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Exploratory study of barriers to use of Feigenbaum's quality cost strategy within design engineering firms

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EXPLORATORY STUDY OF BARRIERS TO

USE OF FEIGENBAUM'S QUALITY COST STRATEGY

WITHIN DESIGN ENGINEERING FIRMS

by

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ABSTRACT

It has been more than a half century since Armand Feigenbaum first conceived of the strategy for the manufacturing sector, yet quality costing strategies have not found a foothold among engineering firms. This study was aimed at constructing a set of theories that explains possible barriers to acceptance of the Feigenbaum strategy by analyzing attitudes and opinions of players in an actual engineering firm and the culture in which they work.

Modeled after the Feigenbaum approach and tailored to the business model of engineering and architectural firms, a system was developed to classify and record costs of quality. A local office of a large engineering firm was recruited to apply the system on a hand-picked design project. Using qualitative study with a phenomenology approach, records were examined and participants were interviewed.

The observed concepts and emergent hypotheses begin to tell an interesting story that might be the key to the ultimate success or failure of the Feigenbaum approach to quality costing in engineering firms. Concepts related to the mechanics of a quality cost reporting system were originally thought to be overwhelming when applied to a working engineering firm; instead they have been observed to be relatively simple and have practical and straightforward solutions. However, concepts related to perceptions of quality and quality management appear to be much more daunting barriers to a prevention-based system due to policies and perceptions that have persisted for years.

ACKNOWLEDGMENTS

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DEFINITIONS

Appraisal – CoQ activity related to finding and identifying errors and defects in the product or service so that it may ultimately be fixed, scrapped, or downgraded.

Architect – Practitioner of architecture; applies scientific knowledge to planning, design and oversight of the construction of buildings; architects address building's materials, form, and character, building's weather integrity, internal and external finishes, and most issues related to human occupancy.

ASQ – American Society for Quality. Formerly known as the ASQC: American Society for Quality Control.

CoQ – Cost of Quality as discussed in this study.

Client – One who contracts for professional services; the customer in an engineering firm business model.

Consultant – A person (or firm) with an area of expertise or professional training who contracts to perform a particular activity for a client that, once completed, ends the client's financial obligation to the consultant.

Contractor – A firm that contracts to do work for a client according to its own processes and methods; the contractor is not subject to another's control except for regulatory requirements and what is specified in a mutually binding agreement for a specific project.

Engineer – practitioner of engineering; one who applies scientific knowledge, mathematics, and physics to solve technical problems. Engineers design structures, machines, and systems while keeping mindful of technical and practical limitations, such as safety and cost.

External Error – CoQ activity arising from defects discovered after the service is performed or the product leaves the firm.

Internal Error – CoQ activity arising from defects caught internally and dealt with by discarding, downgrading, or reworking the defective items.

Investment – CoQ activity conceived in this study to describe special prevention CoQ activities that are not performed to support a single project, but intended to support all projects or a class of projects.

Owner – Project client that contemplates the involvement of a contractor, utility, or building official; intended to imply an advocacy relationship among parties in construction activity.

Prevention – CoQ activity designed to empower workers to avoid errors and defects from occurring.

Subcontractors – An individual or company hired by a general contractor to perform a specific task related to or part of the overall construction project.

Subconsultants – An individual or company hired by a consulting engineering or architectural firm to perform a specific task related to or part of the overall services which the consultant owes under a contract with a client.

1. INTRODUCTION

1.1. BACKGROUND

In a perfect world, employees in an engineering and architectural firm always perform work correctly; design and drafting is flawless; subcontract work is always perfect and delivered on time. We do not, however, live in a perfect world. People commit errors, software malfunctions, and processes break down. As a result, engineering firms need formal plan checkers and design reviewers to identify errors and validate designs, rework and redesign to correct errors, personnel to handle client complaints, liability insurance to indemnify errors and omissions and, at worst, attorneys to defend against lawsuits.

The environment where engineers and architects do business has evolved over the years; involving more complex regulations, advancing technology, and clients and contractors that are more sophisticated and less tolerant of errors and omissions. Nationally-recognized project management specialist and construction claims consultant Andrew Civitello (2002) suggests a leaner and more aggressive construction contractor that is unwilling to inflate cost proposals to construction clients to cover contingencies of, among other things, errors and omissions by architects and engineers.

> "…if a contractor is going to win a bid and earn a profit, the contract documents must be interpreted in a lean fashion. There is no longer any room in a contractor's vocabulary for the concepts 'contingency' or 'absorbed cost'…"

Civitello coaches contractors to be vigilant as they study contract documents from architects and engineers, such as drawings and specification, and spot flaws that could be used as the basis for change orders. He discusses how architects and engineers deliver flawed designs caused by coordination failures among the different engineering disciplines working on a construction project:

> "…projects are becoming increasingly complex, design budgets are often tight, and review times are short. Difficulties also arise because the separate plans and details are developed independently by individual consultants. For these reasons, among others, designs may be completed without full consideration for the other disciplines."

The measures that firms take so as to deliver engineering documents that are reasonably free of errors is fast becoming an important consideration as clients become more sophisticated, fees become leaner, and competition intensifies. Rework is justifiably more expensive than work performed correctly the first time. Nonetheless, engineering firm managers and supervisors act daily without considering this point.

1.2. COST OF QUALITY

To some, quality is considered an elusive concept that is difficult to measure. According to the American Society of Quality, a sizeable portion of quality costs are neglected because managerial accounting systems are not designed to isolate them. It is not unfair to suggest that most company top managers respond more to cost and schedule issues than to matters related to quality. (Campanella, 1999)   The Feigenbaum cost of quality (CoQ) model is defined as all costs over and above the basic cost of delivering value to clients on-time and without error. More specifically, it is the cost of doing things wrong. It permits management to speculate 'what would this operation cost if nobody made mistakes?'

