifications and requirements to the suppliers, who then submit proposals based on the project requirements. The proposals generally include availability, price, and the supplier's terms and condition.

In general, every supplier has its own protocol, terms, and conditions for the business, and the supplier's proposal will reflect this, so contractors should thoroughly review and compare each supplier's proposal and select the supplier who best meets their needs. The contractor then draws up an official contract with the selected supplier. This is usually requested by the supplier, as significant costs are incurred by them in gathering the information needed for a final submittal, such as product information, samples, and catalogs. Few suppliers are prepared to wait until after the Architect/Engineer's (A/E's) approval for the submittal has been obtained before an official contract is signed.

After receiving detailed product information, the contractors perform a final review before preparing and sending a submittal to the A/E for approval. In this final review the contractors identify potential problems due to material defects, confusing terms, and so on. Once all the issues have been resolved, the A/E signs off on the submittal, certifying that it meets both the contractual requirements and contractor's requirements. Each sequential task in Figure 5-2 contributes to other construction processes that are analyzed and standardized further to develop OIM.

The submittal process is a necessary and entrenched step in construction projects, and various factors will affect the its performance and ultimately the successful completion of the project. The experimental prototype of ILM described in the previous chapter can be used to identify these factors to ensure their effective and efficient performance, which is the first step toward organizational intelligence management.

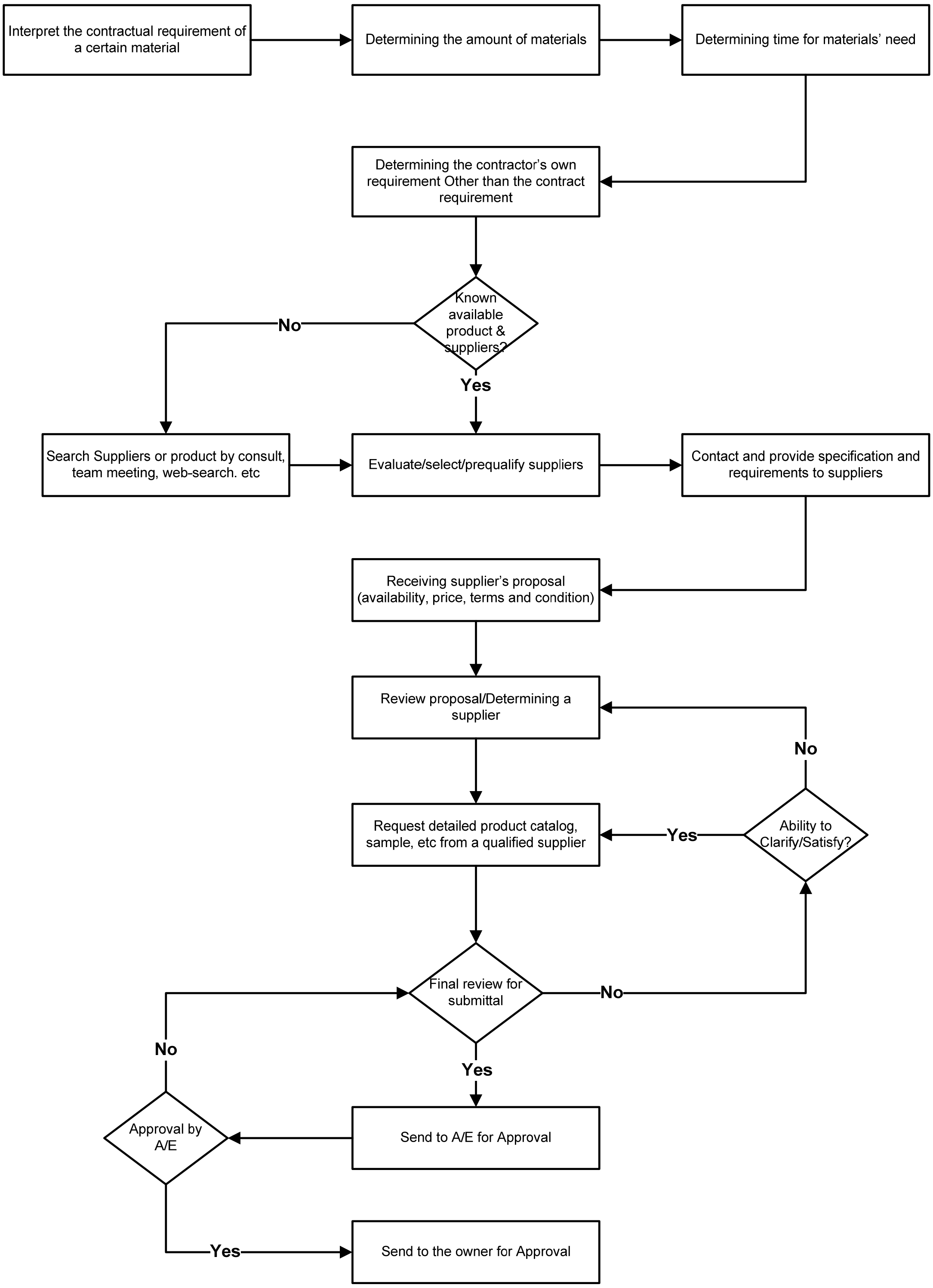


Figure 5-2: Submittal Process Model – Illustrative Case Study

According to the model of the submittal process in Figure 5-2, contractors may face various problems. To ensure that all eventualities are considered during the submittal process, this research applies the ILM prototype to two cases. One is the common process without any conflicts, and the other presents a contingent process during the submittal process.

5.2.1. Procedural Perpective

The procedural perspective adopted in the ILM is based on initializing a learning model and considering contingent activities. Therefore, the analysis of the managerial processes by a flow chart is an appropriate way to demonstrate how unexpected events can be dealt with. Construction submittals are routinely performed by professional managers. Therefore, the professional who is responsible for the submittal process in a project team must be familiar with various aspects of construction activities. To better understand the process, the submittal process can be broken down into four stages, 1) Integration, 2) Pre-qualification 3) Decision Making, and 4) Implementation, as shown in Figure 5-3. This classification of submittal processes can be compared to the general decision making process, which consists of four or five steps: 1) state the problem 2) identify alternatives 3) evaluate alternatives 4) make a decision, and 5) implement (Reavis, 2006). As the classification of the decision making process into steps also helps to analyze and explain the current status, the classification of the submittal process into stages establishes a strategic foundation from which to analyze and apply other managerial processes.

In submittal processes, the activity of interpretation equates to stating the problem, and pre-qualification is the process of identifying and evaluating alternatives in the decision making process. After the evaluation of alternatives, two or more potential alternatives are generally very close to the evaluation criteria or requirements. Making decisions is about eliminating all the low ranked alternatives and the carefully examining the high ranked alternatives in the light of the evaluation criteria. The evaluation criteria are the results of interpreting the contractual requirements and assessing the benefits to the contractors in the submittal process. After making a decision, the implementation of the decision follows. The contractor contracts with the supplier officially and sends the submittal to the A/E for approval.

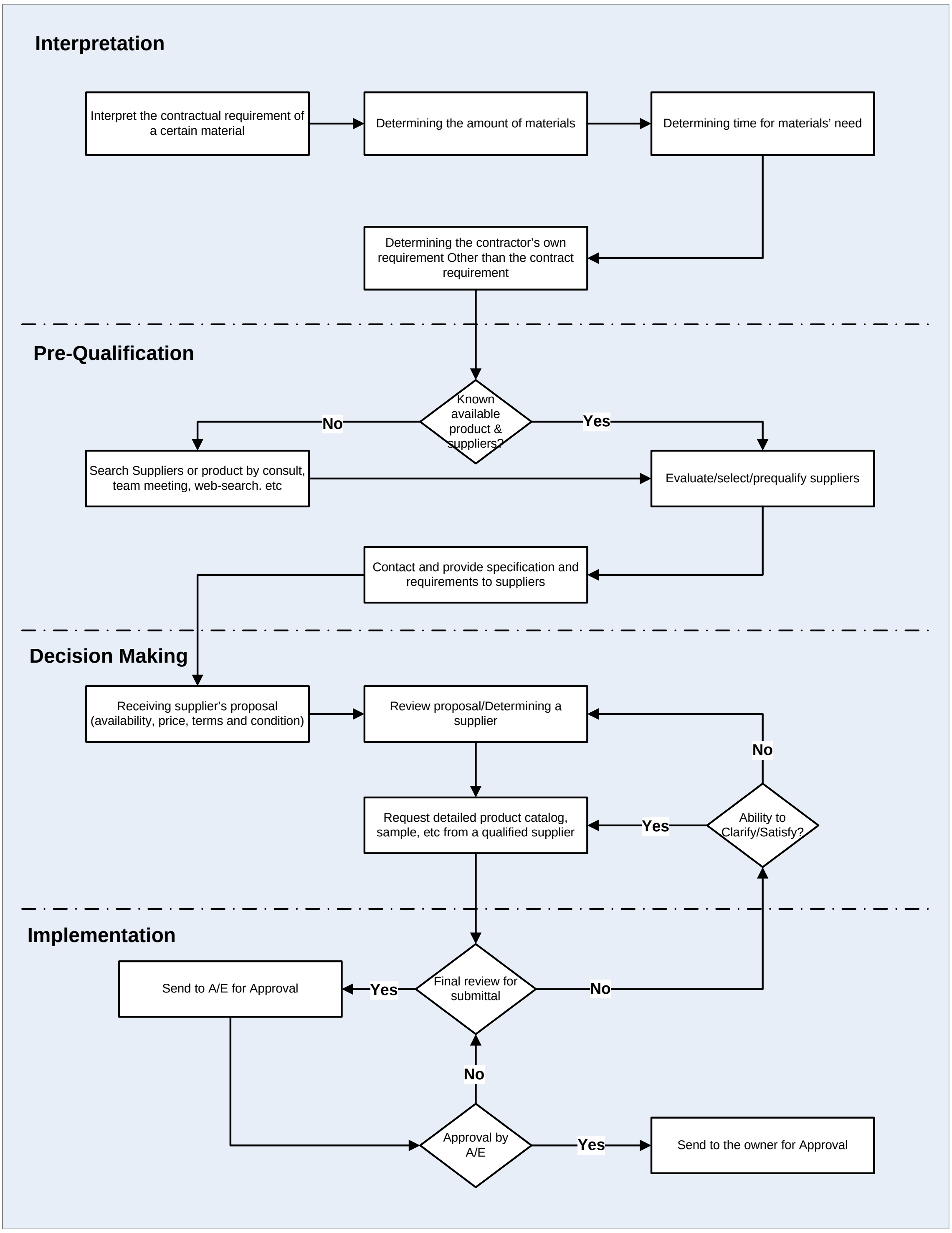


Figure 5-3: Classifying the Submittal Process into Four Stages

As with the process of general decision making, each sequential task can be broken down into four distinct stages, as shown in Figure 5-4, to clearly identify the sequential tasks involved. This is what happens for common sequential tasks where no conflicts occur. Here, the interpretation stage may include four steps: 1) interpret the contractual requirements 2) determine the amount of material needed, 3) determine the time for delivery, and 4) determine the administrative requirements. The contractor's scheduling system or computer project management tools can be used to perform these activities efficiently and effectively.

According to the type of materials and installments, the contractor may need "shop drawings" in addition to material data sheets at the "Interpretation Stage." For example, structural steel works usually need shop drawings that contain more detailed materials and actual installments information, such as the designation of each member, bolt and welding type. Generally, however, contract drawings do not include this level of detail. After the initial task, "Interpret the contractual requirements," responsible personnel must decide on the amount of materials that will be needed. The amount of materials is important because it affects the material price and the availability from suppliers. As more materials are ordered, the contractor gets a better discount from the supplier. Alternatively, if the amount exceeds the amount available from the suppliers' stock, this will increase procurement times.

The project schedule is focused on actual installment activities on the site, so the professional who is responsible for the submittal process must be familiar with the project schedule. The third step, "Determine time for delivery," is important. For instance, consider the instruction "Bldg. 550 installing acoustic ceiling grid", which is supposed to start May 1, 2008. In order to ensure that the materials are at the job site before May 1, the contractor must consider the manufacturing period and how often suppliers receive materials from the manufacturer, as well as the delivery times, submittal preparation, and submittal approval process. If the required materials are contracted and processed through suppliers or manufacturers and approving entities, the contractor may have to allow for as much as 30 days for manufacturing, 15 days for delivery, 10 days for submittal preparation, and 10 days for submittal approval. Consequently, in this case the contractor must start all submittal work at least 65 days before May 1. In addition, various administrative times affect the submittal process as follows:

- Calculating material amounts
- Inquiring and contacting suppliers
- Waiting for the suppliers' responses

These additional times are also part of the submittal process. Therefore, the professional has to consider an even longer lead time to prevent delays caused by a lack of materials.

The fourth step in the interpretation stage, "Determine administrative requirements," varies based on the environment of each project. The contractor must be clear concerning their specific requirements from suppliers, rather than the requirements given in the contractual documents, because the contractual requirements only specify the quality aspects of materials. Most contractors' requirements from suppliers are generally concerned with the administrative aspects. For example, "who delivers this material to the job site," "who unloads the material from the delivery truck," and "whose equipment is used for unloading," are generally considered to be administrative issues by contractors. In addition, the professional needs to decide whether a one time delivery or phased delivery methods is preferable because this administrative decision is directly concerned with the condition of sites, for example the project location, storage stock availability, and the maintenance of the quality of materials. These administrative aspects are thoroughly examined in conjunction with the contractual requirements by professionals.

In the prequalification stage, the contractor identifies possible suppliers who are expected to be able to provide products in a correct manner, taking into account their historical trading record and reputation. If the contractor is not familiar with the available products or suppliers, they must take other action to locate suitable products. The contractor can find available products or suppliers by consulting colleagues or other contractors, team meetings, and web-searches, and this additional process is described in Figure 5-5 as a contingent process. The contactor can then contact the potential supplier and provide them with detailed information concerning the products in the integration stage. Suppliers prepare their proposals according to the information provided by the contractor. The contractor will then choose from the suppliers' proposals. To prevent unnecessary communications with suppliers, the contractor must provide precise information regarding the products and requirements, including the contractor's own requirements, at this point. The contractor can then get information on the availability of the product from suppliers, who will provide proposals, including price, terms and conditions.

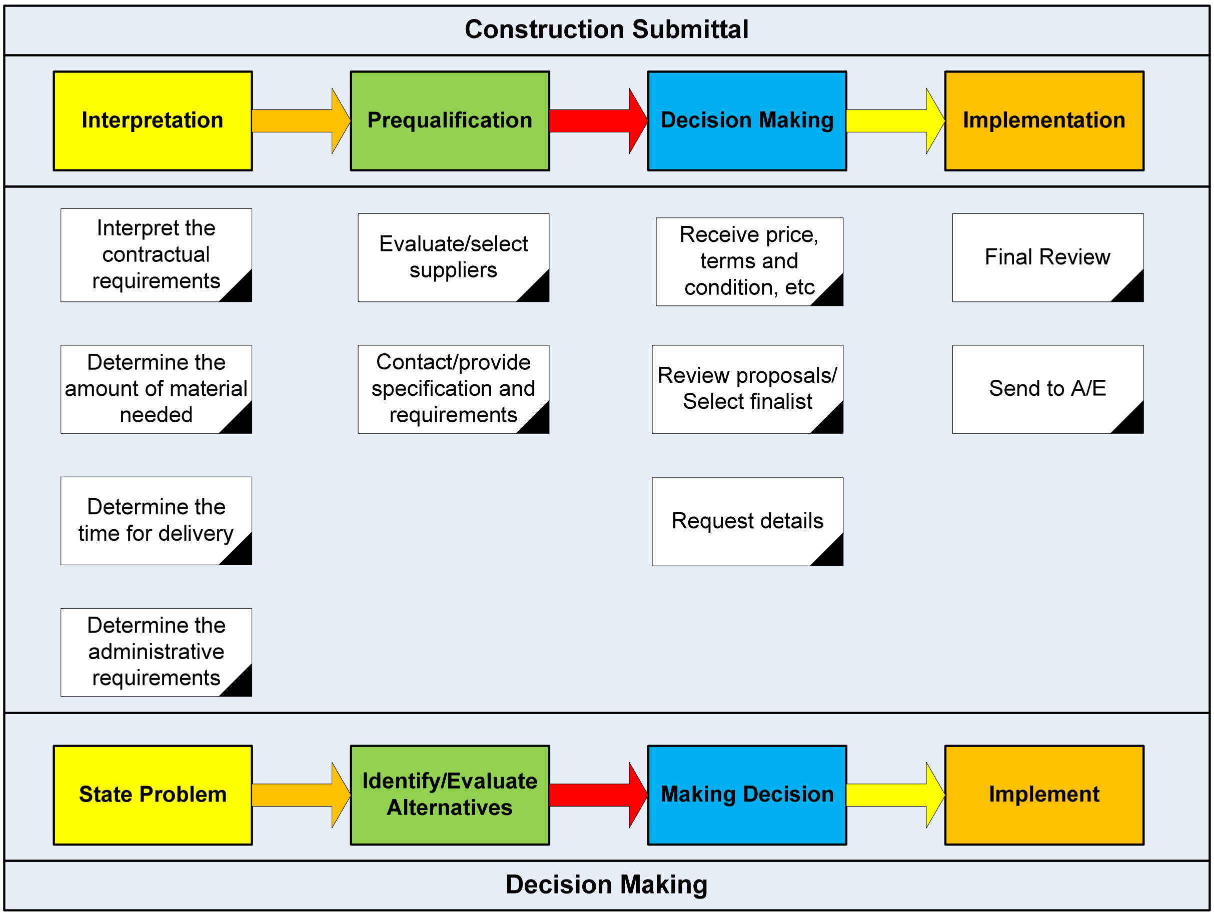


Figure 5-4: Common Submittal Process

In the "Decision Making" stage, the contractor selects the finalist who will supply the products based on the proposals. Although the price of products is a critical criterion in choosing the supplier among the proposals, the contractor must also consider the different terms and conditions from each supplier. As mentioned above, each supplier has their own protocol, terms and condition for their business, so the proposal will reflect and include these various requirements. For example, the proposal generally indicates items such as "This price is valid for 30 days," "Contractor unloads the materials," and "Additional order will increase the cost by 1

$/*sf*.," and so forth. Suppliers' proposals infrequently satisfy all the requirements of the contractor's interpretation of the contractual requirements and the contractor's administrative requirements and there are often conflicts between the supplier's and the contractor's needs. Therefore, the professional must consider various aspects of both contractual and administrative requirements beyond a project schedule when selecting the final supplier.

The contractor requests detailed information, including samples and catalogs, following the selection of the supplier. The supplier generally prepares the submittal documents according to the contractor's template. The contractor does not prepare the submittal that is to be resubmitted to the A/E for approval because this would be duplicated work. In general most contractors require the use of comparable templates for suppliers' submittals.

In the "Implementation" stage, the contractor makes a very thorough, review of the submittal before it is sent to the A/E for final approval. At this stage the contractor identifies defects in the supplier's proposal such as confusing terms. To prevent unexpected problems during the supply process, the contractor must contact the supplier immediately and request clarification of any problems detected during this final review. If the supplier has made a mistake or used confusing terms, the contractor requests that this be corrected in a timely manner. However, if the supplier is not able to fix the problems, the contractor may have to dismiss the supplier. In this case the contractor returns to the "Decision Making" stage and repeats the same tasks, as shown in Figure 5-5.

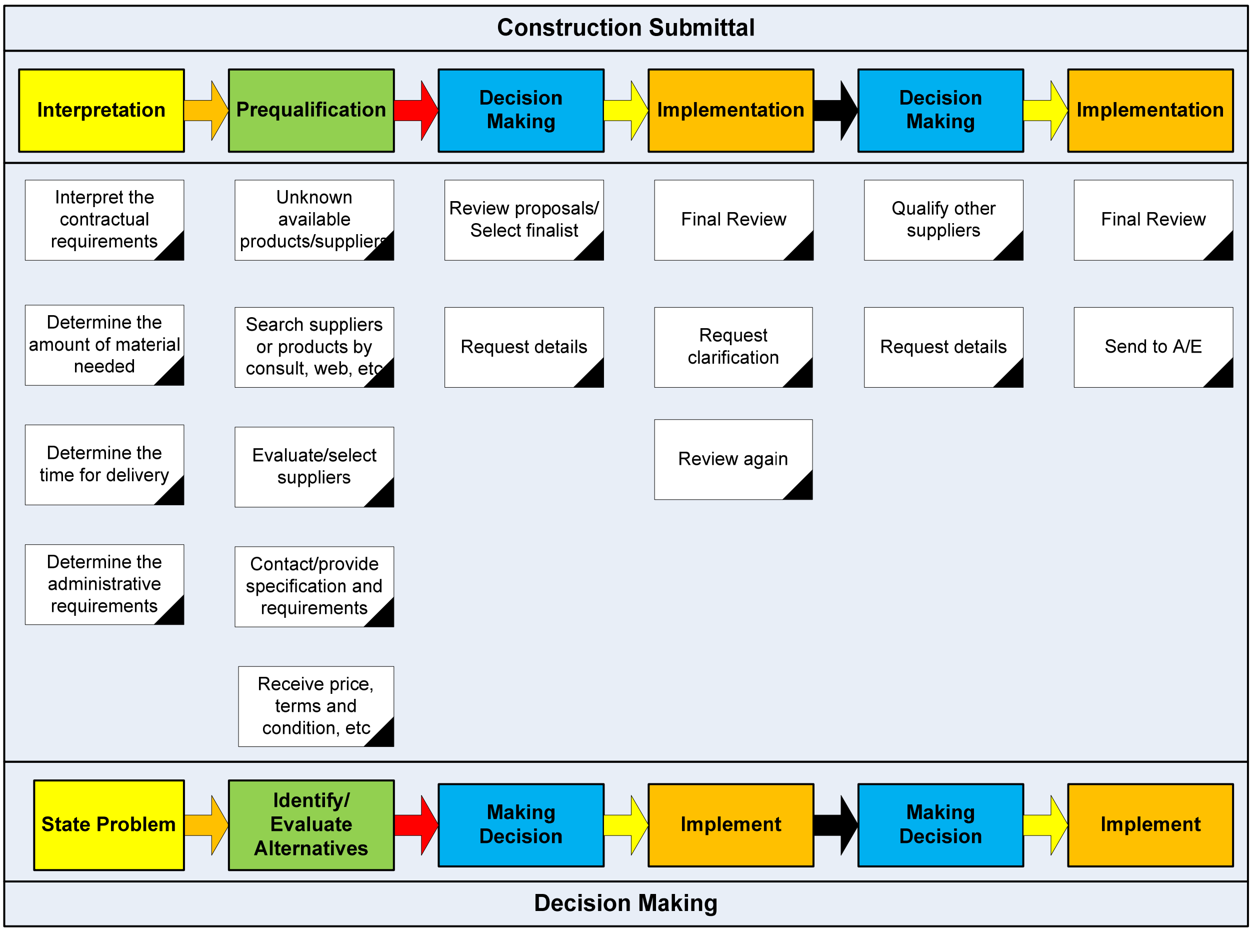


Figure 5-5: Submittal Process with a Contingency

Each sequential task in the two cases, common and contingent, during the submittal process reflects directly on the performance of the organization, and this organizational performance is the result of various factors from the capitals that the organization dedicates to the task. HC and OC contribute different weights to each task, and these are analyzed as part of the “Interdependence Perspective” in the ILM. This perspective determines the proportional contribution of HC and OC in order to optimize the performance of tasks.