While it does not specify how, internationally-recognized business process guideline, ISO 9004-1 (1994) recommends the collection and use of quality costs:

> "…it is important that the effectiveness of a quality system be measured in financial terms. The impact of an effective quality system upon the organization's profit and loss statement can be highly significant, particularly by improvement of operations, resulting in reduced losses due to error and by making contribution to customer satisfaction."

> "…by reporting system quality activities and effectiveness in financial terms, management will receive the results in a common business language from all departments."

Estimates of a company's quality costs vary quite a bit depending on the data source and the industry under study. Publications on the subject suggest that when firms first undertake a study of quality costs, their initial data exposes costs that are much higher than first expected. Crosby (1980) asserts that manufacturing operations with no initial awareness of their quality costs usually discover that CoQ can be between 25 and 30% of sales.

Organizing a process's costs into quality costs categories has a practical benefit. These costs fall into one of four categories. See Table 1.1, below.

Table 1.1 – Cost of Quality Activities

Category	Description of Costed Activity
Prevention	activities that empower employees to avoid errors
Appraisal	activities that uncover errors
Internal Error	Activities associated with correcting errors before reaching the public, including the client
External Error	Activities associated with correcting errors after reaching the public, including the client

Analysis of costs in this way is comparable to analysis using financial ratios in that it serves to focus management attention on aspects of the operation, targeting them for improvement. Identifying and systematically reducing even a small percentage of CoQ can have a tremendous impact on profitability; without visibility into these costs, opportunities for savings might never present themselves.

1.3. CAN ENGINEERING FIRMS USE COQ?

Since its introduction in 1956, product and process manufacturing firms have made use of CoQ systems as a means of tracking the health of their quality systems. In the past quarter century, other business models have been found that engage a CoQ method in some form. The Institute of Management Accountants found that a third of companies that responded to a survey inquiry, 82 percent said they were involved in quality improvement programs and a third of respondents said that they measure the costs of quality. (*IIE Solutions*, 1996) Nonetheless, CoQ systems as a management tool have not yet found their way into engineering and architectural firms. A CoQ reporting structure is but one of many tools needed in a comprehensive, firm-wide quality management system. It is, however, an important tool that directs management attention and measures the success of company efforts to improve. In the opinion of this researcher, engineering firms can begin to uncover substantial savings opportunities that

can be used to improve profitability and competitiveness. By using CoQ in conjunction with a quality system such as Six Sigma or total quality management, quality costing can become an exceptionally useful tool that changes the way employees and management think about the prevention and detection of errors. By using the common language of dollars, management can move beyond the concept of quality as an abstraction and into the realm of reality where it can effectively compete with matters of cost and schedule.

Engineering firms have a legal and ethical duty to the public and are held responsible to ensure that structures are designed free of defects that could endanger the public. Modern structures rely on an integration of engineering and architectural specialties that converge into a coherent design package. Improperly coordinated, the most competent engineering practitioners may not recognize defects that could lead to failures resulting in accidents, property damage, injury, or even death.

1.3.1. Profitability. Crosby (1980) asserts that quality costs in a manufacturing firm can be as high as 30 percent. It is more probable, however, that engineering design firms behave like software development firms. Like design engineering, software development can be described as a (1) high value-added effort, with (2) relatively insignificant material costs, (3) using professional labor, and (4) performing a mix of technical processes. The ASQ Quality Cost Committee asserts that Software Developers with poor or no initial awareness of their quality find a CoQ between 45 and 65 percent of sales. (Campanella, 1999) The ASQ describes a case study involving a software developer that started from 65 percent and was able to slash costs down to 22 percent.

Imagine for a moment that embedded within a particular engineering firm's costs were quality costs on the order of 60 percent of sales (rounded down from the 65 percent asserted by the ASQ), and that firm embarked on a company-wide quality improvement program that was successful in shaving only 10 percentage points from that figure: a CoQ of 50 percent of sales. The revenue gains that result would be extraordinary.

Consider the fiscal year 2005 profit and loss statement from the annual report of an international engineering firm[1] as shown in Figure 1.1. In Figure 1.1a, the firm is shown to realize nearly $46 million net profit before taxes on over $1.4 billion in total

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[1] Financial statistics of this firm was selected for convenience. Do not infer similarities with financial behavior of other engineering firms that serve the same markets or have equivalent revenues.

revenue, or 3.2 percent of total revenue. It shows a line item *Contract Costs* reflecting the collective expenditures of all engineering projects performed by the firm, although not including the portion of revenue paid directly to subconsultants (see the line item *Subcontract Costs)*.

	(a)		(b)		(c)

(a)

Income Statement		
Fiscal Year Ended 28 October 2005		
(in thousands)		
Total Revenue	$ 1,447,756	
Expenses:		
Contract Cost	510,651	100%
Subcontract Costs	345,328	
G & A Costs	545,773	
Income before taxes	$ 45,904	3.2%

Pure Operation + Quality Costs

(b)

Income Statement		
Fiscal Year Ended 28 October 2005		
(in thousands)		
Total Revenue	$ 1,447,756	
Expenses:		
Pure Operational	204,260	40%
Quality Costs	306,391	60%
Subcontract Costs	345,328	
G & A Costs	545,773	
Income before taxes	$ 45,904	3.2%

Level 1
Contract Costs
$510,651

(c)

Income Statement		
Fiscal Year Ended 28 October 2005		
(in thousands)		
Total Revenue	$ 1,447,756	
Expenses:		
Pure Operational	204,260	50%
Quality Costs	204,260	50%
Subcontract Costs	345,328	
G & A Costs	545,773	
Income before taxes	$ 148,134	10%

Level 3
Contract Costs
$408,520

Figure 1.1 – Engineering Firm Income Statements CoQ Contribution

Consider that *Contract Costs* consists not only of the value-added labor, but also a nonvalue-added component – costs-of-quality – that is embedded within. Assume that the contribution of quality costs amounted to 60 percent of the total contract costs; this would essentially make the contribution of strictly value-added labor 40 percent of contract costs. Though far from true, also assume that subcontract or the general and administrative costs have no embedded quality costs for the purpose of this discussion. In this illustration, nonvalue-added, or quality costs, figure to be $306 million. The value-added labor costs required to produce $1.4 billion revenue for the firm is $204 million. See Figure 1.1b.