5.2.2. Interdependence Perspective

The interdependence perspective in the ILM evaluates the human abilities involved in managerial tasks in organizations. In many industries human workforces have been replaced by technologies such as automation or robotics, for example assembly lines in vehicle manufacturing. Labor shortages in Japan compelled the Japanese construction industry to begin to introduce construction robots as long ago as the 1970s (Cousineau and Nobuyasu, 1998). Currently, research and development in the area of automation and robotics in the construction industry has focused on production management operations such as welding, concrete floor finishing, demolition, and bricklaying. In project management itself automation has been limited because managerial activities depend primarily on the decision making by managerial personnel. However, various OC factors can be applied to assist repeated processes in decision making. For the task "Evaluate/Select suppliers" in the prequalification stage, for instance, the project engineer decides on suppliers based on various factors such as their company culture, historical trading record, reputation, and experience, as shown in Figure 5-6. However, if the organization provides a database for the supplier management system that includes contact information, product lists, and current stock levels, the time required for the evaluate/select task is markedly reduced. In addition, if the organization provides the evaluation and selection criteria as a policy that considers cultures and prior experiences with the organization, the professional can decrease minimize the factors that must be taken into account at the prequalification stage. The possible factors of the prequalification stage that could influence performance are illustrated in Figure 5-6.

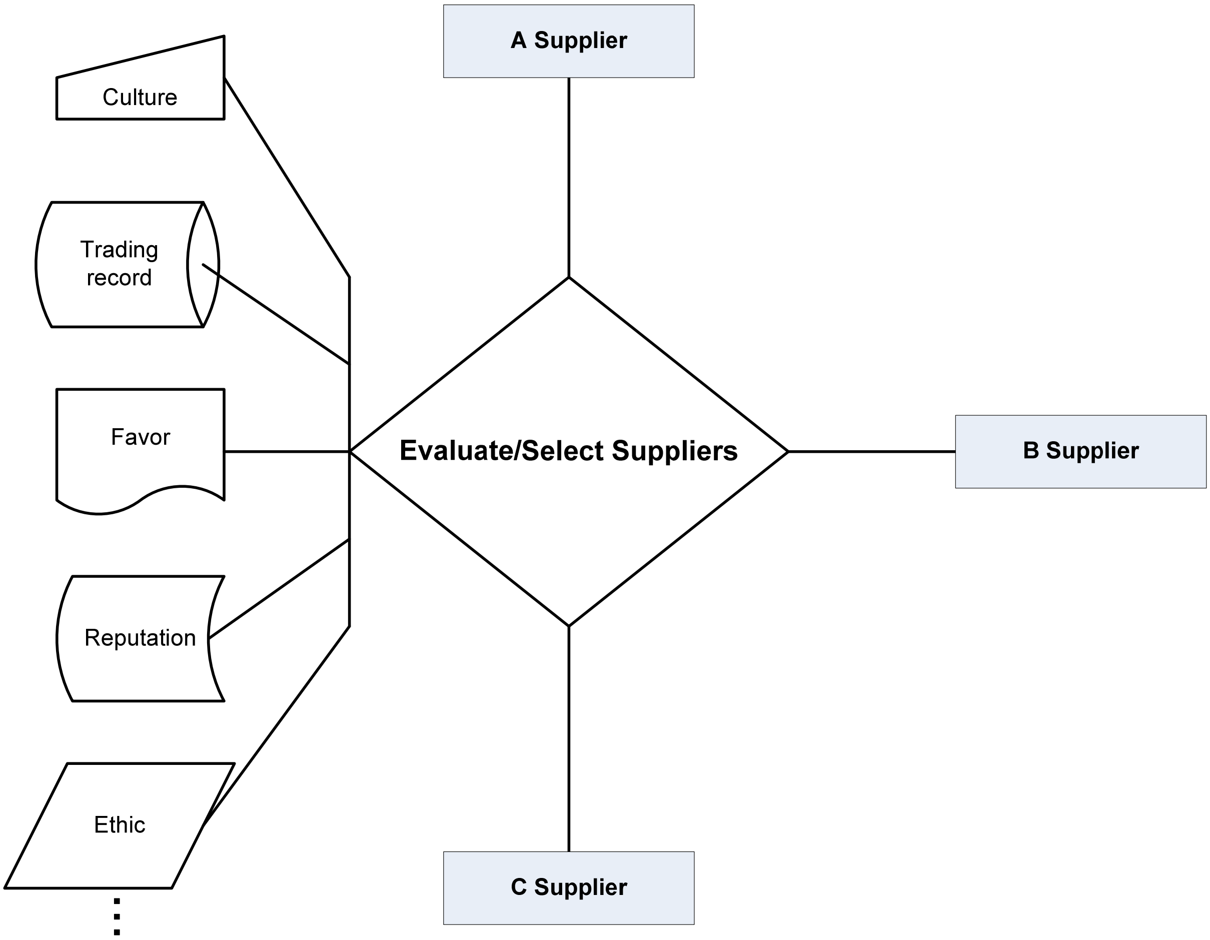


Figure 5-6: Examples of Impacting Factors for a Task

The interdependency perspective determines the proportional contributions of HC and OC for each task, which is expected to vary according to the usage of various factors from the capital. This pilot study developed questionnaires that can be administered to construction professionals in order to help identify the optimum combination of HC and OC for each task.

5.2.3. Capital Transformation Perspective

This perspective depends on the results of the “Interdependency Perspective.” The graph shown in Figure 5-7 indicates how the balance between HC and OC shifts between different tasks in the ILM prototype. Marks on the line indicate the dependency on each type of capital for each task, while the lines joining them show the transformation of the task dependency between each pair of tasks. In the ILM prototype, this transformation indicates directly the composition of RC for each task; the marks indicate “within-task RC,” and the lines indicate “cross-task RC.” The graph displays the capital movements in such as way as to enable users to recognize easily the intensity of the different capitals at each stage during the process, and making it possible to test several major issues concerning the ILM prototype with the aid of the pilot study.

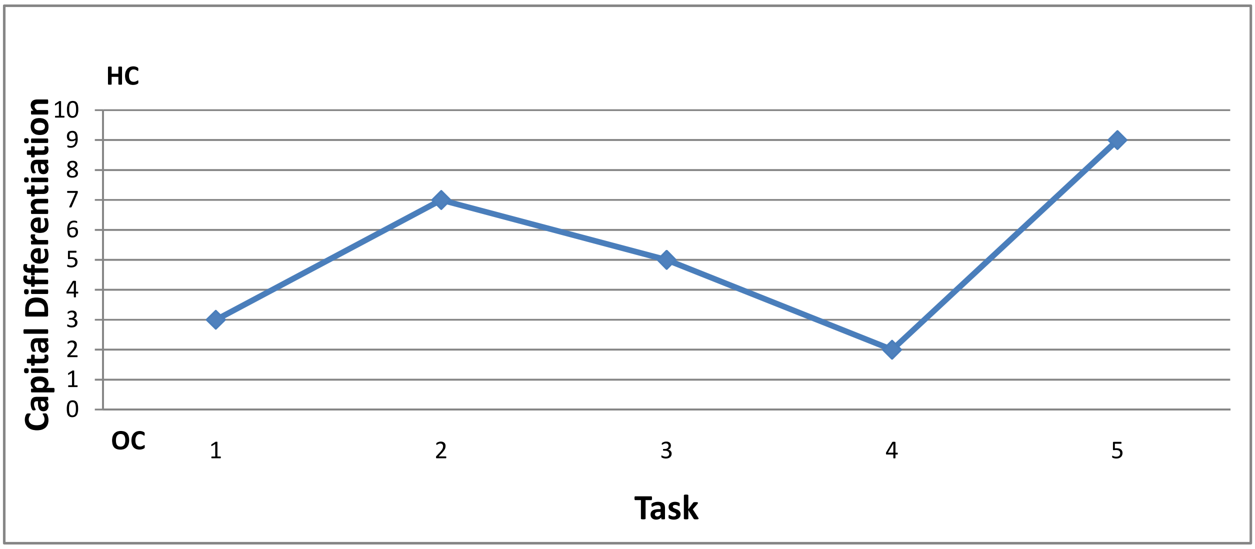


Figure 5-7 : Examples of Capital Transformation Perspective

Overall, this perspective makes it easy to see precisely how each task combines intellectual capitals to create organizational intelligence that enhances the combined performance of both the tangible and intangible assets within the organization.

5.2.4. Performance Factors Perspective

This perspective is directly connected with relational capital and is manifested by the integration of human capital, organizational capital, and organizational activity. The integration of HC, OC, and organizational activity for a specific task places demands on several factors to ensure effective and efficient performance. These factors are the components of Relational Capital for a specific task, and are referred to as performance factors in the ILM. These factors can vary depending on the individuals' backgrounds, including education, experience, and culture, but the factors that are required to perform a task effectively and efficiently will also vary for each sequential task in the process. This research reveals which performance factors are important for each sequential task, thus providing decision makers with frameworks and concepts that describe how those particular factors will affect the strategic success of the organization, namely organizational intelligence management. For example, the decision framework used by managers reflects fundamental and logical elements, such as plan, do, check, and act, that translate into logical connections with such processes as inspection, maintenance, adjustment, and equipment replacement in the area of Total Quality Management (TQM) (Boudreau and Ramstead, 2007). TQM is based on the use of statistical process control, control charts, and time-series statistical analysis. Compared with TQM, this perspective offers an alternative way to determine which factors affect the fundamental and logical elements and thus contribute to the success of the organization with high performance objectives.

The pilot study examined performance factors for each task, specifying ten factors that may be required by organizational activities but allowing additional factors to be added if the participants deemed it necessary. The suggested ten factors in this dissertation were:

- Experience
- Education
- Motivation
- Policy
- Leadership
- Culture
- Training
- Ethic
- Tool
- Teamwork

Three factors, namely experience, education, and motivation, are the basic factors of HC that take among four factors in the study of Hudson (1993). The others are factors of OC. Although many studies consider various factors, such as leadership, teamwork, culture, to affect organizational performance, performance factors for a particular task are not firmly defined yet. Therefore, the pilot study provides an opportunity to define factors that an organization must have to perform each task effectively and efficiently.

When these factors are specified with the task, these factors become part of RC, either within-task RC or cross-task RC. However, in this study only within-task RC was considered, leaving cross-task RC for the further research into the development of organizational intelligence management.

5.2.5. Ability Intensive Perspective

Organizational Cognitive abilities represent basic typical and longstanding characteristics of procedures in a given process in the same way that cognitive ability in humans represents the basic constitutional and longstanding characteristics of a human. Based on the definition of organizational cognitive ability, this perspective can determine the necessary abilities for each sequential task. However, this perspective was not explored in the pilot study because the construction professionals who were interviewed were not familiar with cognitive ability.

The expression of a particular task in terms of organizational cognitive ability is an innovative approach that emphasizes the abilities required for certain activities because the concept of organizational cognitive ability is modeled on human cognitive ability. Figure 5-8 shows the connection between human cognitive ability and organizational cognitive ability. The development of organizational cognitive ability was described in Chapter 3.2.

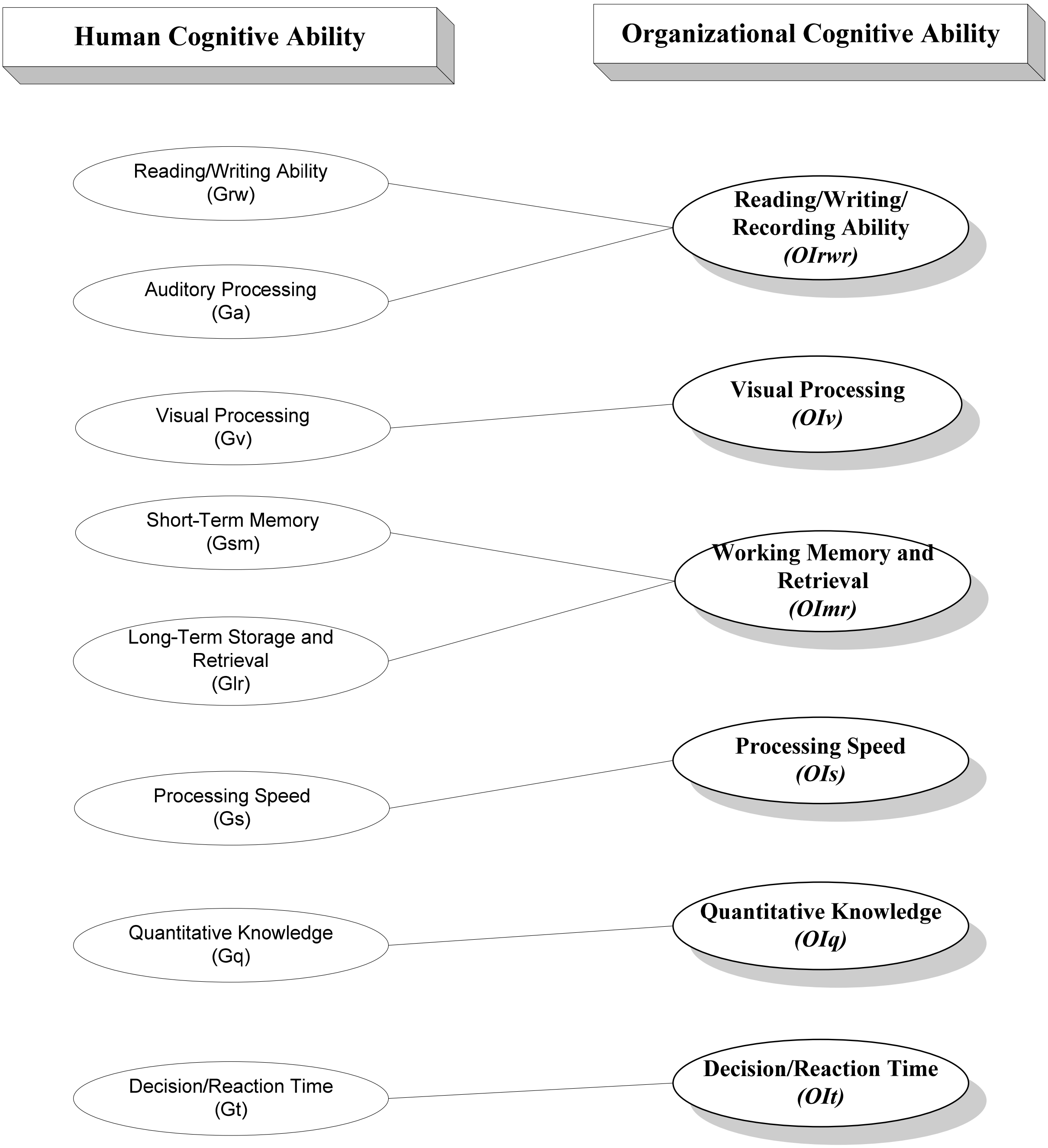


Figure 5-8: The Relationship Between Human Cognitive Ability and Organizational Cognitive Ability

The expression of a particular process in terms of organizational cognitive abilities is an innovative approach to determining the important factors that govern and influence a variety of functional tasks. For instance, the stage of interpretation is broken down into four tasks in Figure 5-4 in the submittal process, which is a common activity in the construction industry. This stage involves gathering information, data from working drawings, specifications, addenda, amendments, and other contract documents. This task is typically coded or input into a standard agreement format. In Figure 5-8, Reading/Writing/Recording Ability *(OIrwr)* and Visual Processing *(OIv)* characterize the ability to transmit or create the standard information with template forms, while Processing Speed *(OIs)* is the characteristic that describes the quickness of the transmission and creation and Working Memory & Retrieval *(OImr)* prevents duplication. These four organizational cognitive abilities are closely linked with OC. However, HC is also required because it is a vital component of decision making, although the degree of HC involved will vary depending on the task. This degree of HC is the key factor affecting the overall organizational performance. Decision/Reaction Time *(OIt)* is the determining ability for HC. The integration requires five cognitive abilities: Reading/Writing/Recoding Ability *(OIrwr)*, Visual Processing *(OIv)*, Processing Speed *(OIs)*, Working Memory & Retrieval *(OImr)* and Decision/Reaction Time *(OIrwr)* before action can be taken.

Once the organizational cognitive abilities are identified for each sequential task of the process, the HC and OC contributions can be determined in terms of organizational cognitive ability and which capital is appropriate to perform each task.

5.2.6. Performance Attribute Perspective

When a construction process is strongly dependent on OC, such as the use of e-forms or project software, the tools used for the particular process are critical factors affecting performance measures. Many intellectual and technical business improvements continue to flow into the construction industry, and these improvements are considered to be part of OC, for example bar coding, RFID, and group software. The efficient use of OC is deeply related to performance, and will depend on familiarity and the degree of control that is possible. The inclusion of performance measures in the performance attribute perspective for each of the sequential tasks is determined in accordance with multiple perspectives in the ILM, including the "Procedural Perspective," "Performance Factors Perspective" and "Ability Intensive Perspective."

Chapter 6 will present an analysis of the results of the pilot study on the ILM of project management operation for the submittal process.

CHAPTER 6: ORGANIZATIONAL INTELLIGENCE MANAGEMENT WITH INTELLIGIBILITY LEARNING MODEL

This chapter presents a systematic factor-based strategy for organizational intelligence management (OIM), including interviews involving experts and a study of the ILM prototype. The pilot study has been developed by illustrative case studies with experts, and the format and questionnaires used for the pilot study are shown in Appendix given as Chapter 8. This prototype of the ILM is expected to facilitate a better understanding and more effective integration of organizational assets and provide new opportunities to enhance the management of both organizational activities and assets. This analysis also provides a good foundation for a pioneering study of OIM.

6.1. A COMPARISON OF DIFFERENT SYSTEMS

Managerial processes in any organization depend heavily on the systems or methods they use because the organization relies on them to provide the appropriate intellectual capital needed to support organizational activities.

Without adequate intellectual capital, the organization cannot operate efficiently. In order to compare systemic process differences in OIM, this research examined three different systems for the submittal process using case studies. These three methods utilize three different degrees of technical applications in the submittal process: 1) a traditional method, 2) a technological method, and 3) a hybrid method. A traditional method relies on paper documentation that mostly uses fax or mail delivery systems and logging through human inputs. Recently, the use of email communications to transmit electronic files and documents has begun to be widely used in many industries. A technical method therefore takes advantage of information technology to transfer documents between players using web-based products or an intranet. A hybrid method uses a combination of both traditional and technological methods, based on an organization's environment.

Various parties are involved in a construction project and all may have different systemic protocols. Interoperability has become an issue in the construction industry, with many construction companies still depending on traditional methods due to the difficulty of interoperability. Consequently, faxing is generally used to exchange documents with different parties. Although many organizations recognize the necessity and advantages of information/communication technologies (ICTs), decision makers often resist adopting ICTs due to their uncertainty over various issues, such as unfamiliarity with the technology and uncertainty regarding the performance that can be expected and the potential return on investment. However, many organizations in construction have now begun to take advantage of ICT. Table 6-1 shows the system usage of the interviewees who assisted in the development of a procedural analysis for a managerial process and participated in the pilot study.

The "TeamLink site" developed by company B is one of the web-sites available for project management. This web site is capable of storing all project-related information so that it is available for managerial personnel to view or upload organizational documents, including templates, pictures, memos, and reports. This system allows professionals at different locations to work together on the same project. It is particularly useful for organizations whose branch offices are distributed across the nation or even internationally in order to provide a forum and tools for sharing common information for managers in different geographical locations. Such a company needs an Information Technology (IT) department, often located in the main office, which controls and maintains a web-site for each project. Each managerial professional employed by the organization is issued with identification and a password by the IT department that allows them to access the TeamLink site. Managerial professionals can access and modify the information on the web-site to ensure all those involved in the current project are working with the most up-to-date information. In many projects, a project owner can also be granted access to the TeamLink site, allowing them to see the submittals uploaded by managerial professionals and add comments.

Table 6-1 shows different methods for the submittal process as the part of Organizational Capital in the organization. Recently most construction companies are using an email to communicate with other players, but the usage of emails is limited and mostly depended on primary methods: 1) a traditional method, 2) a hybrid method, and 3) a technological method. The technological method and the hybrid method are designed to give access to submittal documents to take advantage of the rapid communication with other players, such as owner, supplier, architect, and subcontractor. The management of systems depends on company and project type and size.

Participant	**1**	**2**	**3**
Company	A	B	C
Method	Traditional	Hybrid	Technological
System Usage	Fax, and Mail delivery system	TeamLink Site	Project Management Information System (PMIS)
Email Use	Yes	Yes	Yes
Access	N/A	Owner	Owner, Suppliers, and Other parties
Management	Own	Own	Outsourcing

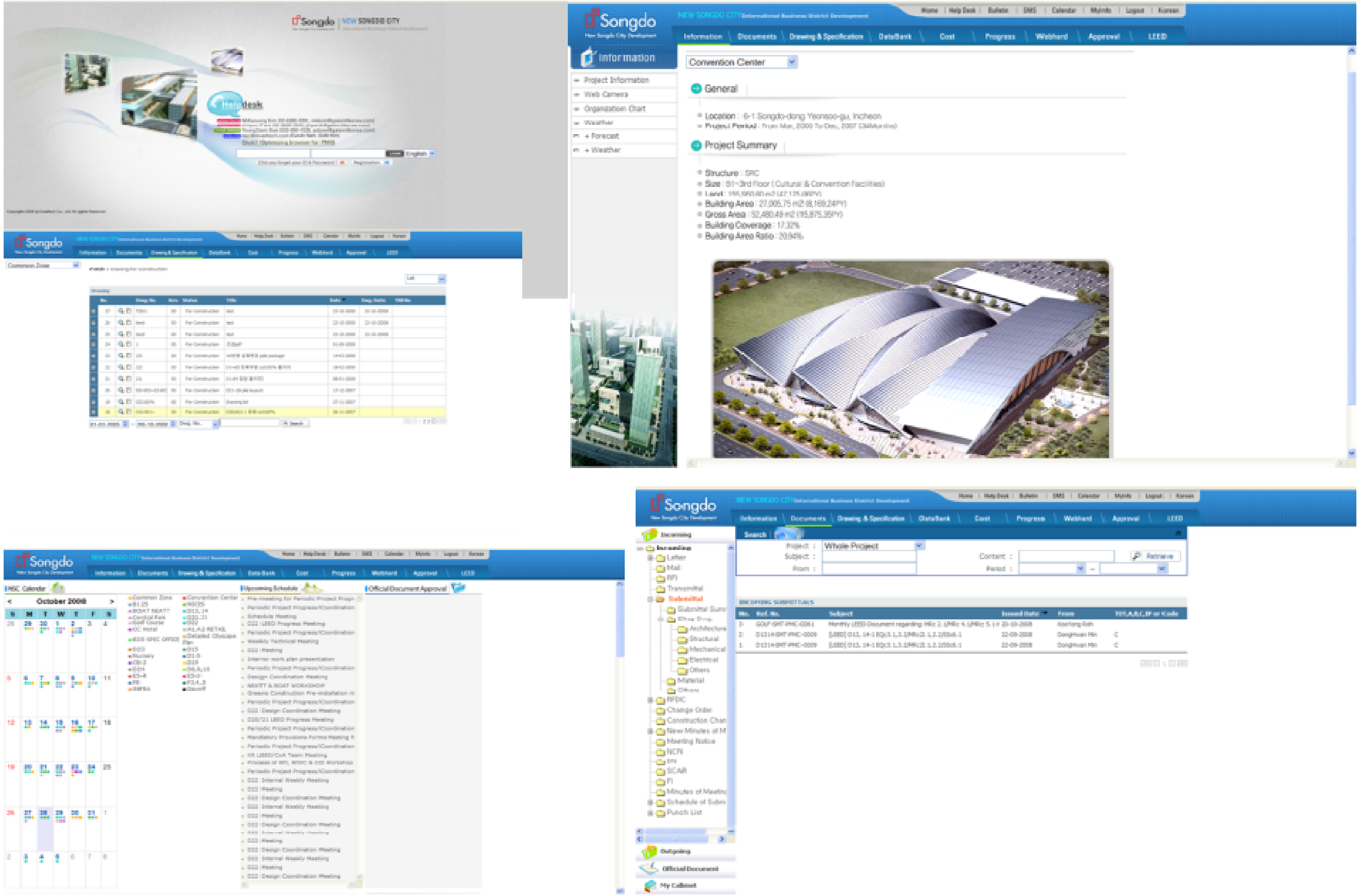
Table 6-1: System Usages of Participants – Organizational Capital

A Project Management Information System (PMIS), as shown in Figure 6-1, is also a web-based product and an electronic information system for construction project management. While the TeamLink site is focused on sharing information between professionals who are located at different geographical locations in the organization, PMIS is able to include information such as handling costs, scheduling planning, reporting, and forecasting for various parties. The PMIS framework generally provides the methodology for collecting, organizing, storing, processing, and disseminating project information, and contains the information that is essential for initiating, planning, executing, controlling, and closing a project (Sifri, 2002). For example, an instance of PMIS was customized for an international business district development in Songdo City, South Korea. This development includes various smaller projects such as a hotel, convention center, golf course, school, and so on. The management and integration of information between the multiple parties involved is therefore particularly important.

PMIS is split into nine specialized areas to ensure interoperability between project participants as follows:

- Project Information
- Data Bank
- Cost
- Approval
- LEED
- Documents
- Drawings & Specification
- Webhard
- Progress

Related parties can access PMIS to work on the project based on the interoperability of PMIS. In the submittal process, four of the major stages, namely interpretation, prequalification, making decisions, and implementation, can be performed through PMIS. Suppliers can send proposals with electronic templates, and managerial professionals can prequalify and review proposals. This system can also load final submittals into the system for approval. A/Es or owners signify their approval of submittals using the "Approval" feature in PMIS. Although managerial professionals must still perform the routine processes involved in submittals, this method offers many benefits compared with the traditional method as it reduces the work load, and time, accuracy, performance, and productivity all improve. Figure 6-1 shows examples of the type of information available through PMIS, including login, project information, schedule, and approval pages.



Location : 6-1 Songdo-dong Yeonsoo-gu, Incheon

Structure : SRC

Size : B1~3rd Floor (Cultural & Convention Facilities)

Building Area : 27,005.75 m2 (8,169.24PY)

Gross Area : 52,480.49 m2 (15,875.35PY)

Building Coverage : 17.32%

Building Area Ratio : 20.94%

Figure 6-1: Figures of PMIS

(Source: http://nsc.nproject.com/)

PMIS is designed for use on large projects, and a PMIS provider is in charge of interoperability between the various players. Figure 6-2 illustrates a typical organizational structure that involves major parties in an international business district development. In this type of development, each of the major parties involved must collaborate with their partners, so the PMIS provider is expected to play a major role in integrating the various requirements from all the different parties.

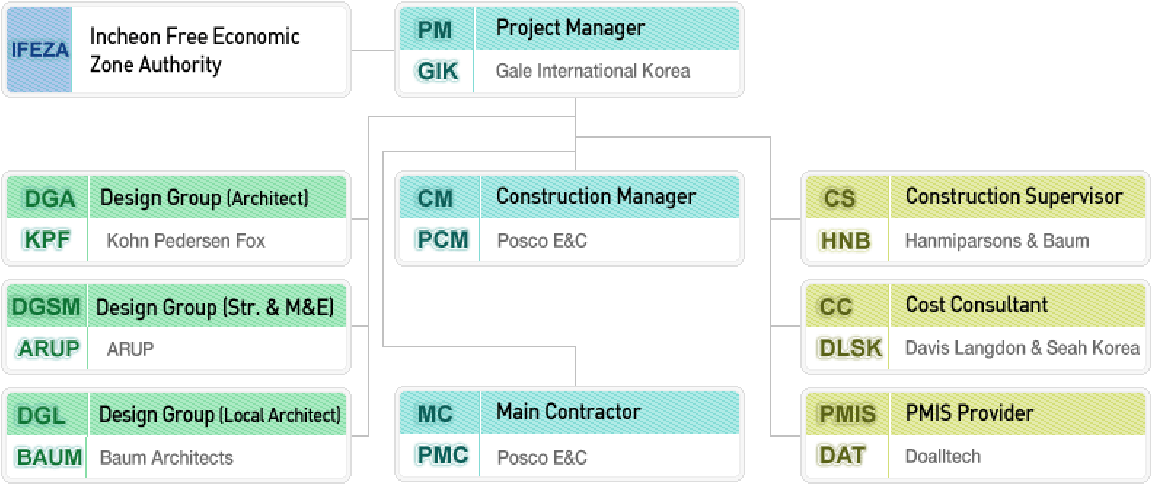


Figure 6-2: Organizational Chart of a Typical PMIS Projects

(Source: http://nsc.nproject.com/)

The selection of systems for organizational activities is very important because the organization must provide appropriate factors such as policy and training that accompany systems to ensure efficient and effective performance. Examining the implications of these three different approaches that can be used for the submittal process therefore sheds new light on various perspectives in the ILM.

6.1.1. The Different Companies

Three construction professionals, each employed by a different company, were interviewed for the illustrative case study and participated in the pilot study survey. One professional works in Seoul, South Korea, while the other two work in Hawaii, United States. Two companies are international in scope and the other is a local construction company in Hawaii. Each company is described in turn below.

1. XX-C Korea – Company C (technological)

XX-C Korea was founded in 2000 and is one of the branches of XX-C, which was itself founded in 1885 and has its headquarters in New York City. XX-C is a leader in the development and operation of infrastructure to meet the needs of communities around the world. It currently has 250 branch offices and about 10,000 employees worldwide. The Korean arm of its operations provides strategic consulting, planning, engineering, and program and construction management services to both public and private sector clients. XX-C Korea is active in multiple market sectors, including transportation, power, buildings/facilities, water/wastewater, environmental, and urban/community development. The firm has the capability to see a project throughout its entire life cycle, from planning through implementation to operation and maintenance, and has earned a distinguished reputation for its technical and management expertise. PB Korea has already completed several major projects and is currently engaged in various projects in both Korea and China.

2. XX-A – Company A (traditional)

XX-A has provided professional construction services to meet the needs of the local construction industry for nearly 20 years in Hawaii, United States. The company was founded in 1990 as a small business contractor and became a corporation in 1995. At the beginning of 2001, the company's business status changed from small to large business, with a current revenue of over $100 million and a bonding capacity of over $500 million. The company currently employs a diverse range of personnel, including engineers, and a technical workforce of estimators, quality control managers, safety officers, schedulers, field supervisors, skilled tradesmen, and accounting and administrative support staff. Its success can be seen by its accomplishments, and it has been included in *Building Industry*'s list of "Hawaii's Top 25 Contractors" since 1999. Since 1996, the company has been involved in over 1900 projects, totaling approximately $800 million.

3. XX-B – Company B (hybrid)

XX-B was founded in 1957 and has its headquarters in the United States. The company currently has 1,800 employees spread over 60 offices around the globe and is devoted to building strong stakeholder relationships and producing solutions that work. XX-B delivers integrated, sustainable solutions for environmental restoration, property redevelopment, design/build construction, green buildings and clean energy.

6.2. EXPLORATORY STUDY

Organizational performance represents the results of integration with organizational assets for organizational activities. In order to obtain reliable results, a comprehensive understanding of organizational activities is important. This pilot study conducted a survey using the questionnaire given in Chapter 8, the Appendix, which poses a series of task oriented questions. The participants were also interviewed to elicit details of the submittal process. The submittal process can be divided into 11 common tasks in four stages, as described in the previous chapter. However, the number of sequential tasks can increase to eighteen (18) tasks with the addition of seven (7) contingent tasks, as discussed in Chapter 5. The contingency tasks are illustrated in Figure 5-5 and the common tasks in Figure 5-4.

Figure 6-3 assigns numbers to each sequential task. The “Integration Stage”, colored black, represents the basic activities involved in preparing the submittal process by professionals. Contingent activities can occur in the later stages. In the figure, blue numbers indicate the common processes and red numbers indicate the contingent processes. These numbers correspond to the numbers assigned to the sequential tasks and questions in the pilot study survey. These sequential tasks make up the procedural perspective of the ILM.

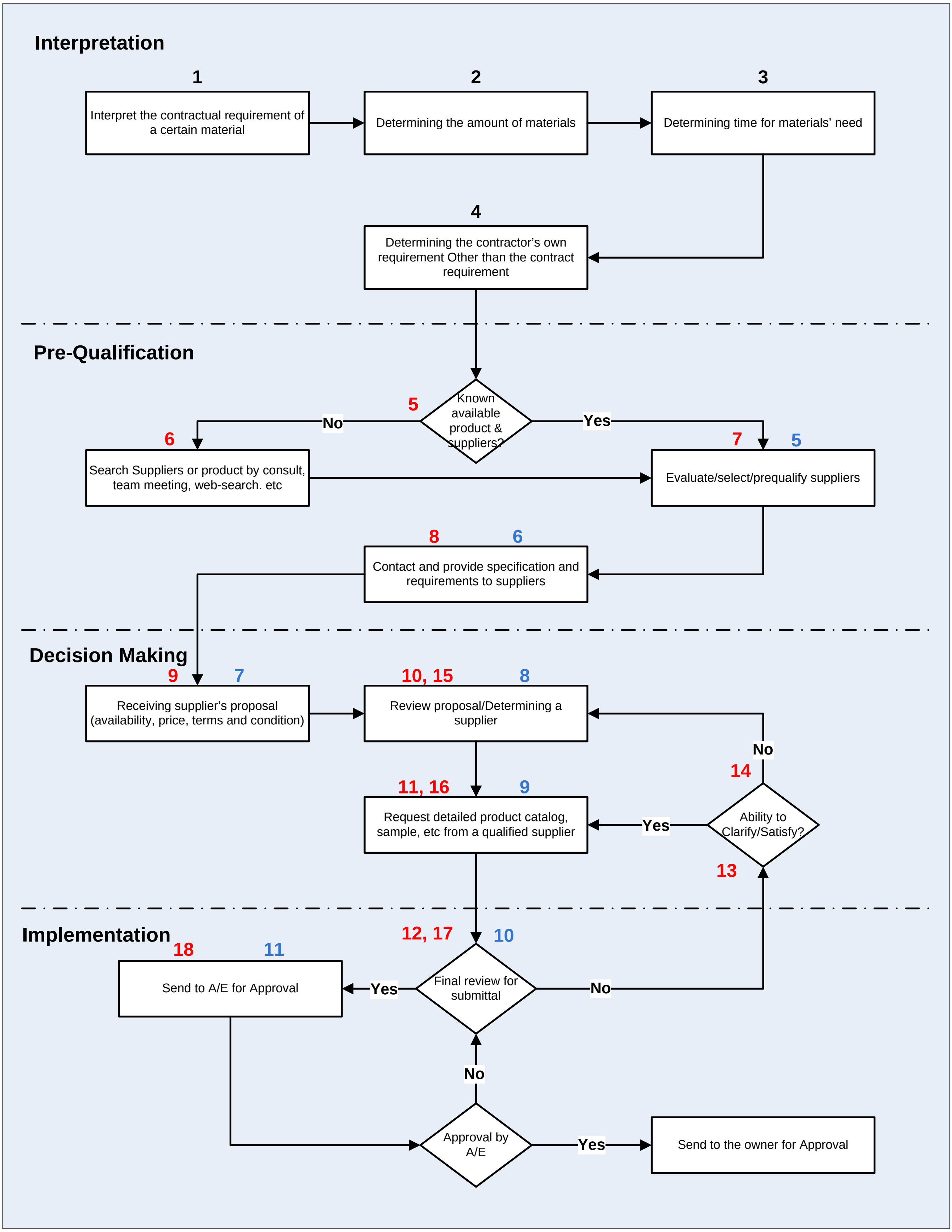


Figure 6-3: Submittal Process with Task Numbers for Pilot Study

6.3. DATA ANALYSIS

This section presents the results from the empirical study, the interviews which consist of four face to face interviews and over thirty interviews by phone and email, for procedural analysis and the pilot studies based on the prototype of the ILM. The survey questionnaires and results for the pilot study are described in Chapter 8, the Appendix.

6.3.1. Interdependency

The interdependence perspective in the ILM evaluates the human contribution to managerial tasks in organizations. Table 6-2 shows how the participants rated the results for human capital (HC) efficacy compared to organizational capital (OC) efficacy based on a proportional scale of 0 (low) to 10 (high). The scale point 5 (mid) indicates the same efficacy from HC and OC. This approach is similar to that used in the learning model prototype in Figure 4-5 and is a good way to quantify the efficacy of human efforts with different systems for a particular activity. Each number indicates the proportional combination of HC and OC that produces the optimal performance of each task based on the participants' work experiences. The configuration of efficacy reveals the most efficient capital usage for particular tasks. Bold and italic characters in Tables 6-2 and 6-3 indicate different responses from the participants regarding HC efficacy compared to OC efficacy. For instance, two participants reported a preference of HC efficacy for Task 2, but the other participant rated the same task as OC efficacy friendly.

Task Participant	Interpretation				Prequalification		Decision Making			Implement	
	1	2	3	4	5	6	7	8	9	10	11
1	9	***7***	***6***	***8***	***5***	***5***	***5***	8	***6***	9	***6***
2	7	***8***	***6***	***9***	***8***	***3***	***2***	9	***8***	9	***7***
3	9	***4***	***5***	***5***	***6***	***2***	***2***	8	***4***	7	***5***

Table 6-2: The Degree of HC Efficacy to OC for a Common Submittal Process

Table 6-3 shows the additional tasks needed by a submittal process with a contingency, which is broken down into 18 sequential tasks. A non-contingent submittal process, the common process, follows the blue numbers in Figure 6-3 and indicates a smooth process by a construction professional. In decision nodes answered by the construction professionals with a “Yes” there is no problem with moving on to the next sequential task, but “No” answers require additional tasks to be performed before moving on to the next task. For instance, if a construction professional does not have information or knowledge they need at the first decision node, “Known available products & suppliers,” the professional must perform additional tasks to remedy this lack before proceeding to the next task. The submittal process with a contingency in Table 6-3 corresponds to the maximum possible occurrence of decision nodes in Figure 6-3.

Task **Participant**	**Interpretation**				**Prequalification**				**Decision Making**			**Implement**			**Decision Making**		**Implement**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1	9	***7***	***6***	***8***	6	***6***	***5***	***5***	***5***	8	***6***	9	8	8	***5***	***6***	9	***6***
2	7	***8***	***6***	***9***	6	***9***	***8***	***3***	***2***	9	***8***	8	8	8	***9***	***8***	9	***7***
3	9	***4***	***5***	***5***	7	***4***	***6***	***2***	***2***	8	***4***	7	6	7	***7***	***4***	7	***5***

Table 6-3: The Degree of HC to OC for a Submittal Process with a Contingency

6.3.2. Analysis of Efficacy – Interdependence Perspective

To properly analyze the answers concerning each activity from the participants, the issues that influence how the interviewees experience each activity must be understood. The issues can be divided into two components, the managerial process and the system/method used, i.e. the OC. In this case the managerial process is the submittal process, which is divided into 11 sequential tasks for a common process and 18 sequential tasks for a contingent process. All three of the participants use different systems or methods, as explained in section 6.1. This study is developed from task based questions. Although the dependency between HC and OC for each task is combined into a similar scale, some tasks have the advantage of technological supports as shown in Table 6-4 for a common submittal process and Table 6-5 for a submittal process with a contingency. The dependency results between HC and OC indicate the average of participates' responses. When the scale is above 5, the dependency indicates that they considered HC to be dominant, while a scalepoint of less than 5 indicates that they thought the process was more OC dependent. The italic characters in the dependency results shown in Tables 6-4 and 6-5 indicate the different ratings for HC and OC efficacies from participants. Although this analysis of efficacy focuses solely on HC and OC, future studies with a larger population could classify these contributions in terms of three discrete levels, HC, HC=OC, and OC for a specific task.

As expected, HC is the dominant factor in determining tasks and for complicated tasks. “Interpret contractual requirements of materials” in the interpretation stage is a complicated task and a construction professional must have various abilities in order to perform this activity efficiently. According to the type of material and installment, the professional may need “shop drawings” in addition to material data sheets. For example, structural steel usually needs shop drawings that contain more detailed materials and actual installment information, such as the designation of each member, bolt, and type of weld. Contract drawings only include general information on materials and thus require input from a construction professional, who reads the drawings and identifies appropriate materials. The tasks of “Determining the amount of materials” and “Determining time for material’s need” can have different values for the relationship between HC and OC, because a scheduling system or computer project management tools can perform the majority of these tasks for simple tasks, which thus depend primarily on OC; these tasks, task 6 and 7, do not require human intervention unless the construction is complex.

No	STAGE	TASK	Average Scale	Dependency
1	Interpretation	Interpret the contractual requirement of materials	8.33	**HC**
2		Determining the amount of materials	6.33	***HC***
3		Determining time for material's need	5.67	***HC***
4		Determining the administrative requirements	8.33	***HC***
5	Prequalification	Evaluate/select/prequalify suppliers	6.33	***HC***
6		Contact and provide specification and requirements to suppliers	3.33	***OC***
7	Decision Making	Receiving supplier's proposal (availability, price, terms and condition)	3.00	***OC***
8		Review proposal/Determining a supplier	8.33	**HC**
9		Request detailed information (sample, catalog, etc.) from a qualified supplier	6.00	***HC***
10	Implementation	Final review for submittal	8.33	**HC**
11		Send to A/E for approval	6.00	***HC***

Table 6-4: Dependency of Tasks in a Common Submittal Process

Contingent activities, for example tasks 5 and 6, in Table 6-5 also place conflicting demands on HC and OC. In other contingencies, for example tasks 13 and 15, HC dominates because these tasks depend on human activity, rather than the support of tools and systems. The stage of "Interpretation" is not included in Table 6-5 because this stage does not have any contingent activities. The dependency between HC and OC for each task in the interpretation stage has the same results in both a common submittal process and a submittal process that includes a contingency.

No	STAGE	TASK	Average Scale	Dependency
5	Prequalification	Known available products/suppliers	6.33	**HC**
6		Search suppliers or product by consult, team meeting, web-search, etc	6.33	***HC***
7		Evaluate/Select/Prequalify suppliers	6.33	***HC***
8		Contact and provide specification and requirements to suppliers	3.33	***OC***
9	Decision Making	Receiving availability, price, supplier's terms and condition	3.00	***OC***
10		Review proposals and Determine a supplier	8.33	**HC**
11		Request detailed product information, catalog, sample, etc	6.00	***HC***
12	Implementation	Final review for submittal	8.00	**HC**
13		Request clarification (Insufficiency from the selected supplier)	7.33	**HC**
14		Review again	7.67	**HC**
15	Decision Making	Qualify other suppliers - Failure of the selected supplier	7.00	***HC***
16		Request detailed product information, catalog, sample, etc	6.00	***HC***
17	Implementation	Final review for submittal	8.33	**HC**
18		Send to A/E for approval	6.00	***HC***

Table 6-5: Dependency of Tasks in a Submittal Process with a Contingency

Whether or not construction activities are supported by technological improvements, most human-oriented and complicated activities require HC. However, some activities in the interpretation stage differ depending on the tools used.

6.3.3. Performance Factors – Relational Capital

Performance factors for an organizational activity are generally treated as latent factors, as are the various factors that affect organizational activities that have not previously been identified before this research. These factors are from HC and OC. HC basically consists of education, experience and motivation and the other factors are the tangible and intangible assets of OC, as explained in Chapter 3. When organizational activity needs HC and OC, these factors both require and contribute to the production of organizational performance. In this research the appearance and manifestation of factors from the combination of HC and OC for a particular task is referred to as Relational Capital (RC). The determination of the particular factors that affect the performance of a task require that the construction professional charged with performing that task has an appropriate educational level to do so effectively. Therefore, the performance factor "education" is considered an additional requirement that enhances task performance.

As construction is a practical, rather than a theoretical, activity, many tasks require experience as a performance factor. Some OC intensive activities, such as tasks 6 and 7 in Table 6-6, also require experience. Although some tasks are strongly HC intensive, additional factors, such as policy and training from OC are required to performance the tasks efficiently. Hence, decision makers in the organization must support those factors needed for the tasks. HC intensive tasks are influenced by additional factors, rather than OC alone or the equivalent amounts of HC and OC. This means that for a human intensive activity good management is a vital component for higher performance and this must be supplied by decision makers.

The most important factors as determined from the results of the individual case study are highlighted, italicized and colored red in Table 6-6, which are linked with the interdependency perspective. For instance, task 4, “Determining the administrative requirements,” indicates HC intensive activity and four performance factors, culture, education, experience, and policy. Education and experience is more important than other factors to improve the performance of the task because task 4 is a human intensive task.