If only 10 points were shaved off of the quality costs so that CoQ reflected only 50 percent of the Contract Costs, the effect on profitability would be quite dramatic. The value-added required to produce the $1.4 billion in net profit is still $204 million, but a

50 percent CoQ would reflect a nonvalue-added labor of only $204 million. Contract Costs shows a drop of over $102 million, which would arguably fall to the bottom line and increase net profit from under $46 to over $148 million, or a net profit of 10 percent of sales. See Figure 1.1c. A 10-point reduction in CoQ results in a phenomenal 222 percent increase in profit.

There should be no misunderstanding: the quality improvement leading to the reduction of CoQ in Figure 1.1c reflects no small effort. CoQ can never be eliminated, but through systematic improvements using opportunities targeted by quality cost data and effective management of the quality cost portfolio, total CoQ can be minimized. In a manufacturing operation with mature quality system and excellent visibility into quality costs, Crosby (1980) asserts that total quality costs of less than 5 percent are possible. In software development operations, also with mature quality systems and excellent visibility into quality costs, the ASQ reports on studies of total quality costs down to nearly 20 percent. (Campanella, 1999)

A CoQ system can rank and prioritize improvement projects with quality costs to help maximize return on scarce investment dollars. By measuring the true impact of corrective actions and changes made to improve key business processes, this researcher believes that it is also possible to gain insights into client and stakeholder quality costs and eventually reveal their quality cost drivers to improve the engineering firm's service offerings.

1.3.2. Avoiding Defects. Bill Smith, of Six Sigma fame, was an engineer at Motorola. He recognized that Motorola was making personal electronics that were not particularly reliable, despite the heavy investment in inspection and rework. In a paper that he published in 1985, he wrote:

> "If a product was found defective and corrected during the production process, other defects were bound to be missed and found later by the customer during early use of the product. However, when the product was manufactured error-free, it rarely failed during early use by the customer." (Harry, et al., 1999)

With engineering firms designing structures used by the public on a daily basis, the consequence of defects are arguably more ominous than a defect in a personal pager. All construction has contact with the public in some way. Bridges must be structurally

sound to support most vehicular traffic and withstand natural events such as high winds and earthquake. Roadways must be constructed to support safe and efficient use by a wide range of vehicular traffic and be free of most collision risks. A single-family home must be resistant to collapse from severe snow load and high winds, and be free of most fire risks. A townhouse complex must be constructed so a severe fire in one unit does not spread to connected dwelling units. Hydroelectric dams should make maximum use of technology to harness the most energy within the limits of the construction while imposing the least impact on the environment.

Engineers have real influence on the public and can have disastrous results when due care and skill are lacking. Consider these two actual incidents that occurred here in Missouri:

A group of children narrowly escaped a roof collapse of the Faith Church in Fenton. Part of a youth choir, the children noticed falling ceiling tiles and evacuated the building only moments before the ceiling came crashing down. Investigators tentatively identified two causes of the roof failure: weight of water from heavy rains and the weight of the roof air conditioner unit. (KSDK.com, 2010) While not resolved as of this writing, it is this researcher's opinion that both factors will likely lead investigators to the professionals responsible for the design:

- an architect who was tasked with designing a roof contour that limited the accumulation of water,
- a structural engineer who was responsible for designing roof structure that could safely support known loads including the rooftop unit and a finite amount of accumulated water, and
- a mechanical engineer who was responsible for designing roof drains and coordinating weight of roof equipment with the structural engineer

One of the most famous breaches in recent history was the Kansas City's Hyatt Regency disaster in 1981, where a skywalk flaw in the hotel's atrium contributed to a deadly collapse during a dance contest at the new hotel. The failure of a tie-rod assembly resulted in the death of 114 people and injury to hundreds of others. That investigation uncovered flawed shop drawings from the contractor showing an alternate method for tie-rod supports for the multiple skywalks. While the consulting structural engineer did not

prepare the defective design, he approved for the Owner the contractor's shop drawings that contained the defect and was, thus, held criminally responsible. (Petroski, 1992)

Motorola embarked on a quality improvement program where quality was built into the design, thus all but eliminating early failures of pagers in the hands of the customer. For engineers and architects of structures used by the public, the stakes are much higher.

1.4. WHY HAVE ENGINEERING FIRMS NOT EMPLOYED COQ?

Unfortunately, the principle project delivery mechanism of the engineering firm is not conducive to management of CoQ. In a factory environment, activity costs are relatively easy to determine; processes and products are repetitive and in plain view, and costs are relatively easy to assign. In a service environment, particularly a *professional* service environment, quality activity costs are also in plain view, but far from repetitive and, thus, comparatively more difficult to identify systematically. Engineering firms would not be conducive to CoQ reporting because in an engineering project, CoQ cost collection would have to rely on self-reporting mechanisms and be classified by its work breakdown structures.