No	STAGE	TASK	Dependency	Performance Factor
1	Interpretation	Interpret the contractual requirement of materials	**HC**	Culture ***Education*** ***Experience*** ***Motivation*** Policy Training
2		Determining the amount of materials	**HC**	Culture ***Education*** ***Experience*** ***Motivation*** Policy Tool Training
3		Determining time for material's need	**HC**	Culture ***Education*** ***Experience*** Policy Tool Training
4		Determining the administrative requirements	**HC**	Culture ***Education*** ***Experience*** Policy
5	Pre-qualification	Evaluate/select/prequalify suppliers	**HC**	Ethic ***Experience*** Policy Tool
6		Contact and provide specification and requirements to suppliers	**OC**	Experience ***Policy*** ***Tool*** ***Training***
7	Decision Making	Receiving supplier's proposal (availability, price, terms and condition)	**OC**	Experience ***Policy*** ***Tool***
8		Review proposal/Determining a supplier	**HC**	***Education*** Ethic ***Experience*** Policy Training
9		Request detailed information (sample, catalog, etc.) from a qualified supplier	**HC**	***Education*** Policy Tool
10	Implementation	Final review for submittal	**HC**	Culture ***Education*** ***Experience*** Policy Tool Training
11		Send to A/E for approval	**OC**	Experience ***Policy*** ***Tool***

Table 6-6: Performance Factors of a Common Submittal Process

The submittal process with contingency shown in Table 6-7 once again does not include the interpretation stage, which is the same as that shown in Table 6-6. Here, the contingent tasks are task numbers 5, 6, 13, 14, and 15 and all are dependent on HC. Elements of OC such as policy and tools can be found in every task except task 15. Therefore, policy and tools take on important roles if the tasks are to be performed without delays even though every contingent task is also HC intensive. Thus, it is important for decision makers in the organization to prepare contingency plans to prevent unexpected events such as problems with policies or tools.

No	STAGE	TASK	Dependency	Performance Factor
5	Pre-qualification	Known available products/suppliers	**HC**	Culture ***Education*** Ethic ***Experience*** Policy Tool
6		Search suppliers or product by consult, team meeting, web-search, etc	**HC**	Culture ***Experience*** Policy Tool Training
7		Evaluate/Select/Prequalify suppliers	**HC**	Ethic ***Experience*** Policy Tool
8		Contact and provide specification and requirements to suppliers	**OC**	Experience ***Policy*** ***Tool*** ***Training***
9	Decision Making	Receiving availability, price, supplier's terms and condition	**OC**	Experience ***Policy*** ***Tool***
10		Review proposals and Determine a supplier	**HC**	***Education*** Ethic ***Experience*** Policy Training
11		Request detailed product information, catalog, sample, etc	**HC**	***Education*** Policy Tool
12	Implementation	Final review for submittal	**HC**	Culture ***Education*** ***Experience*** Policy Tool Training
13		Request clarification (Insufficiency from the selected supplier)	**HC**	***Education*** ***Experience*** Policy Tool Training
14		Review again	**HC**	***Education*** Ethic ***Experience*** Policy Tool Training
15	Decision Making	Qualify other suppliers - Failure of the selected supplier	**HC**	***Education*** Ethic ***Experience*** Policy
16		Request detailed product information, catalog, sample, etc	**HC**	***Education*** Policy Tool
17	Implementation	Final review for submittal	**HC**	Culture ***Education*** ***Experience*** Policy Tool Training
18		Send to A/E for approval	**HC**	***Experience*** Policy Tool

Table 6-7: Performance Factors of a Submittal Process with a Contingency

Analyzing the results from the performance factors perspective, one of the performance factors, policy, is found in every procedural task in the submittal process. Organizational policies are an important factor because policy represents the organization's goals both directly and indirectly.

6.4. INTELLIGIBILITY LEARNING MODEL

The Intelligibility Learning Model (ILM) is a prototype that models the way knowledge of new concepts of management enhances the performance of organizational assets and activities. The application of this prototype will enable decision makers to better understand and integrate the organization's activities with its intellectual capital. Figures 6-4 and 6-5 display how the ILM functions for a submittal process from four perspectives: 1) procedural 2) interdependency, 3) transformation, and 4) performance factors. This ILM is a learning process for occupational groups, especially the decision makers in the organization. The procedural perspective has been developed with an illustrative case study. Other perspectives have been analyzed using a pilot study based on questionnaires developed from the illustrative case study and the learning model prototype. Note that for the case of a submittal process that has a contingency, Figure 6-5, the “Interpretation Stage” on the left side of the ILM has been omitted as this stage is the same as that shown in Figure 6-4, the common submittal process.

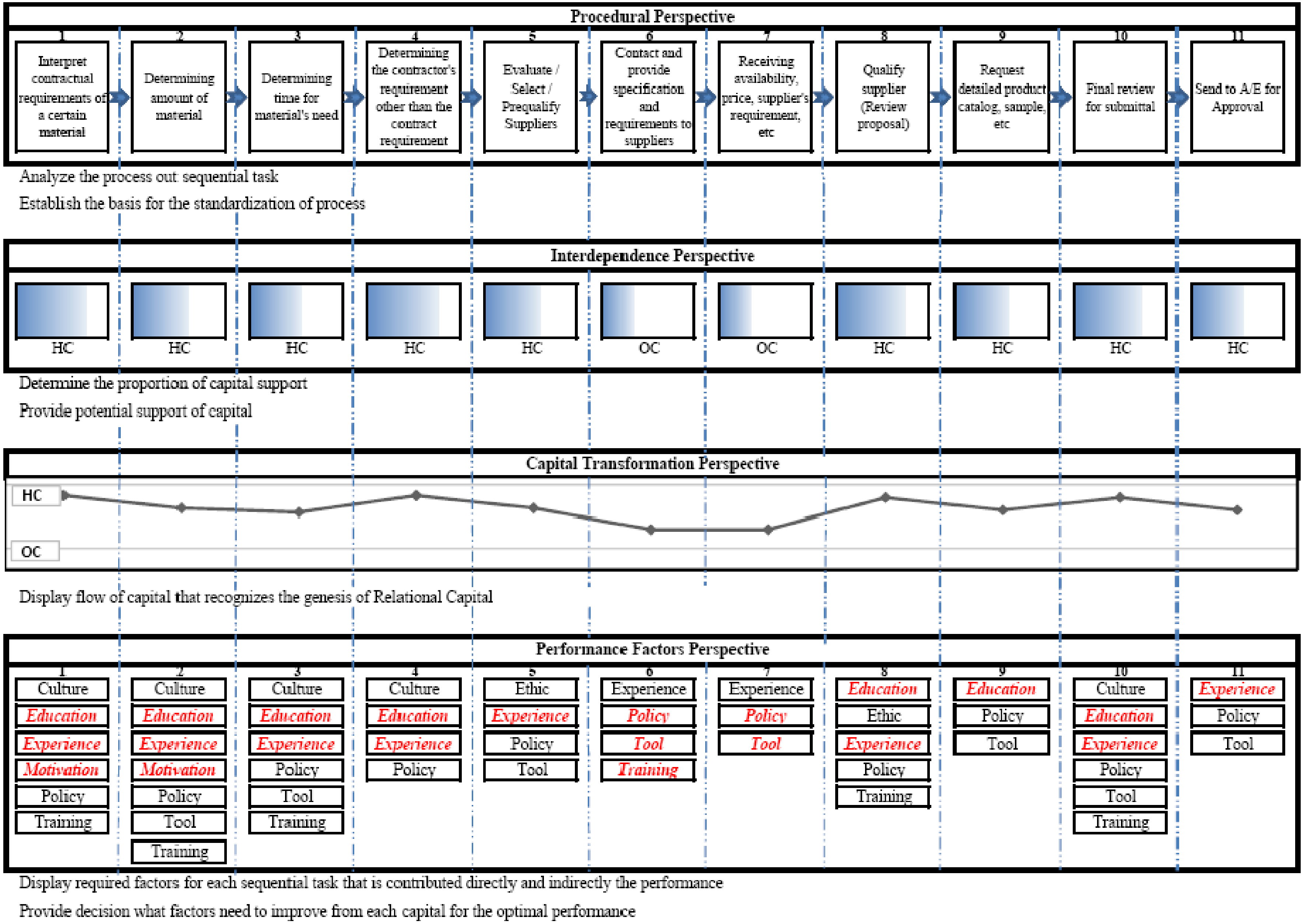


Figure 6-4: Intelligibility Learning Model of the Common Submittal Process

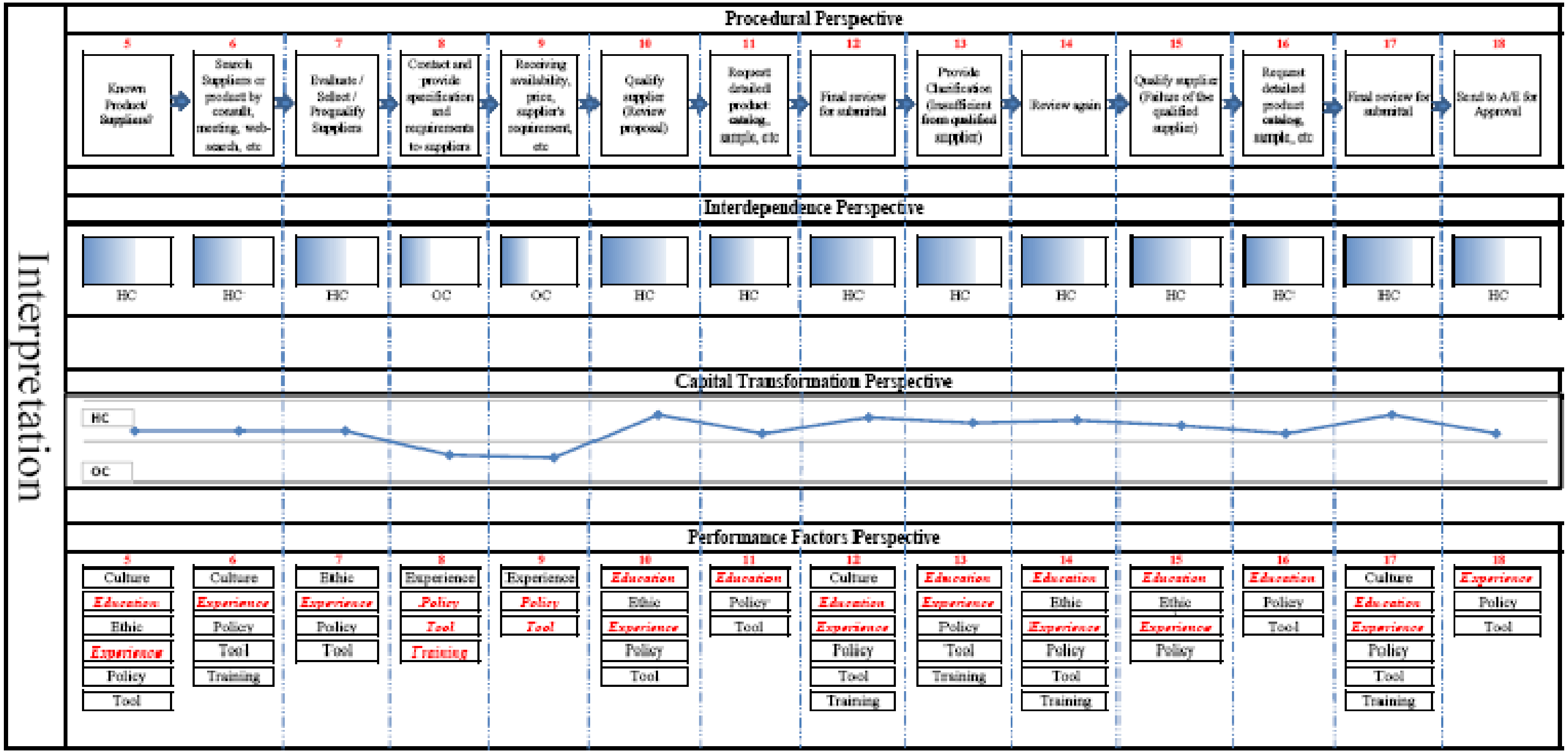


Figure 6-5: Intelligibility Learning Model of the Submittal Process with a Contingency

6.5. STRATIFIED METHOD OF THE INTELLIGIBILITY LEARNING MODEL

Managerial processes in the construction industry depend heavily on the methods used because the input from construction professionals for a particular task can vary widely depending on the approach adopted. This research examined three different systems for the submittal process using case studies. These three methods utilized three different degrees of technical applications, as well as three different types of contributions from construction professionals that are treated as aspects of human capital in this dissertation. Figures 6-6 and 6-7 display how the ILM distinguishes between human capital and organizational capital for a submittal process for three different methods: 1) traditional, 2) hybrid, and 3) technological.

6.5.1. Interpretation Stage

The interpretation stage consists of four steps: 1) interpreting the contractual requirements for a certain material, 2) determining the amount of the material needed, 3) determining the time when the material will be needed, and 4) determining the contractor's requirements that are not specified in the contract, as shown in Figure 6-6. Two methods, traditional and hybrid, demonstrate a very similar pattern during the interpretation stage. Most tasks in both the traditional and hybrid methods depend on the use of human capital, while the technological method demonstrates comparable worth of human and organizational capitals except for in the first task of the interpretation stage. This reflects how the contractor's scheduling system or computer project tools can perform these tasks efficiently and effectively. For example, tasks 2 and 4 in the common submittal process shown in Figure 6-6 clearly indicate the different efforts of human capital. These tasks primarily depend on HC at the beginning, but computer project management tools can help to retrieve required information by interpreting drawings and specifications. The technological method can partially eliminate the need for human input to fulfill these tasks.

6.5.2. Prequalification and Decision Making Stages

These two stages include task numbers 5 to 9, as shown in Figure 6-6. In the prequalification stage (tasks 5 and 6), the contractor identifies possible suppliers who are expected to be able to provide products in a correct manner, taking into account their historical trading record and reputation. In the "Decision Making" stage (tasks 7 to 9), the contractor selects who will supply the products based on the proposals.

These activities are heavily dependent on the ability of human, human capital. However, communicating activities, such as contacting (task 6), providing (task 6), receiving (task 7), and requesting (task 9), during the stages of prequalification and decision making can be enhanced and thus performed more efficiently using technological tools.

6.5.3. Implementation Stage

In the "Implementation" stage, the contractor makes a review of the submittal (tasks 10 and 11 in Figure 6-6) before it is sent to the A/E for final approval. At this stage the contractor identifies defects in the supplier's proposal such as confusing terms. To prevent unexpected problems during the supply process, the contractor must contact the supplier immediately and request clarification of any problems detected during this final review. This stage depends primarily on human capital, but the human efforts of this task "send to A/E for approval" can be reduced by stratified methods.

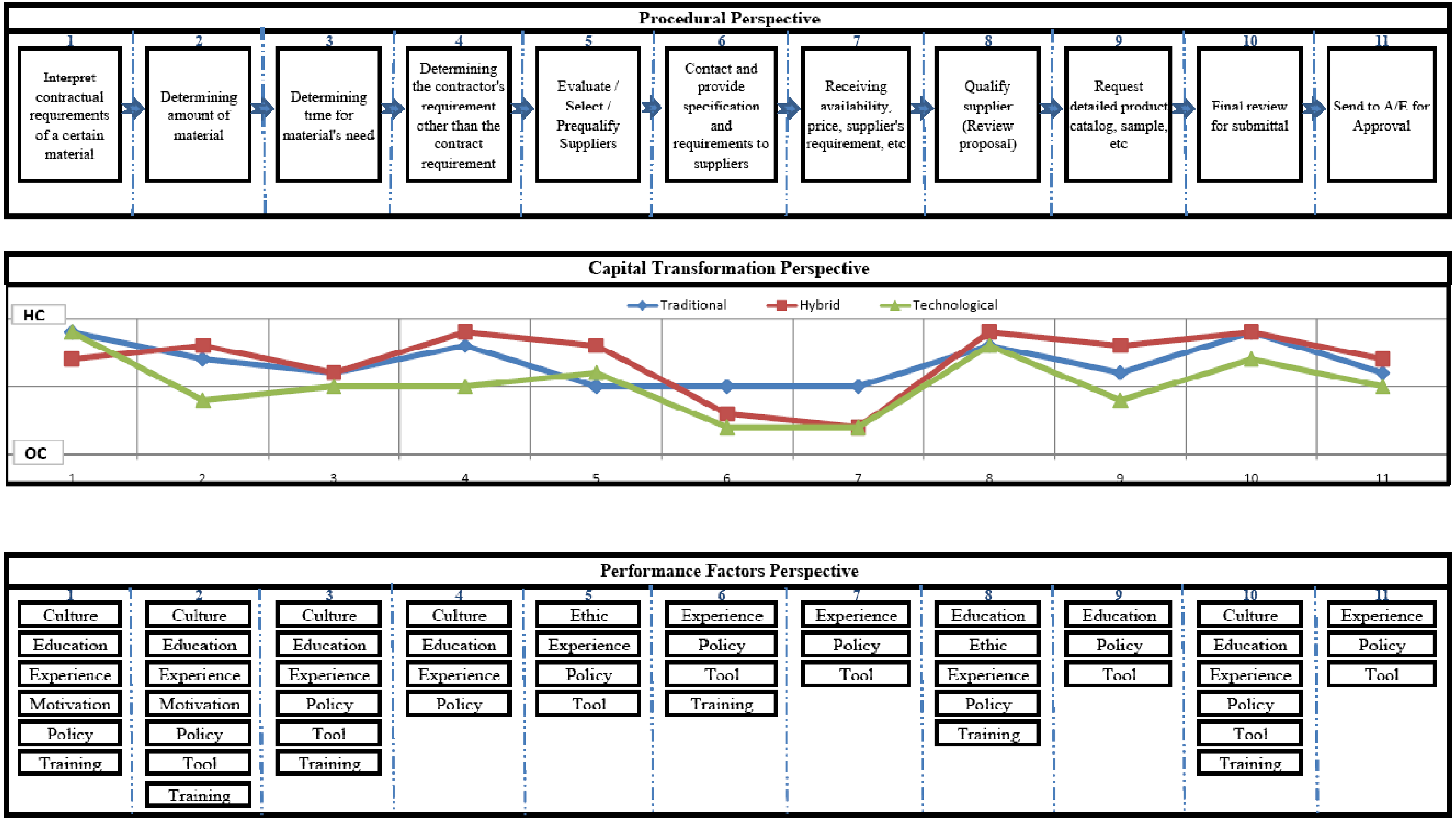


Figure 6-6: Comparison of Different System Usage in the Common Submittal Process

6.5.4. Stratified Methods in the Contingency Process

The dependency of capital clearly demonstrates the difference usage of methods during the submittal process with a contingency, as shown in Figure 6-7. In the prequalification stage, the activities increase to four tasks from the two tasks in a common submittal. This increase in the number of tasks directly reflects the performance of the organization and how well it manages unexpected events.

The traditional method demonstrates a mild curve between human and organizational capitals while the hybrid and technological methods demonstrate a similar distribution, especially communication tasks between task number 7 and number 10. To compare communication tasks in a common submittal process, the contingency process depends heavily on organizational capital. In other words, the use of information/Communication Technology (ICT) can directly affect the performance of specific tasks that are closely related to interactions between various parties.

Additionally, decision makers can recognize the processes involved in organizational activities and the capital usage for the specific systems or methods that are directly concerned with performance through the ILM. This ability to compare different systems with performance factors presents a new way of looking at potential future investments that makes it possible to determine the best way to proceed in order to accomplish managerial processes both effectively and efficiently.

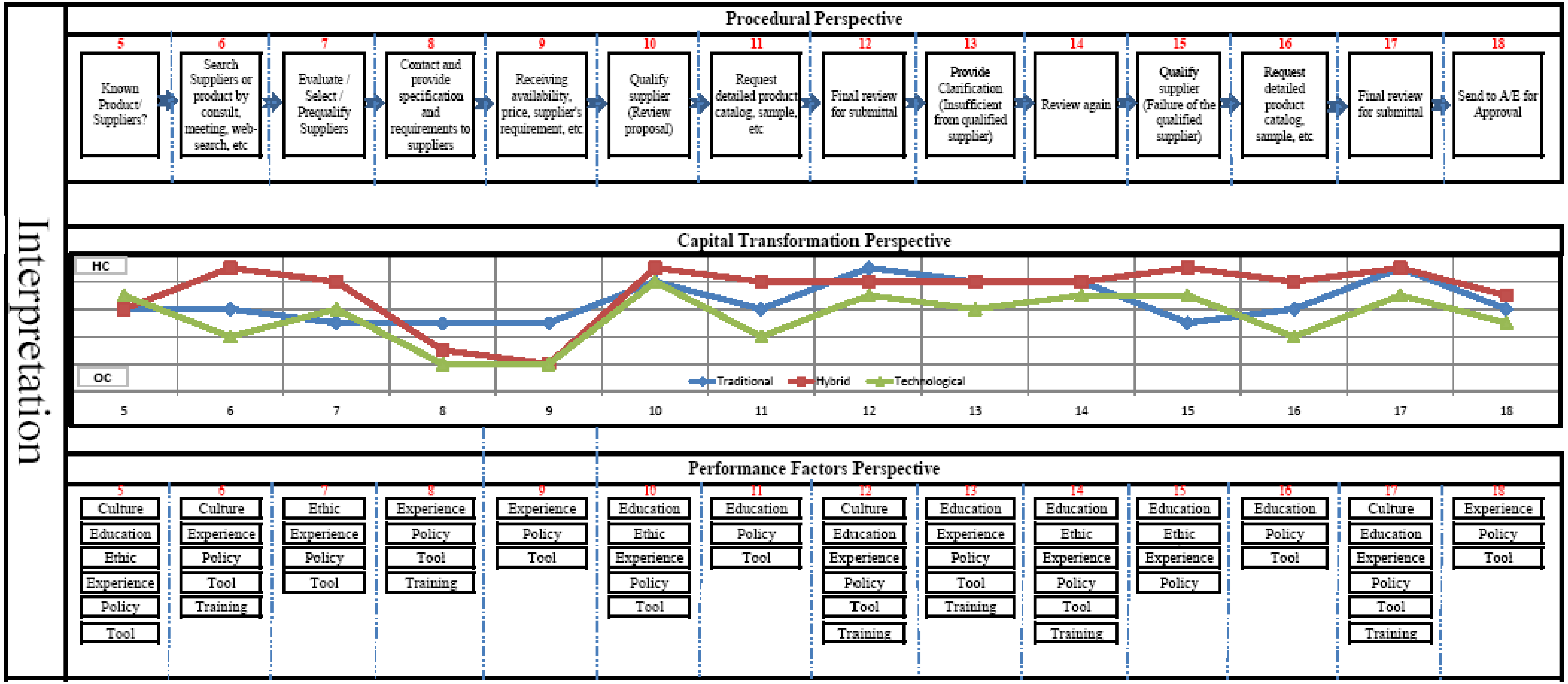


Figure 6-7: Comparison of Different System Usage in the Submittal Process with a Contingency

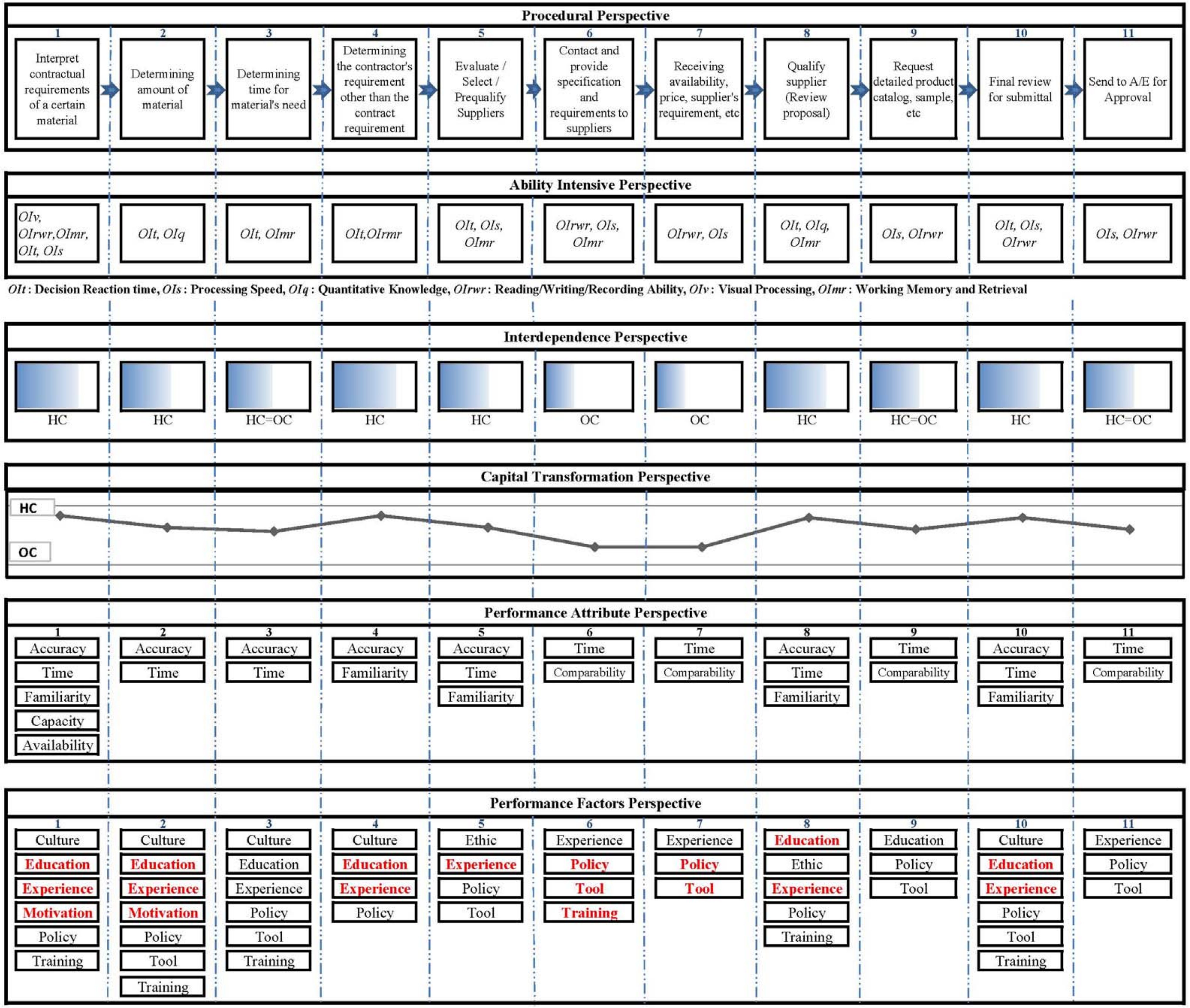
The analysis of processes with the ILM contributes to the establishment of a new model of knowledge management in various areas. Decision makers must first recognize the processes involved in organizational activities and the requirements of each, such as the policy, tools, personnel, and so forth that will be needed, which are indicated by the performance factors perspective in the ILM. The use of the new model presents the whole managerial process in a way that makes it possible to determine the most effective way to deploy the organization's assets and processes.

It is worth noting that this approach to organizational intelligence management has as yet only been conceptually developed in order to promulgate a theory of new organizational management that is capable of identifying unknown factors that may enhance the performance of the organization. Future research should focus on how to develop an organization's intellectual capital to enhance specific activities with a specific method and thus ensure higher performance based on these findings, as indicated by the performance factors perspective.

6.6. THE COMPLETION OF THE INTELLIGIBILITY LEARNING MODEL

The ILM prototype, which was presented earlier in Chapter 4, consists of six perspectives. Figures 4-5 and 4-6 represent the six perspectives and their relationships with the knowledge framework. Each perspective, except for the procedural perspective, is designed to explore and determine various aspects for each of the sequential tasks identified in the procedural perspective of the ILM. The ability intensive perspective dominates the organizational tasks from the human cognitive perspective because organizational activities are human activity phenomena. In this research the author developed six organizational cognitive abilities that are analogous to those used to describe human cognitive abilities in order to explore the potential technological advantages for organizational cognitive activities such as visual, memory, speed, communication. According to the definitions given in Chapter 3, each sequential task can be expressed in terms of the organizational cognitive abilities. In addition, performance parameters are suggested to monitor the performance of each sequential task that go beyond the traditional simple measurements (time and cost) by considering the Performance attribute perspective in the ILM. The development of performance parameters provides not only measurement criteria for organizational activities but also feedback for organization activities.

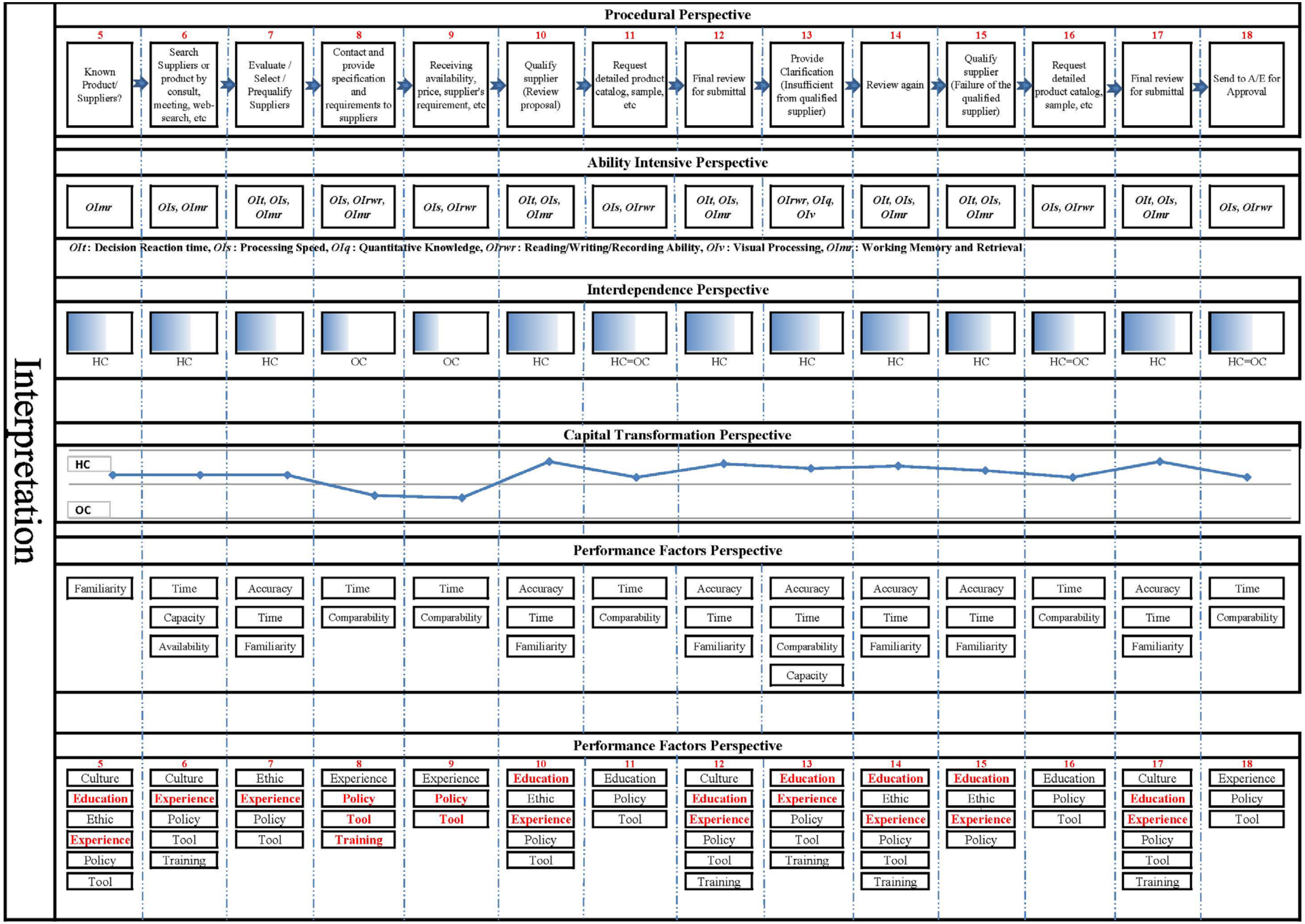
Figures 6-8 and 6-9 illustrate the complete intelligibility learning model with six perspectives, four practical perspectives and two theoretical perspectives, which are suggested in this dissertation for future development. Two theoretical perspectives are offered by the author as promising avenues for further research on organizational cognitive abilities and performance attribute. This model offers comprehensive information regarding organizational processes, common submittal processes and submittal processes with a contingency.



	1	2	3	4	5	6	7	8	9	10	11
Procedural Perspective	Interpret contractual requirements of a certain material	Determining amount of material	Determining time for material's need	Determining the contractor's requirement other than the contract requirement	Evaluate / Select / Prequalify Suppliers	Contact and provide specification and requirements to suppliers	Receiving availability, price, supplier's requirement, etc	Qualify supplier (Review proposal)	Request detailed product catalog, sample, etc	Final review for submittal	Send to A/E for Approval
Ability Intensive Perspective	*OIv, OIrwr,OImr, OIt, OIs*	*OIt, OIq*	*OIt, OImr*	*OIt,OIrmr*	*OIt, OIs, OImr*	*OIrwr, OIs, OImr*	*OIrwr, OIs*	*OIt, OIq, OImr*	*OIs, OIrwr*	*OIt, OIs, OIrwr*	*OIs, OIrwr*
Interdependence Perspective	HC	HC	HC=OC	HC	HC	OC	OC	HC	HC=OC	HC	HC=OC
Performance Attribute Perspective	Accuracy Time Familiarity Capacity Availability	Accuracy Time	Accuracy Time	Accuracy Familiarity	Accuracy Time Familiarity	Time Comparability	Time Comparability	Accuracy Time Familiarity	Time Comparability	Accuracy Time Familiarity	Time Comparability
Performance Factors Perspective	Culture **Education** **Experience** **Motivation** Policy Training	Culture **Education** **Experience** **Motivation** Policy Tool Training	Culture Education Experience Policy Tool Training	Culture **Education** **Experience** Policy	Ethic **Experience** Policy Tool	Experience **Policy** **Tool** **Training**	Experience **Policy** **Tool**	**Education** Ethic **Experience** Policy Training	Education Policy Tool	Culture **Education** **Experience** Policy Tool Training	Experience Policy Tool

OIt : Decision Reaction time, _OIs_ : Processing Speed, _OIq_ : Quantitative Knowledge, _OIrwr_ : Reading/Writing/Recording Ability, _OIv_ : Visual Processing, _OImr_ : Working Memory and Retrieval

Figure 6-8: The Complete Intelligibility Learning Model of the Common Submittal



	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Procedural Perspective	Known Product/ Suppliers?	Search Suppliers or product by consult, meeting, web-search, etc	Evaluate / Select / Prequalify Suppliers	Contact and provide specification and requirements to suppliers	Receiving availability, price, supplier's requirement, etc	Qualify supplier (Review proposal)	Request detailed product catalog, sample, etc	Final review for submittal	Provide Clarification (Insufficient from qualified supplier)	Review again	Qualify supplier (Failure of the qualified supplier)	Request detailed product catalog, sample, etc	Final review for submittal	Send to A/E for Approval
Ability Intensive Perspective	*OImr*	*OIs, OImr*	*OIt, OIs, OImr*	*OIs, OIrwr, OImr*	*OIs, OIrwr*	*OIt, OIs, OImr*	*OIs, OIrwr*	*OIt, OIs, OImr*	*OIrwr, OIq, OIv*	*OIt, OIs, OImr*	*OIt, OIs, OImr*	*OIs, OIrwr*	*OIt, OIs, OImr*	*OIs, OIrwr*
Interdependence Perspective	HC	HC	HC	OC	OC	HC	HC=OC	HC	HC	HC	HC	HC=OC	HC	HC=OC
Performance Factors Perspective	Familiarity	Time Capacity Availability	Accuracy Time Familiarity	Time Comparability	Time Comparability	Accuracy Time Familiarity	Time Comparability	Accuracy Time Familiarity	Accuracy Time Comparability Capacity	Accuracy Time Familiarity	Accuracy Time Familiarity	Time Comparability	Accuracy Time Familiarity	Time Comparability
Performance Factors Perspective	Culture **Education** Ethic **Experience** Policy Tool	Culture **Experience** Policy Tool Training	Ethic **Experience** Policy Tool	Experience **Policy** **Tool** **Training**	Experience **Policy** **Tool**	**Education** Ethic **Experience** Policy Tool	Education Policy Tool	Culture **Education** **Experience** Policy Tool Training	**Education** **Experience** Policy Tool Training	**Education** Ethic **Experience** Policy Tool Training	**Education** Ethic **Experience** Policy	Education Policy Tool	Culture **Education** **Experience** Policy Tool Training	Experience Policy Tool

OIt : Decision Reaction time, *OIs* : Processing Speed, *OIq* : Quantitative Knowledge, *OIrwr* : Reading/Writing/Recording Ability, *OIv* : Visual Processing, *OImr* : Working Memory and Retrieval

Figure 6-9: The Complete Intelligibility Learning Model of the Submittal Process with a Contingency

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

Human intelligence is an innate ability that is a measure of an individual's ability to solve verbal, mathematics, spatial, memory, and reasoning problems. As yet there is no widely accepted definition for Organizational Intelligence (OI), which includes items such as individual human intelligence, corporate knowledge management, decision support systems, business strategy and its deployment across functions and levels.

This research has attempted to define organizational intelligence in terms of the knowledge and skills and the combined contributions from the tangible and intangible assets within an organization. Unlike human intelligence, organizational intelligence is easily modified and developed by the utilization of various resources. The activities of continued modification and development are both management processes. In terms of this definition, the elements of organizational intelligence can be divided into three intellectual capital domains: Human Capital, Organizational Capital, and Relational Capital. The performance of an organizational activity is the result of the capability of these capitals within the organization. The concept of Organizational Intelligence Management (OIM) offers comprehensive information concerning organizational resources and issues that includes both ordinary and contingency activities to help decision makers identify a potential solution, a trait of successful organizations. This research has helped to determine which organizational factors affect the overall performance of organizations and establish the concept and importance of OI in the construction industry and beyond.

Specifically, this research sought to validate a new theoretical framework by implementing a learning model prototype through a series of interviews with construction professionals conducted as part of a pilot study of construction processes that considered two scenarios. The Intelligibility Learning Model (ILM) prototype developed for this study offers a new approach to the management of organization, the primary contribution of this research. This chapter summarizes the research findings and discusses the case studies that have served as the theoretical foundation for OIM.

7.1. RESEARCH FINDINGS

Organizational Intelligence (OI) is an emerging area in the construction industry, although this term has often been used as an extension of Knowledge Management (KM) in business, with various definitions in various industries. Human intelligence is measured using an Intelligence Quotient (IQ) test, and each individual's IQ score remains constant throughout their life, but OI is the intellectual capability of an entire organizations and can be improved in many ways, for example by the adoption of new technology, policy enhancement, and investment. Therefore, OI shows great potential as a new approach to improving the performance of organizational activities through successful decision making. Key challenges are to understand both organizational resources and activities and to integrate these optimally.

The case based studies with experts conducted for this research were based on the use of a multi-perspective analysis of the ILM prototype in order to comprehensively explore the factors that influence managerial processes in construction. More specifically, the results easily recognize differences among the three differences methods for a specific submittal task. Future research into OIM is needed to develop a stratified categorization of different methods and assess the advantages and disadvantages of each organizational method for specific tasks.

7.1.1. Understanding the Managerial Process

A procedural analysis of a construction process was conducted for this research based on the use of illustrative case studies to standardize a managerial process that is frequently performed. Sequential tasks were divided into four stages; 1) Interpretation, 2) Pre-qualification, 3) Making decision, and 4) Implementation. The categorization of those stages facilitated the comparison of the ordinary decision process, and each stage included instances of many construction processes. For instance, the interpretation stage was broken down into four sequential tasks, namely 1) interpreting drawings and specifications, 2) determining amount of materials, 3) determining time for material's need, and 4) administrative requirements. Although the degree of each of these requirements for a specific task may be different, this stage represents the basic knowledge that construction professionals must have to perform a construction project, which can be simply expressed as the ability to read and understand drawings. In addition, by comparing each stage in the ordinary decision making process, it makes it easier to understand how decision making functions within the managerial process.

This sequential approach provides a better understanding of managerial processes for decision makers and highlights intervention points for organizational development. In addition, this sequential analysis of a process was used to construct a theoretical foundation for researchers and educators to learn about managerial processes from a practical perspective.

7.1.2. Understanding Organizational Assets

Assets in the organization are divided into two areas: 1) tangible assets and 2) intangible assets. The utilization of these assets is "management." The general definition of management is that

"*The attainment of organizational goals in an effective and efficient manner through planning, organizing, leading, and controlling organizational resources*," (Daft and Marcic, 2001).

To understand what is meant by organizational resources, this research utilized the term intellectual capital to represent the contributions of its tangible and intangible assets to organizational intelligence, knowledge and skills. This intellectual capital was classified into three capitals: 1) human capital, 2) organizational capital, and 3) relational capital. An organization consists of two capitals, human capital and organizational capital with limited interaction. When the organization initiates an activity, these two capitals integrate to create the relational capital needed to perform it, contributing different proportions for each particular activity. The integration of capitals within organizational activities is a deciding factor for organizational performance, and the management of the operational mechanism is referred to in this research as organizational intelligence management (OIM), shown in Figure 7-1. Specifically, the ILM of submittal process in this dissertation crystallizes latent factors for particular activities and promises opportunities to improve organizational performance. Understanding how the various capitals interact during organizational activities provides a way of assessing the viability of the decision making process in the organization.

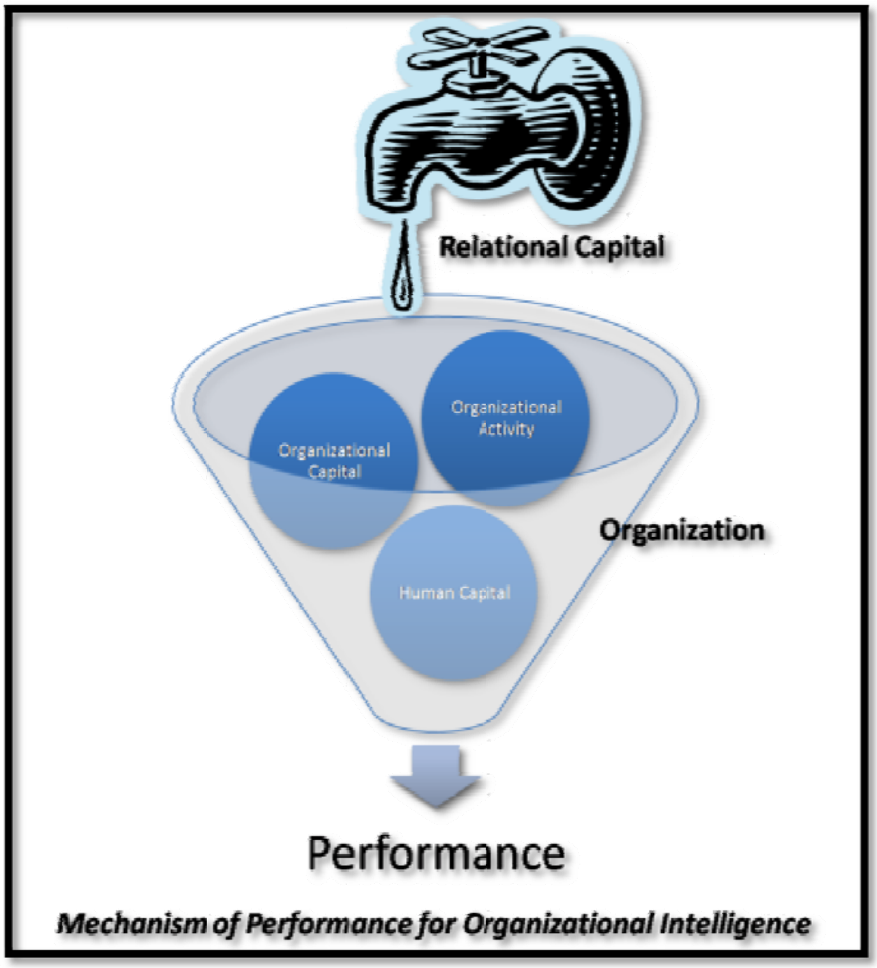


Figure 7-1: Mechanism of Organizational Performance

This research identified the various factors involved for each sequential task. These factors all contribute to the new model that initiates and standardizes a unified way of presenting comprehensive information for managerial processes.

7.1.3. The Synergy of Organizational Intelligence Management

One of the most exciting opportunities in the field of research into organizational intelligence is the potential to apply the theory of organizational intelligence to organizational activities and resources. The potential benefits of such an application of OIM are:

- Construct a understanding of managerial processes using a procedural analysis for decision makers and professionals
- Standardize a managerial process with contingent events
- Identify various organizational factors that affect performance, for example systems, culture, leadership, teamwork, policy, experience, and education
- Examine processes using the learning model to provide fundamental guidelines that can be applied to establish higher levels of organizational intelligence
- Implement organizational intelligence that allows users to be adaptive at all levels of management
- Achieve necessary integration among organizational resources and assets
- Recognize and identify gaps between traditional and innovative methods for decision makers
- Develop a learning model prototype for a theory of organizational intelligence that expands and applies a wide range of organization-related topics in addition to managerial issues, including decision-making, human resource management, educational curriculum development, and knowledge management.

The author believes that the OIM provides a solid foundation with which to manage various organizational issues that go beyond managerial issues. Specifically, it will help entrepreneurs and decision makers to understand, adopt, and optimize organizational resources and facilitate the attainment of organizational goals.