Processes within an engineering firm do not resemble manufacturing operations so correlation with manufacturing quality costs would be uncertain at best. Engineering is an intellectual, rather than a physical product, so its development is subject to special human and logical constraints. These constraints, paraphrased from a discussion by the ASQ on the use of quality costs in software development, (Campanella, 1999) are identified below:

- Engineering requirements cannot be assumed as stable; changing requirements is expected behavior in the development of an engineering design.
- While the design phase of a manufactured product is usually insignificant, the design phase of an engineering and architectural product is, by definition, substantial.
- Statistics are difficult to apply to engineering products. While there are similarities among sub-processes, engineering and architectural projects are often one of a kind.

- There is a tremendous variation in productivity levels among individuals in engineering firms.

- Manufactured goods are valued for their features; engineering is valued for its competence, clarity, comprehensiveness, economy, and other abstract qualities.

- Defects are almost exclusively the result of human misunderstanding, not faulty materials. The economics of engineering depends, to a large degree, on the process of understanding requirements. This process, more than any other factor, is responsible for the value of the engineering product.

1.5. THE DESIGN ENGINEERING FIRM BUSINESS

This research seeks to apply a system of Cost of Quality in consulting engineering firms. While the work of an engineer plays a part, fundamental concepts involve the engineering firm's business model.

The consulting firm can provide professional services to major market sectors such as construction, transportation, government, energy, and utilities. They offer services such as feasibility studies, landscape architecture, urban planning, structural design, bridge and roadway design, flood risk assessments, and energy assessments. These activities are alike in at least one respect: they are all projects, not ongoing processes.

1.5.1. The Consulting Engineer. The appeal of the consulting engineer is direct personal service, practiced expertise, and advice in highly technical areas and activities that clients could not afford to maintain on their full-time payroll. Functioning as an independent contractor retained to help with operation, maintenance, design, and construction, a consulting engineer is retained by governments, institutions, businesses, and individual clients to work on a project-by-project basis to work alone or as a member of a consulting firm.

Practicing consulting engineers must be licensed professional engineers in their state of residence and must qualify to obtain licensure in other states where they practice or provide services. In many states, the title of "Engineer" is legally protected. It is generally unlawful for a person to represent him/herself as an engineer to the public unless licensed by the state. A license as a "professional" or "registered" engineer is

usually granted upon providing proof of an accredited engineering degree, evidence of appropriate internship experience under the direction of another licensed engineer, passing a criminal background check, affirmation of several licensed engineers, and successful completion of at least an eight-hour written examination. The earmark that distinguishes a professional engineer is the authority to "seal" engineering documents (drawings, specifications, calculations, and reports). A professional engineer's signature over a personal inked stamp or embossed seal demonstrates to the public that the document was competently prepared and that the engineer assumes personal legal responsibility. See Figure 1.2 for a sample signature and seal. Local government authorities require certification of a professional engineer in this way on documents used in conjunction with most construction.

      1.5.2. The Consulting Engineering Firm. As an added safeguard, firms that offer engineering services to the public must also be authorized by the state. Most states require some combination of management and ownership to be registered as professional engineers and, depending on their business form (partnership, corporation, etc.), the state issues a certificate of authority.

Figure 1.2 – Professional Engineer's Seal with Signature

      Consulting engineering firms assemble the appropriate engineering talent to successfully complete the client's project, administer the effort to stay within the client's scope, schedule, and budget and, once completed, depart and leave the client with no further ongoing financial obligation.

1.5.3. Customers. While the dictionary defines *customer* as one who pays for goods or services, a *client* is defined as someone who seeks professional advice. Engineering consultants provide professional technical advice to governments, businesses, institutions and individuals; as such, when engaging the services of engineering consultants, these entities are called clients. When professional services provided to clients contemplate the involvement of a contractor, utility, or building official, that client becomes known as the *Owner*. The term is intended to imply a relationship of advocacy by the consultant on behalf of the client when dealing with others. For example, if communicating with a contractor about ongoing construction of a new science lab for a local high school, both the consultant and the contractor know that the Owner refers to the school district in the person of its facility manager.

1.5.4. Business Alliances. Even with the very largest firms, engineering consultants find themselves in need of assistance in technical areas that can be found only in another firm. Perhaps their overhead structure makes it more cost effective to partner with a smaller firm. In the same way that general contractors hire subcontractors, engineering consulting firms hire subconsultants to help complete projects. Like contractors, consultants remain responsible to the client for the coordination of the subconsultants' work. Subconsultants can include inspectors, surveyors, testing agencies, and other engineers, designers and drafters.

1.5.5. Stakeholders. Consulting firms remain mindful of others who might have a significant stake in the consultant's quality of work. In a construction project, these stakeholders include the general contractor and subcontractors; government plan reviewers, fire marshals, and building inspectors; commissioning agents, sub-consultants, suppliers, and not quite as obvious, but ever present: the public-at-large. Even though none of these entities have a contractual relationship with the consultant, each stands to bear some manner of extra cost or damage if the consultant's project documents, including plans and specifications, are not delivered on time and without error.

General contractors and subcontractors (subs) normally have no contractual arrangement with the engineering consultant. Yet, the general contractor and his/her subs complete the construction as described by the architect/engineer on their plans and specifications and are contractually obligated to coordinate and complete their work on

schedule and to an acceptable level of quality. When contractors encounter design errors, they can incur unexpected costs related to (1) added labor associated with dismantling defective work, (2) added labor and materials for work associated with corrected plans and specifications, and (3) schedule delays. The contractor routinely shifts these unexpected costs back to the Owner by way of change orders. If the change order can be traced to an error or omission by the consultant, Owners frequently chargeback firms that are responsible, or worse – file a lawsuit.