7.2. RECOMMENDATIONS FOR FUTURE RESEARCH

This research has established a foundation for a new conceptual theory of knowledge that allows a better understanding and integration of current managerial processes using an the intelligibility learning model prototype. This application starts by analyzing this process from various perspectives. The author believes that although this multi-perspective analysis was developed here for the construction industry, it can be applied to a wide range of organizational activities. However, this research is in its infancy and a great deal of work is needed to develop the OIM and facilitate its implementation.

7.2.1. Further Development of the ILM prototype

The objective of this ILM prototype is to facilitate the implementation of an OIM theory within managerial processes and recognize gaps between the status quo and more effective ways of utilizing organizational assets, enabling managers to make better decisions and assist decision makers who have the authority to change organizational structures. The ILM prototype was validated using case studies, both illustrative and exploratory. In order to standardize managerial processes future research would need to be expanded to include a comprehensive study.

As presented in this dissertation, the concept of relational capital can be used to represent the factors that determine the sequential tasks that must be performed and thus requires a performance metric that will serve as a measurement of productivity. Although the accurate measurement of performance is complex, the interdependent perspective in the ILM looks at the ratio of total outputs to the inputs from human capital and organizational capital. Relational capital in the performance factors perspective considers whether human capital and organizational capital contribute as effective and efficient factors for each task. Therefore, it may be possible to develop an equation for the total factor performance in further research that will make it possible to identify performance measures for these complex processes that can be applied in the same way as a traditional productivity measurement. One approach to this could be to follow the standardization of the ILM for a particular process as follows:

$$\text{Performance} = \frac{\text{Output}}{\text{Human Capital} + \text{Organizational Capital} + \text{Relational Capital}} \tag{1}$$

$$\text{Productivity} = \frac{\text{Output}}{\text{Labor Dollars}} \tag{2}$$

The development of organizational intelligence management could be considered in terms of a stratified categorization of methods, for example traditional, hybrid, and technological, and applied to a larger sample. Currently, many organizations are beginning to implement a range of new technologies and improvements that generally contribute to intelligence and performance in the organization. However, many organizations are still uncertain regarding the proper usages and applications of these technologies and improvements for specific organizational activities.

The submittal process in this dissertation was divided into discrete sequential tasks in the Intelligibility Learning Model and used to determine the effectiveness of the method applied in each participant's company (see Figure 6-6 and 6-7). Further research is needed to develop a stratified categorization index capable of discriminating between the methods for specific organizational activities. This could be based on the recognition of three technological groups in industries, namely those with a low, mid, or high technological index, and applied to a larger population. This promises to be a useful way to identify successful performance measures for each method for specific organizational activities to facilitate the further development of new managerial strategies in the industry.

7.2.2. Strategic Development of Performance Factors

Factors in the “Performance Factors Perspective” can be determined for each sequential task. These factors indicate the necessary requirements to complete each task efficiently and effectively. In order to achieve this effectively, however, more work remains to be done. For instance, every task requires support from appropriate organizational policies. The policy that applies to a particular task is not only useful for the decision makers concerned but also has implications for the organization as a whole. If a strategy can be fully developed and each task defined with performance factors, it can then be applied to other similar tasks. This process can also be expanded for each of the four stages: 1) Interpretation, 2) Pre-qualification, 3) Decision making, and 4) Implementation.

Since this OIM theory has been tested here for construction processes to validate the process, the strategy can be applied to other processes in other industries to identify important performance factors and enhance organizational activities.

7.2.3. Incorporation of Organizational Cognitive Ability

The performance of an organizational activity involves typical and longstanding characteristics that have been defined as organizational cognitive ability in this research. This organizational cognitive ability functions by deploying appropriate organizational assets to accomplish the organizational activity and how well it does so is measured in terms of the level of integration between organizational cognitive ability and assets for a particular task. The determination of the factors involved in the integrated activity, namely the cognitive ability and the assets, is used to measure organizational performance.

Traditionally, productivity is defined as the amount of output per unit of input. In industry, productivity is typically measured as output per man-hour or equipment-hour. However, it is difficult to measure the effectiveness of intellectual capital as contributors to OI using these measures. Intellectual capitals can and are replacing many redundant and labor intensive human processes, for example bar coding, extranet, and RFID, yet there is no acceptable standard for measuring enhanced performance/intelligence as a result of intellectual capital integration.

To accurately measure IT integration and performance requires a completely different set of criteria and metrics. One possible measure is modeled after Rush's (1986) definition of performance as the measurement of achievement against intention, as shown equation in (3).

$$\text{Performance (P)} = \frac{Achievement\ (A)}{\text{Importance (I)}} \tag{3}$$

Using this approach requires that performance achievements be continually monitored and reported against pre-established goals. By introducing the concept of organizational cognitive ability into performance measurement, this method can be used to clarify the level of support provided by organizational assets for a particular activity, as shown in equation (4). Critical metrics such as time, comparability, accuracy, and reliability have been proposed for use in analytical measurements that quantify the product of organizational assets integrated within organizational activities.

$$\text{Activity Performance (AP)} = \frac{\text{Cognitive Provision (CP)}}{\text{Cognitive Requirement (CR)}} \tag{4}$$

CR for an activity, for instance, can be characterized into two organizational cognitive abilities, Processing speed (*OIs*) and Visual Processing (*OIv*), and the organization must decide whether or not to invest in "Interactive 3D" for this activity. CP is the degree of satisfaction in two CR by "Interactive 3D." This can be converted into critical methods based on CR. *OIs* is extracted from Processing Speed *(Gs)* in human cognitive ability and indicates the ability to perform tasks fluently. *OIv* is extracted from Visual Processing (*Gv*) in human cognitive ability, and indicates the ability to generate, perceive, analyze, synthesis, store, retrieve, manipulate, transform, and deliver visual patterns or objects. Therefore, a selected organizational asset with which to perform a specific organizational activity can measure its performance in terms of whether its level of Cognitive Requirement (CR) matches its Cognitive Provision (CP). In addition, performance factors are necessities that enable decision makers in the organization to provide a rationale for using a selected organizational asset to accomplish a task and thus prevent the distortion of organizational assets.

7.2.4. Expansion of Hierarchical and Communicational Relationship

This approach to OIM is based on a consideration of a task routinely carried out by construction professionals. However, these professionals may be working at different levels in the hierarchy in different organizations, and different stakeholders may be involved in the effort to achieve higher performance. The decisions and activities undertaken by a member of an organization are directly and indirectly related to their position in the hierarchy, both inside and outside the organization, and different performance factors operate and support those decisions and activities. Figure 7-2 shows the possible relationship and roles of personnel for specific activities within the construction process. Future research will focus on the required performance factors associated with different organizational activities and participants, both within the company and outside.

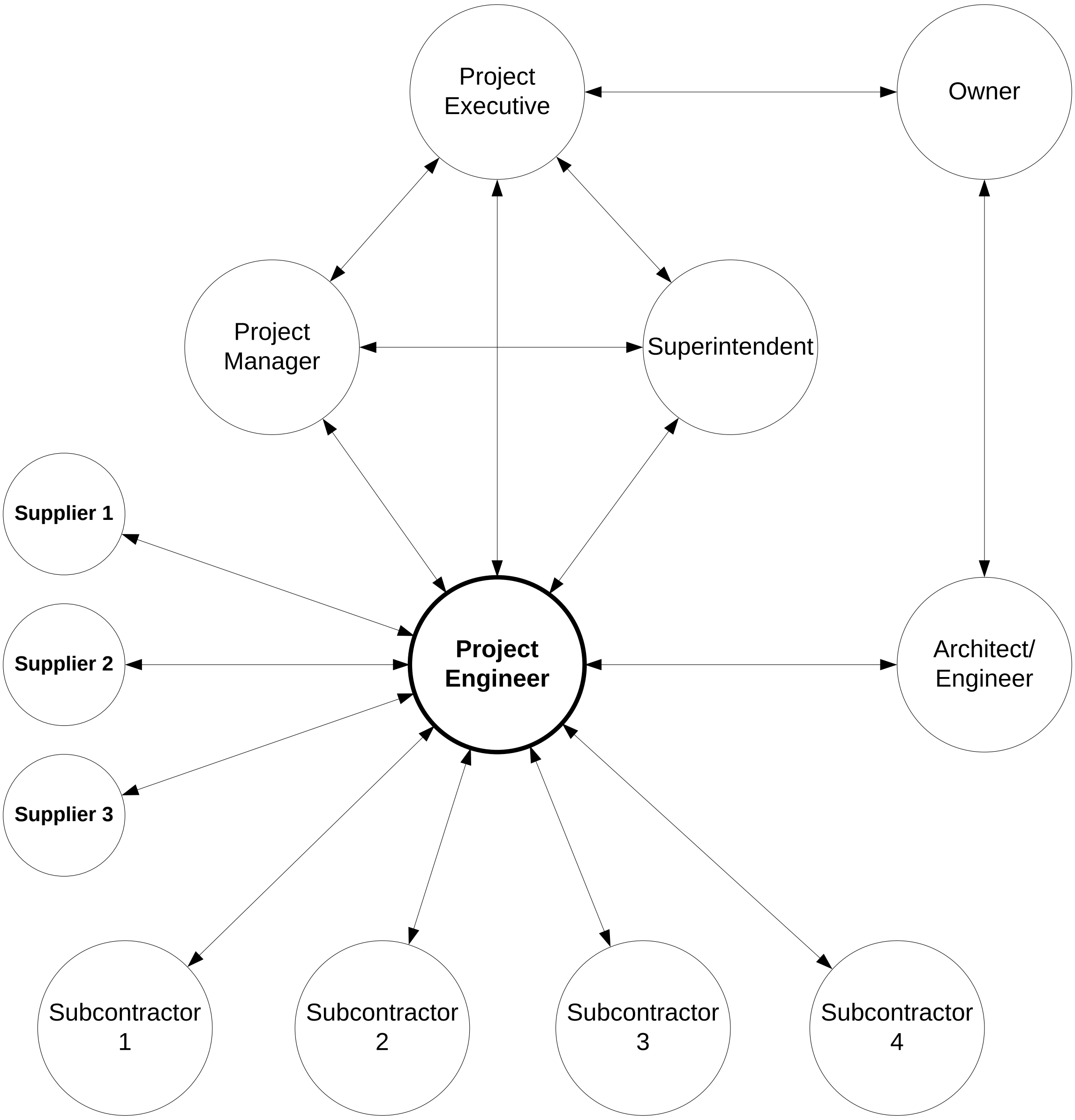


Figure 7-2: Possible Hierarchical Relationship for a Construction Process

7.3. CLOSING THOUGHTS

The challenge of developing the new approach to OIM is to achieve higher organizational performance for members of an organization through successful decision making. Some people pin their hopes on new technological innovations that will enable us to deliver better productivity and performance to meet organizational needs. Others hesitate to adopt and implement the latest products in the twenty-first century.

The concept of Organizational Intelligence Management offers a new way of providing comprehensive information to decision makers seeking solutions to a myriad of organizational issues. In addition, this provides a reasonable theory of management with which to meet an organization's need to succeed. In the Architecture, Engineering, and Construction industry and beyond, key challenges for achieving organizational intelligence management are to understand how best to apply organizational resources and activities and to integrate both optimally.

The main contribution of this research is the development and validation of a theoretical framework for Organizational Intelligence (OI). The use of this framework will offer decision makers many new opportunities to manage their organizations more efficiently and effectively. Although many construction studies have adapted and applied various technologies in order to improve performance, these have had little impact and productivity in the construction industry is still lower than in other industries. This problem stems from the absent of a firm theoretical foundation. The theory of organizational intelligence has the potential to become the cornerstone of construction management, explaining how construction processes, knowledge, skills, and resources used for managerial activities function. Additionally, this theory contributes and establishes an understanding of construction management from organizational resources through to the completion of the construction project. This research is only the beginning. More research needs to be conducted in order to validate this intelligibility learning model for a large population and other organizational activities. However, it already offers great promise for the development of new managerial strategies for the construction industry.

CHAPTER 8: Appendix

This appendix includes an ILM application to the production management operation for possible development as an area in which organizational intelligence management (OIM) can be beneficial. OIM applies the analysis of a process to the production management operation. It enables users to identify and determine the attributes that affect the operational performance of a specific production management operation beyond the traditional productivity measurements, time and cost. This appendix presents the survey form used for the pilot study and gives the results from the pilot studies with three construction professionals.

8.1. PRODUCTION MANAGEMENT OPERATION – EARTHMOVING

Production management operations in construction are heavily dependent on equipment, which is classed as organizational capital. Although the operation of the equipment itself is best monitored using traditional productivity measurements, the associated production management not only depends on the productivity of the equipment but also on the managerial aspects of the organization. Therefore, the application of production management operation to the ILM is another innovative approach that has the potential to improve the overall performance of the organization. This research includes only a theoretical discussion of production management operation.

8.1.1. Earthmoving Process

The earthmoving process is one of the commonest practices in construction. Evaluating the earthmoving process with the ILM introduces a new approach to different managerial aspects that goes beyond the evaluation methods normally used. Traditionally, evaluations of the earthmoving process focus primarily on the capacity of the equipment and its operating costs. Earthmoving productivity is measured by the volume of material carried per load and the number of loads carried (or cycles) per hour, and the cost estimation is based on a unit cost for each work item as follows:

(1) Hourly Production Rate = (Load per cycle)*(Cycles per hour)

(2) Unit Cost = Operation Hourly Cost/Hourly Production Rate

(Schaufelberger, 1999)

These methods are the basic calculations used to estimate cost and productivity, and the organization conducts its project scheduling based on these factors. An improved method for productivity forecasts might contribute to a more efficient process, but it is questionable whether it would influence the overall performance of the process as the earthmoving process is mostly dependent on the productivity of the equipment involved.

Figure 8-1 shows a typical earthmoving activity, in this case the construction of a parking lot, and the designated equipment that performs each task. The grading process is the final step performed before concrete or asphalt is laid on the surface.

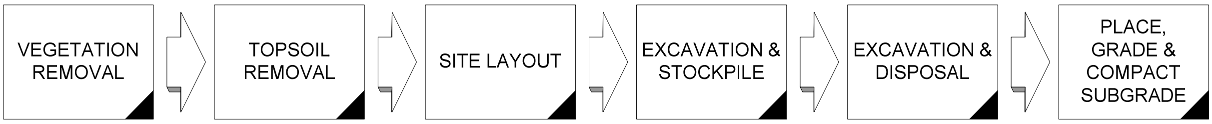


Figure 8-1: The Earthmoving Process

A grader's operations usually consist of stripping light vegetation, grading, backfilling, cutting ditches, slopping banks, scarifying, maintaining haul roads, and blending soils, all of which are performed using equipment such as the grader shown in Figure 8-2. The grader's primary purpose is cutting and moving material (Peurifoy et al., 2006).

Figure 8-2: Motor Grader

There are many technologies available that are designed to enhance this production management operation. For instance, investing in a Laser Positioning System may assist the grading process, but the need to use such a system will generally depend on the contractual requirements.

8.1.2. The Initial Application of Earth Moving to the ILM

The ILM can be applied to the operation management process in conjunction with traditional productivity measurement methods. Figure 8-3 shows the first steps of the procedural analysis for earth moving process.

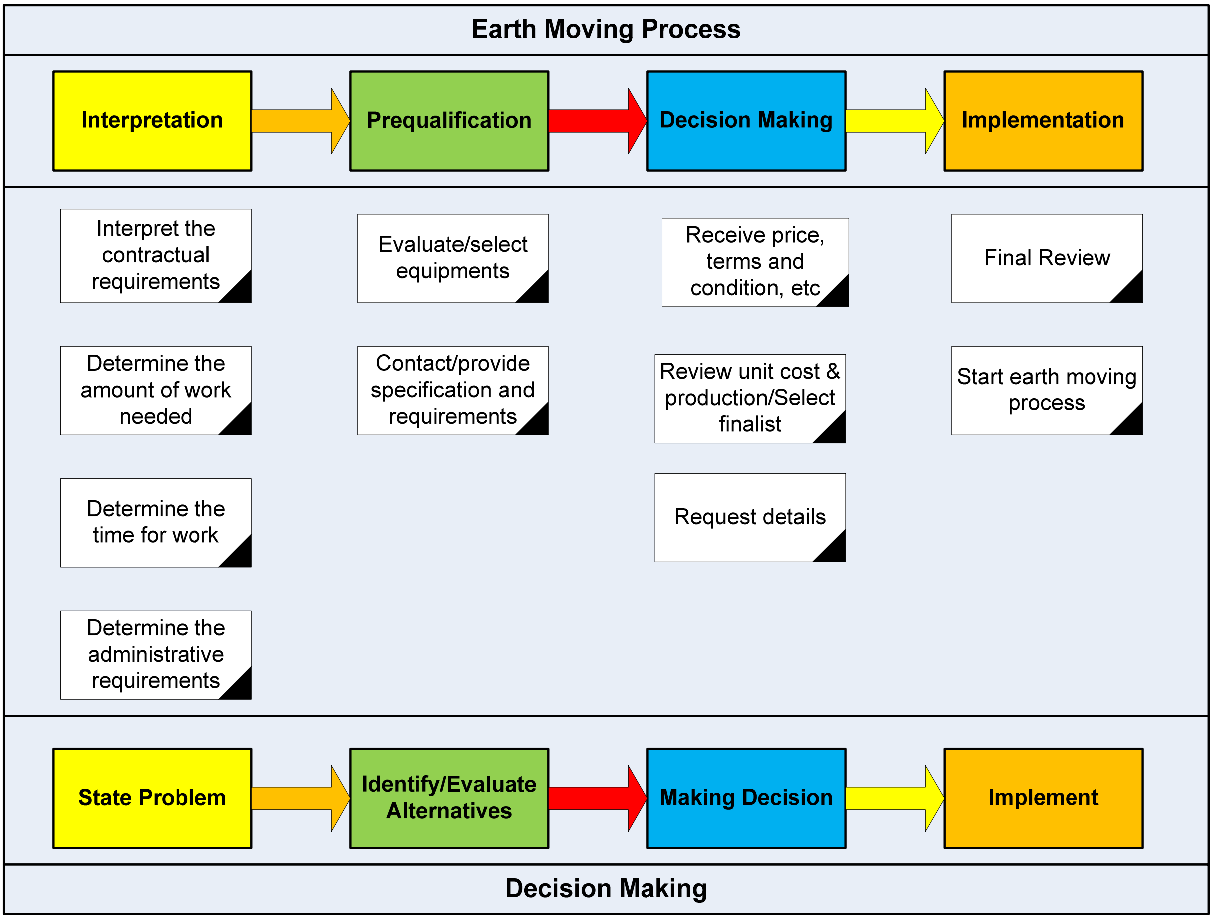
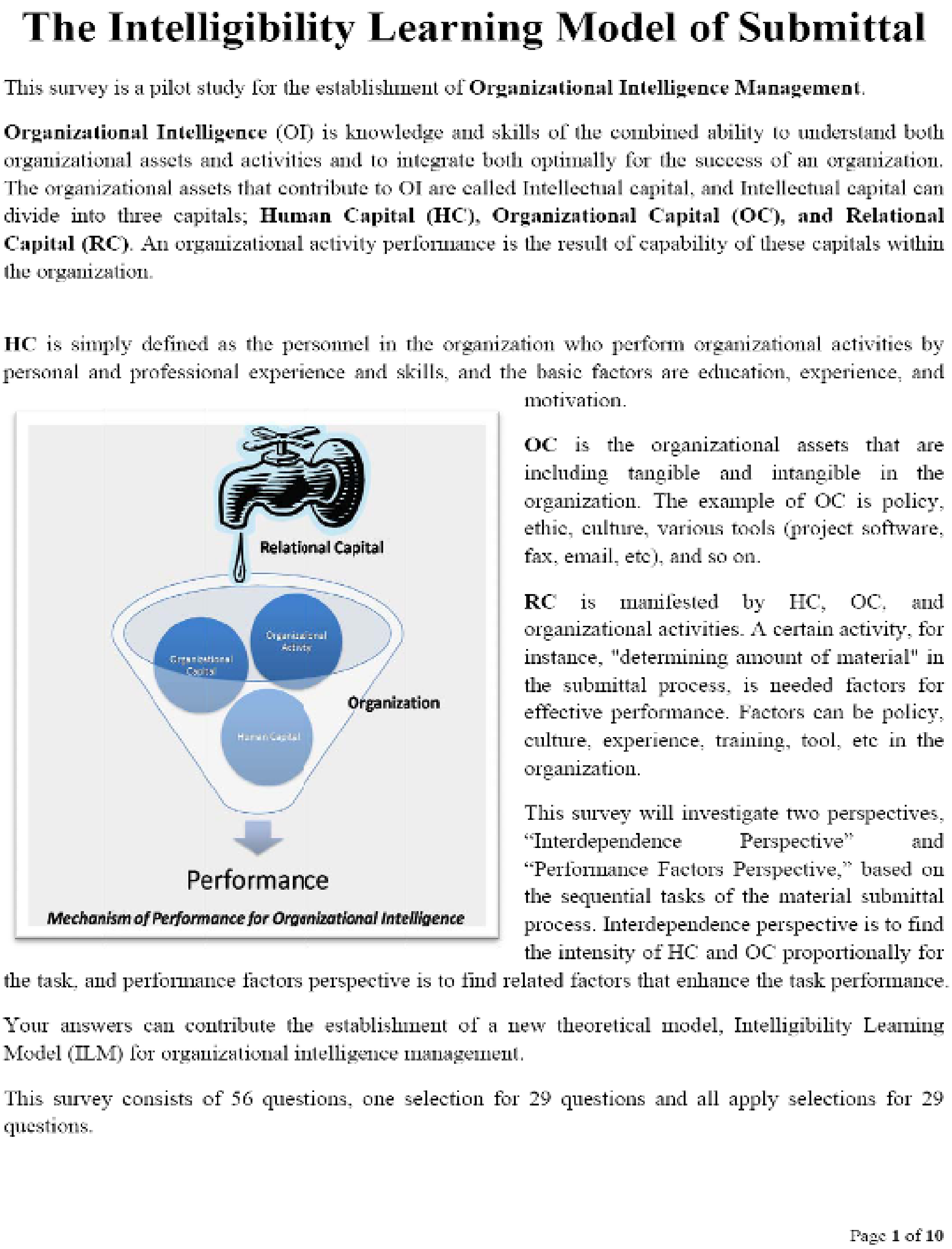


Figure 8-3: Earth Moving Process with Stages

8.2. SURVEY FORM OF A PILOT STUDY



The Intelligibility Learning Model of Submittal

This survey is a pilot study for the establishment of **Organizational Intelligence Management**.

Organizational Intelligence (OI) is knowledge and skills of the combined ability to understand both organizational assets and activities and to integrate both optimally for the success of an organization. The organizational assets that contribute to OI are called Intellectual capital, and Intellectual capital can divide into three capitals; **Human Capital (HC), Organizational Capital (OC), and Relational Capital (RC)**. An organizational activity performance is the result of capability of these capitals within the organization.

HC is simply defined as the personnel in the organization who perform organizational activities by personal and professional experience and skills, and the basic factors are education, experience, and motivation.

Mechanism of Performance for Organizational Intelligence

OC is the organizational assets that are including tangible and intangible in the organization. The example of OC is policy, ethic, culture, various tools (project software, fax, email, etc), and so on.

RC is manifested by HC, OC, and organizational activities. A certain activity, for instance, "determining amount of material" in the submittal process, is needed factors for effective performance. Factors can be policy, culture, experience, training, tool, etc in the organization.

This survey will investigate two perspectives, "Interdependence Perspective" and "Performance Factors Perspective," based on the sequential tasks of the material submittal process. Interdependence perspective is to find the intensity of HC and OC proportionally for the task, and performance factors perspective is to find related factors that enhance the task performance.

Your answers can contribute the establishment of a new theoretical model, Intelligibility Learning Model (ILM) for organizational intelligence management.

This survey consists of 56 questions, one selection for 29 questions and all apply selections for 29 questions.

General Question

Position:

Work years in the construction industry:

What are your company's tools for the submittal process?

Part 1: Common Material Submittal by general contractors

Part 1 - 1: Interdependency Perspective - Proportional Contribution by Human Capital (HC) and Organizational Capital (OC)

Please decide the intensity of HC against the intensity of OC by inferences (0 to 10 scales). 10 is highest contribution to the task by HC.
For example, the following question is the amount of personal and professional experience and skills required (for HC), relative to use of company assets, such as CPM (tool), policy, training and ethic (for OC).

1. Interpret contractual requirements of a certain material	0
2. Determining amount of material	0
3. Determining time for material's need	0
4. Determining the contractor's requirement Other than the contract requirement	0
5. Evaluate/Select/Prequalify suppliers	0
6. Contact and provide specification and requirements to suppliers	0
7. Receiving availability, price, supplier's terms and condition	0
8. Review proposals/Determine a supplier	0
9. Request detailed product information, catalog, sample, etc	0
10. Final review for submittal	0
11. Prepare and send official submittal to A/E for approval	0

Part 1 - 2: Performance Factors Perspective - Determination of Performance Factors

These questions are to find various factors that contribute to each task for efficient performance. Please select answers all that apply and add your factors that contribute to the task. (Select all applicable answers by Ctrl+ Mouse click)

1. Interpret contractual requirements of a certain material

[✓ Culture]
Education
Ethic
Experience
Leadership
Motivation
Policy
Teamwork
Tool
Training

Other:

2. Determining amount of material

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other:

3. Determining time for material's need

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other:

4. Determining the contractor's requirement Other than the contract requirement

Culture
Education
[✓ Ethic]
Experience
Leadership
Motivation
Policy
Teamwork
Tool
Training

Other:

5. Evaluate/Select/Prequalify suppliers

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other: ☐

6. Contact and provide specification and requirements to suppliers

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other: ☐

7. Receiving availability, price, supplier's terms and condition

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other: ☐

8. Review proposals/Determine a supplier

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other: ☐

9. Request detailed product information, catalog, sample, etc

- Culture
- Education
- Ethic
- Experience
- [✓ Leadership]
- Motivation
- Policy
- Teamwork
- Tool
- Training

Other:

10. Final review for submittal

- Culture
- Education
- Ethic
- Experience
- [✓ Leadership]
- Motivation
- Policy
- Teamwork
- Tool
- Training

Other:

11. Prepare and send official submittal to A/E for approval

- Culture
- Education
- Ethic
- Experience
- [✓ Leadership]
- Motivation
- Policy
- Teamwork
- Tool
- Training

Other:

Part 2: Material Submittal with Contingency by General Contractor

Part 2 - 1: Interdependency Perspective - Proportional Contribution by HC and OC

Please answer questions with the same manner of part 1. HC intensity 0 to 10 scales. You may don't need to answer same questions in part 1-1.

1 ~ 4: Same questions in part 1

5. Known available products/suppliers 0

6. Search suppliers or product by consult, team meeting, web-search, etc 0

7. Evaluate/Select/Prequalify suppliers 0

8. Contact and provide specification and requirements to suppliers 0

9. Receiving availability, price, supplier's terms and condition 0

10. Review proposals and Determine a supplier 0

11. Request detailed product information, catalog, sample, etc 0

12. Final review for submittal 0

13. Request clarification (Insufficiency from the selected supplier) 0

14. Review again 0

15. Qualify other suppliers - Failure of the selected supplier 0

16. Request detailed product information, catalog, sample, etc 0

17. Final review for submittal 0

18. Prepare and send official submittal to A/E for approval 0

Part 1 - 2: Performance Factors Perspective - Determination of Performance Factors

Choose the factors with the same manner of Part 1. You may don't need to answer the same questions in part 1-2.

1 ~ 4: Same questions in part 1

5. Known available products/suppliers

- Culture
- Education
- Ethic
- Experience
- [✓ Leadership]
- Motivation
- Policy
- Teamwork
- Tool
- Training

Other:

6. Search suppliers or product by consult, team meeting, web-search, etc

- Culture
- Education
- Ethic
- Experience
- [✓ Leadership]
- Motivation
- Policy
- Teamwork
- Tool
- Training

Other:

7. Evaluate/Select/Prequalify suppliers

- Culture
- Education
- Ethic
- Experience
- [✓ Leadership]
- Motivation
- Policy
- Teamwork
- Tool
- Training

Other:

8. Contact and provide specification and requirements to suppliers

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other: ☐

9. Receiving availability, price, supplier's terms and condition

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other: ☐

10. Review proposals and Determine a supplier

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other: ☐

11. Request detailed product information, catalog, sample, etc

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other: ☐

12. Final review for submittal

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other: ☐

13. Request clarification (Insufficiency from the selected supplier)

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other: ☐

14. Review again

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other: ☐

15. Qualify other suppliers - Failure of the selected supplier

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other: ☐

16. Request detailed product information, catalog, sample, etc

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other:

17. Final review for submittal

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other:

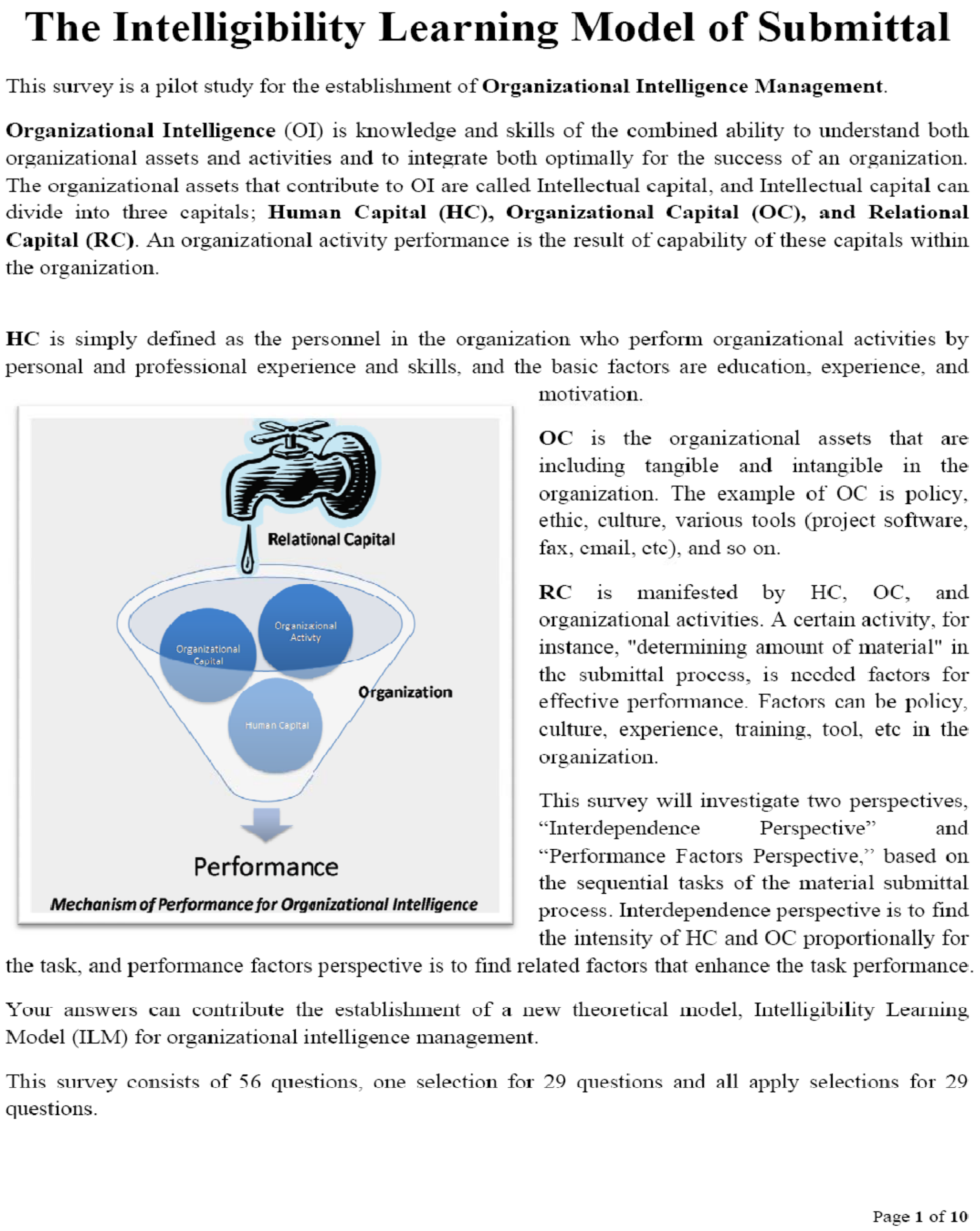
18. Prepare and send official submittal to A/E for approval

Culture
Education
Ethic
Experience
[✓ Leadership]
Motivation
Policy
Teamwork
Tool
Training

Other:

Thank you for your feedback

8.3. THE PILOT STUDY RESULT FROM PARTICIPANT 1



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RC is manifested by HC, OC, and organizational activities. A certain activity, for instance, "determining amount of material" in the submittal process, is needed factors for effective performance. Factors can be policy, culture, experience, training, tool, etc in the organization.

This survey will investigate two perspectives, “Interdependence Perspective” and “Performance Factors Perspective,” based on the sequential tasks of the material submittal process. Interdependence perspective is to find the intensity of HC and OC proportionally for the task, and performance factors perspective is to find related factors that enhance the task performance.

Your answers can contribute the establishment of a new theoretical model, Intelligibility Learning Model (ILM) for organizational intelligence management.

This survey consists of 56 questions, one selection for 29 questions and all apply selections for 29 questions.

Page **1** of **10**

General Question

Position: Project Engineer

Work years in the construction industry: 3years (Doosan Construction and Engineering) + 3years (Nan Inc.)

What are your company's tools for the submittal process?

Fax and email

Part 1: Common Material Submittal by general contractors

Part 1 - 1: Interdependency Perspective - Proportional Contribution by Human Capital (HC) and Organizational Capital (OC)

Please decide the intensity of HC against the intensity of OC by inferences (0 to 10 scales). 10 is highest contribution to the task by HC.
For example, the following question is the amount of personal and professional experience and skills required (for HC), relative to use of company assets, such as CPM (tool), policy, training and ethic (for OC).

1. **Interpret contractual requirements of a certain material**	9
2. **Determining amount of material**	7
3. **Determining time for material's need**	6
4. **Determining the contractor's requirement Other than the contract requirement**	8
5. **Evaluate/Select/Prequalify suppliers**	5
6. **Contact and provide specification and requirements to suppliers**	5
7. **Receiving availability, price, supplier's terms and condition**	5
8. **Review proposals/Determine a supplier**	8
9. **Request detailed product information, catalog, sample, etc**	6
10. **Final review for submittal**	9
11. **Prepare and send official submittal to A/E for approval**	6

Part 1 - 2: Performance Factors Perspective - Determination of Performance Factors

These questions are to find various factors that contribute to each task for efficient performance. Please select answers all that apply and add your factors that contribute to the task. (Select all applicable answers by Ctrl+ Mouse click)

1. Interpret contractual requirements of a certain material

- Culture
- [✓ Education]
- Ethic
- [✓ Experience]
- Leadership
- [✓ Motivation]
- Policy
- Teamwork
- Tool
- Training

Other: ☐

2. Determining amount of material

- [✓ Culture]
- [✓ Education]
- Ethic
- [✓ Experience]
- [✓ Leadership]
- [✓ Motivation]
- [✓ Policy]
- Teamwork
- [✓ Tool]
- [✓ Training]

Other: ☐

3. Determining time for material's need

- [✓ Culture]
- Education
- Ethic
- [✓ Experience]
- Leadership
- Motivation
- [✓ Policy]
- Teamwork
- [✓ Tool]
- Training

Other: ☐

4. Determining the contractor's requirement Other than the contract requirement

- [✓ Culture]
- Education
- Ethic
- [✓ Experience]
- Leadership
- Motivation
- [✓ Policy]
- Teamwork
- Tool
- Training

Other: ☐

5. Evaluate/Select/Prequalify suppliers

Culture
Education
[✓ Ethic]
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other: ☐

6. Contact and provide specification and requirements to suppliers

Culture
Education
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other: ☐

7. Receiving availability, price, supplier's terms and condition

Culture
Education
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ☐

8. Review proposals/Determine a supplier

Culture
[✓ Education]
[✓ Ethic]
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ☐

9. Request detailed product information, catalog, sample, etc

- Culture
- Education
- Ethic
- Experience
- Leadership
- Motivation
- [✓ Policy]
- Teamwork
- [✓ Tool]
- Training

Other:

10. Final review for submittal

- [✓ Culture]
- [✓ Education]
- Ethic
- [✓ Experience]
- Leadership
- Motivation
- [✓ Policy]
- Teamwork
- Tool
- Training

Other:

11. Prepare and send official submittal to A/E for approval

- Culture
- Education
- Ethic
- Experience
- Leadership
- Motivation
- [✓ Policy]
- Teamwork
- [✓ Tool]
- Training

Other:

Part 2: Material Submittal with Contingency by General Contractor

Part 2 - 1: Interdependency Perspective - Proportional Contribution by HC and OC

Please answer questions with the same manner of part 1. HC intensity 0 to 10 scales. You may don't need to answer same questions in part 1-1.

1 ~ 4: Same questions in part 1

5. Known available products/suppliers	6
6. Search suppliers or product by consult, team meeting, web-search, etc	6
7. Evaluate/Select/Prequalify suppliers	5
8. Contact and provide specification and requirements to suppliers	5
9. Receiving availability, price, supplier's terms and condition	5
10. Review proposals and Determine a supplier	8
11. Request detailed product information, catalog, sample, etc	6
12. Final review for submittal	9
13. Request clarification (Insufficiency from the selected supplier)	8
14. Review again	8
15. Qualify other suppliers - Failure of the selected supplier	5
16. Request detailed product information, catalog, sample, etc	6
17. Final review for submittal	9
18. Prepare and send official submittal to A/E for approval	6

Part 1 - 2: Performance Factors Perspective - Determination of Performance Factors

Choose the factors with the same manner of Part 1. You may don't need to answer the same questions in part 1-2.

1 ~ 4: Same questions in part 1

5. Known available products/suppliers

Culture
Education
[✓ Ethic]
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other: ☐

6. Search suppliers or product by consult, team meeting, web-search, etc

[✓ Culture]
Education
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ☐

7. Evaluate/Select/Prequalify suppliers

Culture
Education
[✓ Ethic]
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other: ☐

8. Contact and provide specification and requirements to suppliers

Culture
Education
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other: ____

9. Receiving availability, price, supplier's terms and condition

Culture
Education
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ____

10. Review proposals and Determine a supplier

Culture
[✓ Education]
[✓ Ethic]
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ____

11. Request detailed product information, catalog, sample, etc

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other: ____

12. Final review for submittal

[✓ Culture]
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ☐

13. Request clarification (Insufficiency from the selected supplier)

Culture
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ☐

14. Review again

Culture
[✓ Education]
[✓ Ethic]
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ☐

15. Qualify other suppliers - Failure of the selected supplier

Culture
[✓ Education]
[✓ Ethic]
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ☐

16. Request detailed product information, catalog, sample, etc

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other:

17. Final review for submittal

[✓ Culture]
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other:

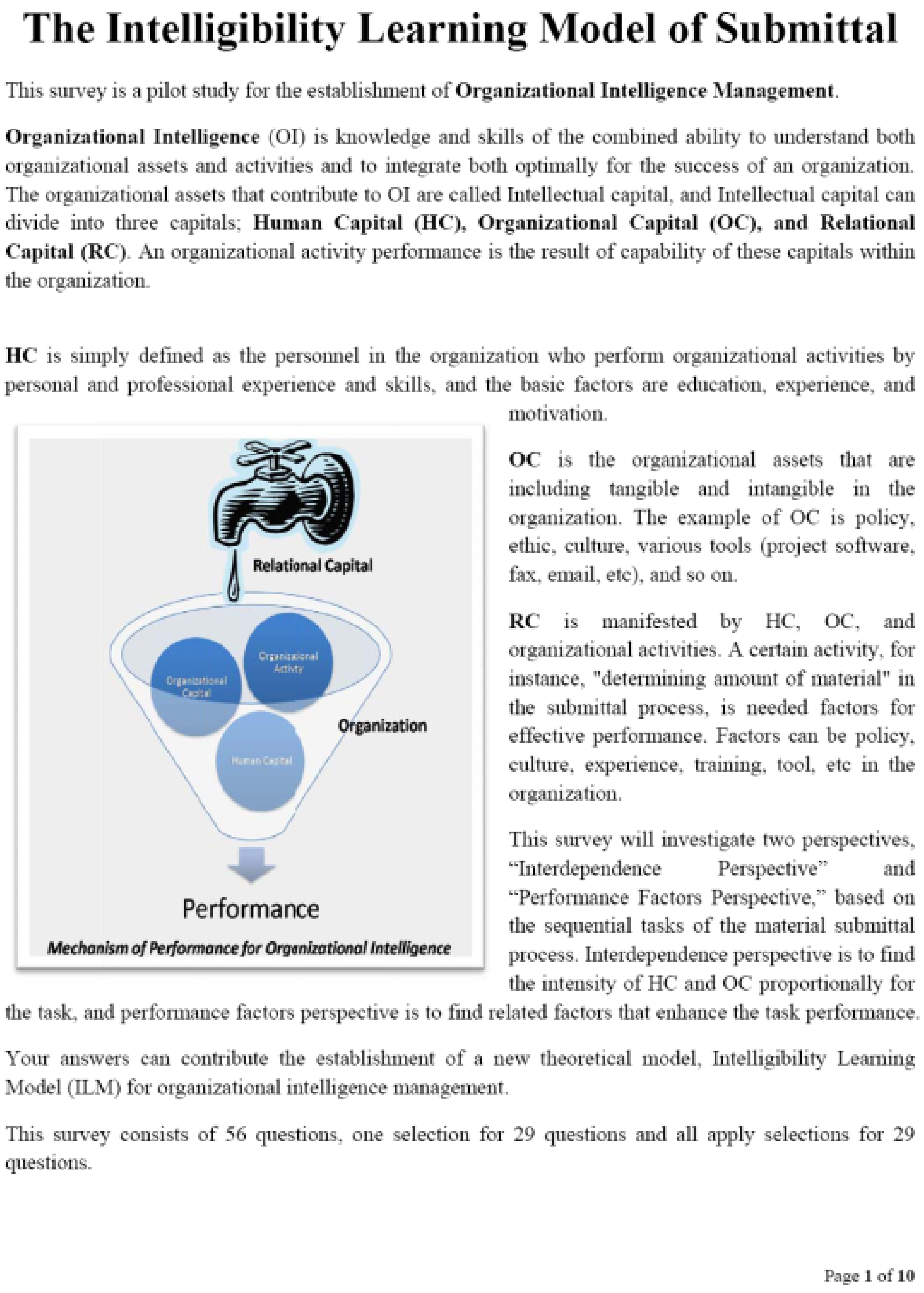
18. Prepare and send official submittal to A/E for approval

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other:

Thank you for your feedback

8.4. THE PILOT STUDY RESULT FROM PARTICIPANT 2



The Intelligibility Learning Model of Submittal

This survey is a pilot study for the establishment of **Organizational Intelligence Management**.

Organizational Intelligence (OI) is knowledge and skills of the combined ability to understand both organizational assets and activities and to integrate both optimally for the success of an organization. The organizational assets that contribute to OI are called Intellectual capital, and Intellectual capital can divide into three capitals; **Human Capital (HC), Organizational Capital (OC), and Relational Capital (RC)**. An organizational activity performance is the result of capability of these capitals within the organization.

HC is simply defined as the personnel in the organization who perform organizational activities by personal and professional experience and skills, and the basic factors are education, experience, and motivation.

OC is the organizational assets that are including tangible and intangible in the organization. The example of OC is policy, ethic, culture, various tools (project software, fax, email, etc), and so on.

RC is manifested by HC, OC, and organizational activities. A certain activity, for instance, "determining amount of material" in the submittal process, is needed factors for effective performance. Factors can be policy, culture, experience, training, tool, etc in the organization.

This survey will investigate two perspectives, "Interdependence Perspective" and "Performance Factors Perspective," based on the sequential tasks of the material submittal process. Interdependence perspective is to find the intensity of HC and OC proportionally for the task, and performance factors perspective is to find related factors that enhance the task performance.

Mechanism of Performance for Organizational Intelligence

Your answers can contribute the establishment of a new theoretical model, Intelligibility Learning Model (ILM) for organizational intelligence management.

This survey consists of 56 questions, one selection for 29 questions and all apply selections for 29 questions.

General Question

Position: Project Engineer

Work years in the construction industry:
3yrs Project Engineer + 3yrs Cost Engineer (LG Construction & Engineering),3.5yrs (Weston Solutions Inc.)

What are your company's tools for the submittal process?
TeamLink Site and email

Part 1: Common Material Submittal by general contractors

Part 1 - 1: Interdependency Perspective - Proportional Contribution by Human Capital (HC) and Organizational Capital (OC)

Please decide the intensity of HC against the intensity of OC by inferences (0 to 10 scales). 10 is highest contribution to the task by HC.
For example, the following question is the amount of personal and professional experience and skills required (for HC), relative to use of company assets, such as CPM (tool), policy, training and ethic (for OC).