According to Ashcraft (2002), a fellow of the American College of Construction Lawyers, the customary standard of care for engineering consultants is not infallibility, but reasonable care and competence at the level of other engineers practicing in the same profession. Courts have consistently ruled that clients of architects and engineers do not purchase insurance, but rather professional services. Still, the case law does not protect engineering consultants from charges of negligence, incompetence, and other misconduct. Engineering consultants can suffer in several different ways: the expense of rework and redesign of plans and specifications, charge-backs for contractor change orders, lawsuit judgments, loss of business and loss of reputation.

Registered architects and engineers are held individually and independently responsible for the safety of the public. Canons of ethics and state regulators require that architects and engineers behave competently, responsibly, and honestly.

1.5.6. Costing Structure. The consulting firm is in business to sell professional services to clients so it hires engineers and others to perform those services. Armed with a staff of professionals and others, consulting firms attract clients and contract for technical tasks pursuant to a project. Project management selects employees to perform the work of the project. The consulting firm pays its employees for their work out of revenue from client billing. The key managerial accounting tool that is central to this process is the individual timesheet.

This researcher speculates that data collection for a cost-of-quality system in an engineering firm will require personally-recorded data and may substantially resemble the individual timesheet. Such a system involves risks that may ultimately affect its reliability. A discussion of key features of the timesheet process within a consulting firm and its congruence with a system to collect CoQ data would therefore be useful.

1.5.6.1 Timesheet process. In an engineering firm, employees record time on a timesheet and code each hour with a charge number. See Figure 1.3. The timesheet has a two-fold purpose: (1) it signals payroll to pay the employee for the hours worked, and (2) it serves as a base document with which to bill clients for time spent working on their projects. There are a few checks and balances in the timesheet system to keep it moving and to infuse it with a degree of integrity.

In order to be paid, employees in an engineering firm must record hours worked on timesheets in a manner required by the firm. Timesheets allow employees to record time in one of two fundamental ways: billable and non-billable. Time coded as billable can be directly or indirectly charged to a client. Time coded as non-billable becomes a non-reimbursable expense to the firm, increasing its overhead burden. A worker's billability is the ratio of recorded billable hours to his/her total recorded hours. With some exceptions, employees with chronic low billability are disciplined and ultimately terminated; for this reason, employees seek out billable work rather than remain idle.

Figure 1.3 – Example of an Official Timesheet

The firm wants to charge clients for work their employees perform on their projects, so they select a mix of workers with the appropriate technical skills to

effectively, but economically complete the project. Workers not performing up to expectations are removed and replaced with higher performing personnel. Staff performing work on a project is given a charge number, against which their time can be recorded on timesheets, thus becoming billable for the hours worked.

Projects are ordinarily constrained with project budgets, so project leadership remains vigilant as to how the project budget is spent. Project staffs are provided with a budget or other guidance that keeps project expenditures in check. Project managers normally have the power to prevent unauthorized persons from charging to their budgets.

To keep their project moving, clients desire technical expertise brought to bear for timely and competent completion of project work. Many contracts for services between clients and consulting firms require that timesheet records accompany invoices for payment of services. Even when timesheets are not required for payment, they are normally open to clients for inspection. Timesheets provide clients with a level of confidence that engineering staff is working on their project and not otherwise engaged.

1.5.6.2 Cost of quality data collection process. There are very few cost-of-quality activities that can be hidden from view in a product manufacturing operation. CoQ activities such as product design, product inspections, complaint department activities, and warranty work can be immediately recognized by the casual observer. Cost accountants who collect CoQ data can usually rely on existing cost accounting tools to accumulate CoQ data with an acceptable degree of confidence. (Crosby, 1980) Not so within a consulting firm engaged in design engineering. Some firm activities may be immediately recognized as a CoQ activity, particularly if done in a group setting, such as a coordination or design review meeting. However, even a direct supervisor may have difficulty distinguishing individual actions of his/her worker as value-added work or an actual CoQ activity if attempted by casual observation alone. For example, the physical activity of a drafter when performing rework is nearly the same as value-added work.

While not immune to corruption, the individually-recorded timesheet for employees derives some integrity from check and balances described in Paragraph 1.5.6.1 above and the system to record CoQ data resembles that process. However, several incentives inherent in the timesheet process that are key to its integrity are conspicuously absent in the CoQ data recording process.

- Most notably, employees need not be conscientious in logging their own CoQ data in order to obtain a complete paycheck. Missed opportunities to log CoQ data does not result in a reduction of pay for an employee as would a missed opportunity to charge time on a timesheet.

- Labor law requires that employees be paid, even for idle time. A full-time employee will charge 40-hours in a week, with idle time charged to non-billable accounts. CoQ data collection is not so constrained. The intermittent nature of CoQ activi1ties means that employees need not account for every hour worked and could conceivably miss opportunities to record CoQ data without attracting the suspicion from management.

- Project managers have learned to maintain some level of surveillance over individuals charging time to their projects through timesheets and have some capability to match an employee's level of effort with time charged. As conceived, the CoQ data collection process has no way of comparing time records with an individual's level of effort.

- The integrity of an official timesheet used to pay employees and bill clients are protected by law that puts both employees and management on notice that violators are subject to criminal penalties for falsifying timesheet records. A managerial accounting tool such as a system to record CoQ data is meant solely to advise management and is thus not subject to the same legal protections.

Together, these realities suggest a reason for concern about the integrity of CoQ data collected when constructed in a fashion similar to timesheets.

1.6. RESEARCH PROBLEM

Engineering firms have, on balance, kept pace–and even pioneered–advances in technology. In the area of quality management, engineering firms appear to be satisfied to adhere to old ways.

In her book *Cultural Patterns and Technical Change*, noted ethnographer and anthropologist Margaret Mead (1985) explored attitudes of persons in areas of the world that, from the perspective of industrialized countries, can only be described as poor and squalid. Nevertheless, technical improvements such as superior diet associated with

better health, and modern agricultural techniques resulting in increased farming yields were not shown to enjoy widespread acceptance from these third-world populations:

> "Those failures can be better understood if it is recognized that explanation and logical interpretation alone are often ineffective in changing behavior because their application is blocked by the emotional satisfaction which the individuals achieves through his present mode of life… new knowledge can be put to use only as the old behaviors, beliefs, and attitudes are unlearned and the appropriate new behaviors, beliefs, and attitudes are learned." (Mead, 1985)

For this study, Mead's observation is particularly on point, even though it was made in the context of primitive cultures. Modern quality thinking from well-respected men in the quality community, such as Deming, Juran, and Feigenbaum, made its mark on product and process manufacturing sectors. However, with more than fifty years after Feigenbaum first conceived of the strategy for the manufacturing sector, design engineering firms have not recognized strategies involving costs-of-quality.

1.6.1. Statement of Problem. Given that personally-recorded measurement systems are susceptible to dysfunction, what are the biases involved in collecting cost-of-quality data in design engineering firms? Because there are no studies found that specifically explores the recording or use of cost-of-quality data in design engineering firms, a phenomenological study devoted to exploring engineering project staff's experiences reporting cost-of-quality data best lends itself to this question.

Accounting for CoQ provides a solid managerial foundation that can help design engineering firms focus on preventing poor quality issues by exposing quality-related nonvalue-added activities. The Feigenbaum-style CoQ system is a managerial accounting system designed to infer the cost of an operation as if there were no errors, or fear of making an error. It accomplishes this by measuring the cost of certain non-value-added activities. The success of a Feigenbaum-style CoQ system in a design engineering firm is substantially related to its capacity to reliably measure and collect data.

The examination of design engineering firms in this study implies an understanding of certain key concepts deemed relevant by this researcher. The traditional application of the Feigenbaum CoQ system is product manufacturing. Use of CoQ methods in this setting is least intrusive compared to other business models because:

- Cost accountants in product manufacturing freely use financial sub-accounts to track costs involved in various key aspects of the production flow. This is an adaptable system that the operation imposes top-down in such a way so as to ensure acceptance.

- Factories have established repetitive processes where statistical methods can be applied easily.

By contrast, the practice of engineering and architecture involves the application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems. It differs from product manufacturing in many meaningful ways that frustrate use of tactics that involve CoQ, most notably:

- The principal cost in an engineering firm is the time professionals charge for engineering work and administrative activities that support engineering work. While there is great flexibility to what employees may charge, costs are still collected in only one way: self-reported on personal time sheets.

- In consulting engineering, the project is the principal business delivery system. Statistical methods like statistical process control are difficult to apply within an environment where each engineering project is unique.

1.6.2. Constructs. The study explores support of and barriers to acceptance by staff to the use of a CoQ system. The study accumulates aspects of acceptance or rejection from interviews with staff in an attempt to reveal their rational motives. This involves reliability of recording CoQ by staff. The study uses individual apathy and fear as a manifestation of reliability and will accumulate aspects of reliability from interviews with staff in an attempt to reveal their rational motives. The study will specifically seek motivations related to cognition, apathy, veracity, and fear.

Finally, the study explores support of and barriers to acceptance by project managers and other management to the use of a system to record CoQ data. The study accumulates aspects of acceptance or rejection from interviews with project managers and other management in an attempt to reveal their rational motives.

1.7. PRÉCIS

It has been over a half century since Feigenbaum (1956) conceived of the system in his seminal Harvard Business Review article. The system has made significant inroads in product and process manufacturing firms. It has been used in firms involved in repetitive services, software development, education, and health care. The system of quality costs has been updated, adjusted, improved and transformed. While construction firms have been found to use CoQ as a tool to differentiate defects derived from the work of architects and engineers, engineering and architectural firms have, themselves, ignored this tool to reflect upon their own internal activities and processes.

Engineering firms that adopt a quality improvement program generally expect gains in quality. Firms that adopt a quality cost strategy as an underpinning to a quality improvement program can expect a more optimized effort that provides a visibility into the interplay between good quality and bad quality costs. In the end, keeping score with quality costing shifts management thinking towards reliance on prevention activities. Without it, quality improvement efforts remain one-dimensional, focusing only on the traditional routines that emphasize appraisal activities.

As Bill Smith from Motorola suggested, relying on an inspection process to uncover and remove defective work will always result in a percentage of defects that elude inspection and find their way into the hands of the customer. Only by prevention activity can a firm expect real and lasting reductions in defective work. Considering that design engineering related to construction work has a protected place in the public trust, the stakes could be quite high. The tragic 1981 collapse of the Hyatt Regency skywalk in Kansas City, or the 2010 collapse of the roof on the Faith Church in Fenton demonstrates how serious lapses in quality can affect the public.

2. LITERATURE REVIEW

2.1. INTRODUCTION

Managerial accounting systems of product manufacturing firms make it relatively easy to collect quality costs. This is due, in part, to processes that are relatively stable and repeatable. Unfortunately, collection and use of quality costs within design engineering firms is not nearly as simple. The managerial accountant deals primarily with financial reports, usually confidential, prepared for the exclusive use of a firm's management. These reports are ordinarily unremarkable in their design but utilize data from the firm's internal operations and assist management decision-making. Costs-of-quality is one such managerial accounting. The engineering business model has not been historically successful, or even willing, in the collection and use of cost of quality (CoQ) data in this type of managerial accounting that has been used for years in other business models, particularly product manufacturing. There has been no scholarly work found that defends, rejects, or even explains the collection or use of CoQ within engineering firms. This research used three principle methods to obtain access to scholarly work: web searches using the Google and Summons Metasearch search engines, and snowball searches using references from technical literature obtained from the web searches.