1. Interpret contractual requirements of a certain material	7
2. Determining amount of material	8
3. Determining time for material's need	6
4. Determining the contractor's requirement Other than the contract requirement	9
5. Evaluate/Select/Prequalify suppliers	8
6. Contact and provide specification and requirements to suppliers	3
7. Receiving availability, price, supplier's terms and condition	2
8. Review proposals/Determine a supplier	9
9. Request detailed product information, catalog, sample, etc	8
10. Final review for submittal	9
11. Prepare and send official submittal to A/E for approval	7

Part 1 - 2: Performance Factors Perspective - Determination of Performance Factors

These questions are to find various factors that contribute to each task for efficient performance. Please select answers all that apply and add your factors that contribute to the task. (Select all applicable answers by Ctrl+ Mouse click)

1. **Interpret contractual requirements of a certain material**

   [✓ Culture]
   [✓ Education]
   Ethic
   [✓ Experience]
   Leadership
   Motivation
   [✓ Policy]
   Teamwork
   Tool
   Training

   Other: ☐

2. **Determining amount of material**

   Culture
   [✓ Education]
   Ethic
   [✓ Experience]
   Leadership
   Motivation
   [✓ Policy]
   Teamwork
   [✓ Tool]
   [✓ Training]

   Other: ☐

3. **Determining time for material's need**

   Culture
   Education
   Ethic
   [✓ Experience]
   Leadership
   Motivation
   Policy
   Teamwork
   [✓ Tool]
   Training

   Other: ☐

4. **Determining the contractor's requirement Other than the contract requirement**

   Culture
   Education
   Ethic
   [✓ Experience]
   Leadership
   Motivation
   Policy
   Teamwork
   Tool
   Training

   Other: ☐

5. Evaluate/Select/Prequalify suppliers

Culture
Education
[✓ Ethic]
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ☐

6. Contact and provide specification and requirements to suppliers

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
[✓ Training]

Other: ☐

7. Receiving availability, price, supplier's terms and condition

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other: ☐

8. Review proposals/Determine a supplier

Culture
Education
[✓ Ethic]
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
[✓ Training]

Other: ☐

9. Request detailed product information, catalog, sample, etc

Culture
[✓ Education]
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other:

10. Final review for submittal

Culture
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
Policy
Teamwork
Tool
[✓ Training]

Other:

11. Prepare and send official submittal to A/E for approval

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other:

Part 2: Material Submittal with Contingency by General Contractor

Part 2 - 1: Interdependency Perspective - Proportional Contribution by HC and OC

Please answer questions with the same manner of part 1. HC intensity 0 to 10 scales. You may don't need to answer same questions in part 1-1.

1 ~ 4: Same questions in part 1

5. Known available products/suppliers	6
6. Search suppliers or product by consult, team meeting, web-search, etc	9
7. Evaluate/Select/Prequalify suppliers	8
8. Contact and provide specification and requirements to suppliers	3
9. Receiving availability, price, supplier's terms and condition	2
10. Review proposals and Determine a supplier	9
11. Request detailed product information, catalog, sample, etc	8
12. Final review for submittal	8
13. Request clarification (Insufficiency from the selected supplier)	8
14. Review again	8
15. Qualify other suppliers - Failure of the selected supplier	9
16. Request detailed product information, catalog, sample, etc	8
17. Final review for submittal	9
18. Prepare and send official submittal to A/E for approval	7

Part 1 - 2: Performance Factors Perspective - Determination of Performance Factors

Choose the factors with the same manner of Part 1. You may don't need to answer the same questions in part 1-2.

1 ~ 4: Same questions in part 1

5. Known available products/suppliers

[✓ Culture]
Education
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other: ☐

6. Search suppliers or product by consult, team meeting, web-search, etc

Culture
Education
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
[✓ Training]

Other: ☐

7. Evaluate/Select/Prequalify suppliers

Culture
Education
[✓ Ethic]
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ☐

8. Contact and provide specification and requirements to suppliers

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
[✓ Training]

Other:

9. Receiving availability, price, supplier's terms and condition

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other:

10. Review proposals and Determine a supplier

Culture
Education
[✓ Ethic]
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
[✓ Training]

Other:

11. Request detailed product information, catalog, sample, etc

Culture
[✓ Education]
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other:

12. Final review for submittal

Culture
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
Policy
Teamwork
Tool
[✓ Training]

Other:

13. Request clarification (Insufficiency from the selected supplier)

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
[✓ Training]

Other:

14. Review again

Culture
Education
[✓ Ethic]
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
[✓ Training]

Other:

15. Qualify other suppliers - Failure of the selected supplier

Culture
Education
[✓ Ethic]
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other:

16. Request detailed product information, catalog, sample, etc

Culture
[✓ Education]
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ____

17. Final review for submittal

Culture
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
Policy
Teamwork
Tool
[✓ Training]

Other: ____

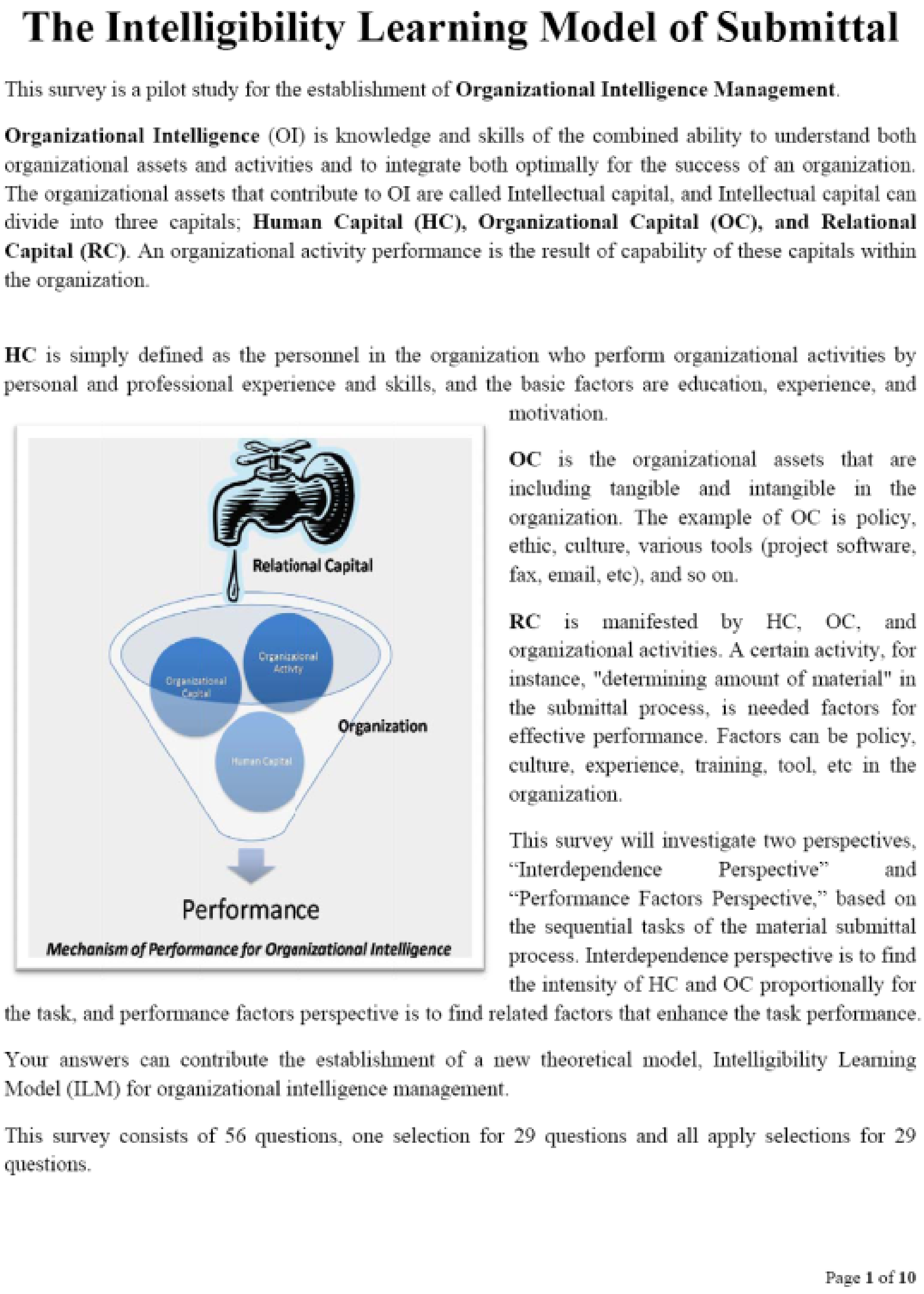
18. Prepare and send official submittal to A/E for approval

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other: ____

Thank you for your feedback

8.5. THE PILOT STUDY RESULT FROM PARTICIPANT 3



The Intelligibility Learning Model of Submittal

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HC is simply defined as the personnel in the organization who perform organizational activities by personal and professional experience and skills, and the basic factors are education, experience, and motivation.

Mechanism of Performance for Organizational Intelligence

OC is the organizational assets that are including tangible and intangible in the organization. The example of OC is policy, ethic, culture, various tools (project software, fax, email, etc), and so on.

RC is manifested by HC, OC, and organizational activities. A certain activity, for instance, "determining amount of material" in the submittal process, is needed factors for effective performance. Factors can be policy, culture, experience, training, tool, etc in the organization.

This survey will investigate two perspectives, "Interdependence Perspective" and "Performance Factors Perspective," based on the sequential tasks of the material submittal process. Interdependence perspective is to find the intensity of HC and OC proportionally for the task, and performance factors perspective is to find related factors that enhance the task performance.

Your answers can contribute the establishment of a new theoretical model, Intelligibility Learning Model (ILM) for organizational intelligence management.

This survey consists of 56 questions, one selection for 29 questions and all apply selections for 29 questions.

Page **1** of **10**

General Question

Position: LEED Engineer

Work years in the construction industry: 10years

What are your company's tools for the submittal process?

PMIS (Project Management Information System) and email

Part 1: Common Material Submittal by general contractors

Part 1 - 1: Interdependency Perspective - Proportional Contribution by Human Capital (HC) and Organizational Capital (OC)

Please decide the intensity of HC against the intensity of OC by inferences (0 to 10 scales). 10 is highest contribution to the task by HC.
For example, the following question is the amount of personal and professional experience and skills required (for HC), relative to use of company assets, such as CPM (tool), policy, training and ethic (for OC).

1. Interpret contractual requirements of a certain material	9
2. Determining amount of material	4
3. Determining time for material's need	5
4. Determining the contractor's requirement Other than the contract requirement	5
5. Evaluate/Select/Prequalify suppliers	6
6. Contact and provide specification and requirements to suppliers	2
7. Receiving availability, price, supplier's terms and condition	2
8. Review proposals/Determine a supplier	8
9. Request detailed product information, catalog, sample, etc	4
10. Final review for submittal	7
11. Prepare and send official submittal to A/E for approval	5

Part 1 - 2: Performance Factors Perspective - Determination of Performance Factors

These questions are to find various factors that contribute to each task for efficient performance. Please select answers all that apply and add your factors that contribute to the task. (Select all applicable answers by Ctrl+ Mouse click)

1. Interpret contractual requirements of a certain material

[✓ Culture]
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
Policy
Teamwork
Tool
Training

Other:

2. Determining amount of material

Culture
[✓ Education]
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
[✓ Training]

Other:

3. Determining time for material's need

[✓ Culture]
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
[✓ Training]

Other:

4. Determining the contractor's requirement Other than the contract requirement

[✓ Culture]
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other:

5. Evaluate/Select/Prequalify suppliers

Culture
Education
[✓ Ethic]
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other:

6. Contact and provide specification and requirements to suppliers

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
[✓ Training]

Other:

7. Receiving availability, price, supplier's terms and condition

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other:

8. Review proposals/Determine a supplier

Culture
[✓ Education]
[✓ Ethic]
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other:

9. Request detailed product information, catalog, sample, etc

- Culture
- [✓ Education]
- Ethic
- Experience
- Leadership
- Motivation
- [✓ Policy]
- Teamwork
- [✓ Tool]
- Training

Other:

10. Final review for submittal

- Culture
- [✓ Education]
- Ethic
- [✓ Experience]
- Leadership
- Motivation
- Policy
- Teamwork
- [✓ Tool]
- Training

Other:

11. Prepare and send official submittal to A/E for approval

- Culture
- Education
- Ethic
- [✓ Experience]
- Leadership
- Motivation
- [✓ Policy]
- Teamwork
- [✓ Tool]
- Training

Other:

Part 2: Material Submittal with Contingency by General Contractor

Part 2 - 1: Interdependency Perspective - Proportional Contribution by HC and OC

Please answer questions with the same manner of part 1. HC intensity 0 to 10 scales. You may don't need to answer same questions in part 1-1.

1 ~ 4: Same questions in part 1

5. Known available products/suppliers	7
6. Search suppliers or product by consult, team meeting, web-search, etc	4
7. Evaluate/Select/Prequalify suppliers	6
8. Contact and provide specification and requirements to suppliers	2
9. Receiving availability, price, supplier's terms and condition	2
10. Review proposals and Determine a supplier	8
11. Request detailed product information, catalog, sample, etc	4
12. Final review for submittal	7
13. Request clarification (Insufficiency from the selected supplier)	6
14. Review again	7
15. Qualify other suppliers - Failure of the selected supplier	7
16. Request detailed product information, catalog, sample, etc	4
17. Final review for submittal	7
18. Prepare and send official submittal to A/E for approval	5

Part 1 - 2: Performance Factors Perspective - Determination of Performance Factors

Choose the factors with the same manner of Part 1. You may don't need to answer the same questions in part 1-2.

1 ~ 4: Same questions in part 1

5. Known available products/suppliers

- Culture
- [✓ Education]
- Ethic
- [✓ Experience]
- Leadership
- Motivation
- Policy
- Teamwork
- [✓ Tool]
- Training

Other: ☐

6. Search suppliers or product by consult, team meeting, web-search, etc

- Culture
- Education
- Ethic
- [✓ Experience]
- Leadership
- Motivation
- [✓ Policy]
- Teamwork
- [✓ Tool]
- Training

Other: ☐

7. Evaluate/Select/Prequalify suppliers

- Culture
- Education
- [✓ Ethic]
- [✓ Experience]
- Leadership
- Motivation
- [✓ Policy]
- Teamwork
- [✓ Tool]
- Training

Other: ☐

8. Contact and provide specification and requirements to suppliers

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
[✓ Training]

Other: ☐

9. Receiving availability, price, supplier's terms and condition

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other: ☐

10. Review proposals and Determine a supplier

Culture
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
Policy
Teamwork
[✓ Tool]
Training

Other: ☐

11. Request detailed product information, catalog, sample, etc

Culture
Education
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other: ☐

12. Final review for submittal

Culture
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
Policy
Teamwork
[✓ Tool]
Training

Other:

13. Request clarification (Insufficiency from the selected supplier)

Culture
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other:

14. Review again

Culture
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other:

15. Qualify other suppliers - Failure of the selected supplier

Culture
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other:

16. Request detailed product information, catalog, sample, etc

Culture
[✓ Education]
Ethic
Experience
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other:

17. Final review for submittal

Culture
[✓ Education]
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
Tool
Training

Other:

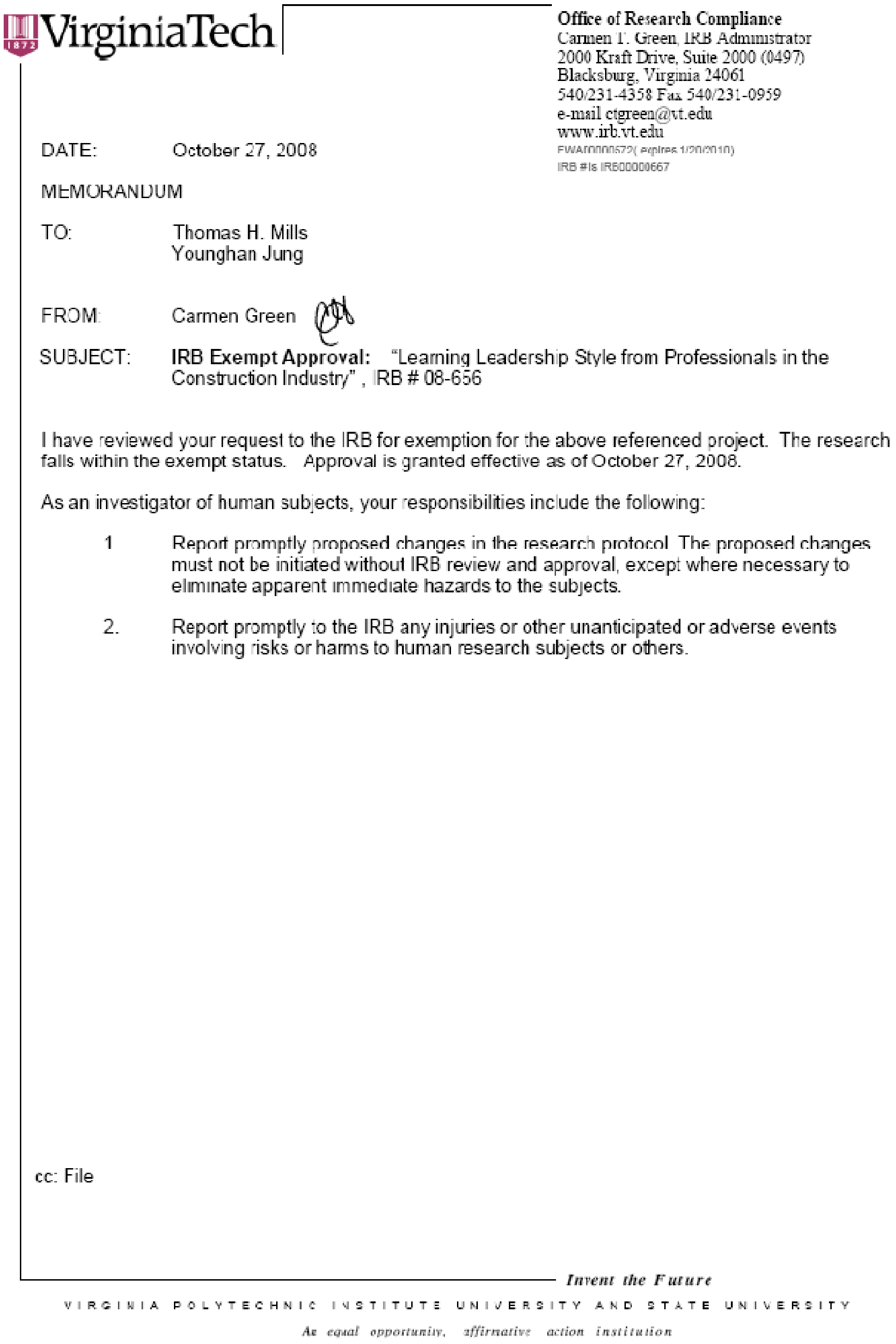
18. Prepare and send official submittal to A/E for approval

Culture
Education
Ethic
[✓ Experience]
Leadership
Motivation
[✓ Policy]
Teamwork
[✓ Tool]
Training

Other:

Thank you for your feedback

8.6. SURVEY APPROVAL FORM FROM IRB



VirginiaTech

Office of Research Compliance
Carmen T. Green, IRB Administrator
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, Virginia 24061
540/231-4358 Fax 540/231-0959
e-mail ctgreen@vt.edu
www.irb.vt.edu
FWA00000572(expires 1/20/2010)
IRB # is IRB00000667

DATE: October 27, 2008

MEMORANDUM

TO: Thomas H. Mills
Younghan Jung

FROM: Carmen Green

SUBJECT: **IRB Exempt Approval:** "Learning Leadership Style from Professionals in the Construction Industry" , IRB # 08-656

I have reviewed your request to the IRB for exemption for the above referenced project. The research falls within the exempt status. Approval is granted effective as of October 27, 2008.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in the research protocol. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

cc: File

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

An equal opportunity, affirmative action institution

CHAPTER 9: REFERENCES

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CHAPTER 10: GLOSSARY OF TERMS

Decision/Reaction Time *(OIt)* reflects how rapidly the organization reacts to changing circumstances and how long it takes to reach a decision on how to proceed. Decision/Reaction Time *(OIt)* reflects the immediacy with which an organization brings to bear its problem solving skills to address an issue, choose between alternative strategies, and apply the chosen strategy to solve the problem. This is a qualitative response that is related to Processing Speed *(OIs)* in organizational activities.

Human Capital (**HC**) refers to the human resources that are within the organization that can be deployed to acquire and apply its knowledge to perform, respond, or control designated work with the available organizational assets.

Intellectual Capital (**IC**) describes the tangible and intangible resources/assets within the organization that can be used to contribute to organizational intelligence and is divided into three types of capital: human capital, organizational capital, and relational capital.

Knowledge is the intelligence that an organization can call upon to assist its operations. This includes the information it produces, builds, organizes, and uses.

Management is defined as the process involved in attaining organizational goals in an effective and efficient manner through planning, organizing, leading, and controlling organizational resources.

Organizational Capital (**OC**) refers to the assets available to the organization, excluding HC, to support the performance of managerial processes. It includes both tangible and intangible values such as systems, policy, culture, and so on. Information/Communication Technology (ICT) is a good example of tangible value.

Organizational Cognitive Ability is an analogue of human cognitive ability. This is the organization-based skill and organizational processes that are needed to perform organizational tasks. The organization should aim to provide organizational cognitive ability appropriately for a specific task.

Organizational Intelligence is the combined knowledge and skills regarding both tangible and intangible assets, or resources, that the organization can use to achieve its goals.

Organizational Intelligence Management (OIM) is characterized by an understanding of both organizational resources and activities, allowing them to be integrated optimally and used to provide comprehensive information to decision makers seeking potential solutions to a myriad of organizational issues.

Performance represents the results of the combined knowledge and skills of organizational assets, or resources. The performance efficiency depends on the OIM that an organization can make available to apply appropriate intellectual capital to its organizational activities.

Processing Speed ***(OIs)*** is the ability to perform tasks fluently, including uncommon tasks, in order to maintain focused collaboration. Faster processing speed is more efficient because it improves the power of the Working Memory and Retrieval *(OImr)* and Decision/Reaction Time *(OIt)*.

Quantitative Knowledge ***(OIq)*** represents both the organization's capacity to acquire quantitative, analytical, and procedural knowledge and its ability to solve quantitative organization activities and problems including numeric calculations e.g., accounting, estimating, scheduling, and resource allocations.

Reading/Writing/Recording Ability ***(OIrwr)*** denotes the organization's ability to acquire and exchange information in unified formats, both among its internal structural hierarchies and with external organizations, encompassing the available usage in the field or office, e.g., field reports, daily logs, submittals, and so on.

Relational Capital (**RC**) is a special phenomenon that combines human capital and organizational capital to perform a specific organizational activity

Visual Processing ***(OIv)*** represents the organization's ability to acquire, generate, analyze, synthesize, store, retrieve, transform, and deliver visual object or pattern images, and its capacity to form and store images such as graphical charts, digital photos, visualizations, and animations.

Working Memory and Retrieval *(OImr)* refers to the organization's ability to apprehend, hold, store, and fluently retrieve new or previously acquired information (e.g., change orders, daily reports, drawings, etc). This is a measure of the efficiency with which information is updated, modified, and stored within the organization, as well as how fast documents can be retrieved from the database when needed.