2.2. EARLY DISCUSSIONS OF QUALITY COSTS

The study of quality management in general and CoQ in particular has historically focused on product manufacturing. The American Society for Quality Control (ASQC) released an article in the 1949 Purchasing Journal that attempted to promote the ASQC and state-of-the-art quality management practices to the nation's manufacturers. In his article, "The Gold Mine in Quality," C.W. Kennedy, the Chairman of the ASQC's Publicity Committee, discussed modern practices of the day, such as in-process inspections, sampling, and control charting. A precursor to future study of quality cost, Kennedy's article framed quality techniques as opportunities for cost reduction and revenue enhancing opportunities, such as increased sales, and reduced scrap and reworks that also tended to diminish need for inspection and testing personnel.

In 1951, the first edition of the *Quality Control Handbook* discussed quality costs and the economics of quality. Juran explained quality costs as all necessary activities to attain merchantability or, in terms of Juran's definition of quality: "fitness for use." Juran described tangible costs, which could include inspections, testing, and losses caused by errors. He went one step further by adding intangible costs, or rather costs that were difficult to evaluate; these might include opportunity costs such as damaged reputation or loss of business. Still, Juran's treatment of CoQ in the *Quality Control Handbook* was a solid perspective of quality activities associated with manufacturing firms, but it did not include an overall strategy to use these costs to manage quality.

Lesser (1954) of the General Electric Company in Schenectady, New York described a strategy for justifying quality management activities in a manufacturing budget environment where dollars could be scarce and cost centers would have had to demonstrate their contribution to the company's bottom line. Lesser examined four major cost categories: direct materials, direct labor, overhead, and engineering; he conceded that many cost items are customarily in full view, but some may be hidden from view, or at least not immediately recognizable. Scrap and rework would be examples of common and visible costs; not-so-visible quality costs included production and shipping delays due to defective work, unnecessary material and manufacturing operations caused by weak product and process design. Lesser recognized that management would not find snapshots of these cost useful; he proposed, instead, the use of trending to frame cost data that could more easily demonstrate effectiveness of quality activities.

The ebb and flow of activity among internal processes within a firm complicated certain correlations needed to correctly evaluate trending analyses. To neutralize this effect, Lesser (1954) discussed the use of an appropriate base, such as net sales or direct materials, to normalize quality costs. In this way, the value of scrap and rework trend data normally obscured by common business ups and downs may be enhanced. Nearly a half-century later, Campanella (1999) identified this type of correlation as still part of developing a cost-of-quality program:

> "The next step is to find the appropriate measure of business activity
> (bases) to which to relate the data. The quality manager selects a sales

base – net sales billed; a cost base – cost of units shipped; and a labor base – factory hours."

Lesser categorized quality costs by where he found them: direct labor, direct materials, overhead, and engineering. Still, his fundamental motive did not appear to be overall higher quality or even overall lower cost, but merely the survival of quality management's budget among other functional departments.

Instead of being the responsibility of a single department, Feigenbaum (1956) proposed a new paradigm of quality as a concept that encompassed every stage of the industrial cycle. According to Feigenbaum, the most widely accepted quality control approach of the day consisted of traditional factory inspections intended to protect the customer by screening out bad product before shipment, called the "modern inspection view." While statistical sampling methods made this activity more efficient and infused more intelligence into industrial decision-making, Feigenbaum asserted that the narrow scope of the modern inspection view appreciated only a small portion of the overall quality problems facing American manufacturing. Instead, Feigenbaum described a "breadth of scope" that began with the product design and ended "only when the product has been placed in the hands of the customer who remains satisfied." Feigenbaum's (1956) breadth of scope incorporated a seven stage of an industrial cycle, whereby each stage played a role in the level of quality of the product. See Table 2.1.

Table 2.1 – Feigenbaum's Seven Stage Industrial Cycle

	Stage	Description
1	Marketing	contributes to product quality by evaluating customer quality expectations and matching them with the firm's product offering
2	Engineering	converts the evaluation from marketing to a precise set of product specifications
3	Purchasing	identifies reliable sources of quality materials
4	Manufacturing Engineering	selects appropriate mix of factory machinery and labor for production
5	Manufacturing Supervision	wields enormous quality influence in designing and enforcing work systems to fabricate and assemble quality products
6	Mechanical Inspection	plays the traditional role of checking conformance to specification
7	Shipping	a large part in meeting customer expectations with timely delivery and convenient packaging

Feigenbaum's (1956) principle of Total Quality Control operates by controlling design, incoming materials, and production, and by analyzing factory and process problems. This operation is a quality cycle that starts with quality control engineering to frame the quality system, inspection and test to assure conformance with specifications, and a quality analysis function to provide rapid feedback to quality control engineering.

2.3. FEIGENBAUM'S COST OF QUALITY

Within the system that Feigenbaum outlines in his article "Total Quality Control," Feigenbaum devised a cost-of-quality model that differentiated it from quality costs described in earlier scholarly work. Unlike previous discussions that defined quality costs as information of limited interest, the Feigenbaum model incorporated classifications that were made to describe even the nuances of the cost behavior related to quality. His model, incorporating the classifications Prevention, Appraisal, and Failure (PAF) made the Feigenbaum quality cost model a paradigm shift. The PAF model is explained in more detail below.

Working at General Electric at the same time as Feigenbaum, Masser (1957) amplified the Feigenbaum quality cost model by describing four results that could be expected from collection and use of such a system: (1) measurement of overall business quality performance, (2) indication of where quality money is spent, (3) programming of quality improvements, and (4) forecasting of quality budgets. The mix of these results advanced the expectations of quality costs as conceived by Kennedy, Lesser, Juran, or even Feigenbaum's (1951) earlier mention of the costs of quality.

In 1963, the Department of Defense (DoD) released MIL-Q-9858A: *Quality Program Requirements*. This military specification did not disclose anything new about quality costs, but it demonstrated that the DoD had enough confidence in CoQ as a quality management tool that it required its collection and use of all military contractors, regardless of product or service.

By 1967, the American Society of Quality Control (ASQC) established a Quality Cost Committee and published instructional guides *Quality Costs – What and How* (ASQC Quality Cost Committee, 1967), *Guide for Reducing Quality Costs* (ASQC Quality Cost Committee, 1977), and *Guide for Managing Supplier Quality Costs* (ASQC

Quality Cost Committee, 1980). Plunkett and Dale (1987) asserted that these publications should be "compulsory reading for anyone undertaking work on the collection and use of quality-related costs."

2.4. CRITICISMS OF QUALITY COSTS

The Feigenbaum model has had its share of critics. Some have suggested that all activities related to the prevention of failures in quality are merely good management practice and might be indistinguishable from "prevention" as a cost of quality category. Juran, et al. (1974) claimed that appraisal and prevention activities are inevitable and not meaningful in a quality cost analysis. Another related shortcoming can be found in Part 2 of BS 6143: *Guide to the Economics of Quality* which conceded that because of how and where an activity appears in a process, it was sometimes difficult to uniquely categorize an activity into one of the three quality cost categories.

Cox (1979) suggested that cost accountants and accounting departments lacked the time and resources to support new activities that quality costing was likely to require. According to Sandretto (1985), companies have spent hundreds of thousands of dollars for cost systems that were never put into service because of incompatibility with their firm's processes, and that the managers responsible have found themselves unemployed.

A severe criticism of a CoQ system by Porter and Raynor (1992) was the implication that a tradeoff between and among prevention, appraisal, and failure costs advocated an acceptable level of quality beyond which it was cost prohibitive. This concept was not compatible with the Total Quality Management concept of continuous improvement. According to Deming (2002), quality costs diverted focus away from the quest for ever higher levels of quality and productivity. In the forward of his book *Out of Crisis* he disparaged the use of CoQ with an excerpt of a letter from his friend Dr. Yoshikasu Tsuda of Rikkyo University in Tokyo that discussed the relationship between quality and productivity:

> "… In Europe and America, people are now more interested in cost of quality and in systems of quality audit. But in Japan, we are keeping very strong interest to improve quality by use of methods which you started… when we improve quality we also improve productivity..."

Using Dr. Tsuda remarks, Deming criticized Western industry by asserting that they were satisfied to improve quality only to a level where there was no economic benefit to further improvement. Deming's close relationship with Japanese industry and economics might have explained why concepts of quality costs were conspicuously absent from Japanese literature, or at least their English translations.

2.5. THE FEIGENBAUM PAF MODEL

The basic PAF (or Feigenbaum) model (See Figure 2.1) was so named because of its three principal component costs:

- Prevention – costs of activities specifically designed to prevent poor quality from occurring in the first place.
- Appraisal – costs of measuring, evaluating, and auditing activities designed to reveal nonconformance to quality standards or performance requirements.
- Failure – resulting costs from products and services not conforming to quality standards or performance requirements, including activities to correct defective products or services or other losses associated with poor quality.

Figure 2.1 – Feigenbaum Cost-of-Quality Model

The model's value, however, is in the interplay between these elements. Increased appraisal (audits, inspections, reviews…) reduce failure costs. Increased prevention (quality design, quality planning…) reduce both failure and appraisal.

2.6. VARATIONS ON THE PAF MODEL

Over the years, the Feigenbaum model had been examined for application on different business models and new quality cost metrics and parameters have been developed. While the fundamental structure remained the same, several CoQ models have emerged to address other business models. Still, all models since Feigenbaum shared the same basic principle:

> "…represent the difference between the actual cost of a product or service and what the reduced cost would be if there was no possibility of substandard service, failure of products, or defects in their manufacture." (Campanella, 1999)

While there have been literally dozens of variations (Schiffauerova and Thomson, 2006) most models can fit loosely into one of three CoQ paradigms: (1) the PAF Model, (2) Process Cost Model, and (3) The Quality-Loss Model.

Freeman (1960) subdivided failure costs into internal and external failure. (See Figure 2.2)

- External Failure addressed losses due to poor quality incurred at some stage in the product's cycle after the product or service found its way out of the factory into the hands of the customer.

- Internal Failure addressed losses due to poor quality incurred at some stage in the product's cycle before the product or service found its way out of the factory.

Figure 2.2 – Freeman Variant to the Feigenbaum Cost-of-Quality Model

This was an innovative enhancement to the PAF system because it focused attention on quality as seen by the customer. The modification also demonstrated the special capability of CoQ organized like the Feigenbaum PAF model to perform as an effective cost control framework, and opened the door to other CoQ models.

Armed with these enhancements, Feigenbaum (1961) formalized his model in with his general textbook *Total Quality Control* which was the successor to his earlier textbook *Quality Control: Principles, Practices, and Administration.* (Feigenbaum, 1951) In the 1961 edition, Feigenbaum began to contemplate other business models besides product manufacturing.

The PAF model was the most widely recognized and universally accepted taxonomy for classifying quality costs. (Plunkett and Dale, 1987) The appeal among users was the behavior among its cost categories, and variations on the PAF theme attracted widespread interest.

In the 3rd edition of the *Quality Control Handbook*, Juran and Gryna (1974) described the relationship between appraisal and failure by suggesting an economic level of quality that is less than 100 percent conformance. By the 4th edition, Juran and Gryna (1988) called this relationship the "classic view" and presented an amended graph with prevention, appraisal and failure costs that placed the economic level of quality at 100 percent conformance; he called this new graph the "modern view". See Figure 2.3.
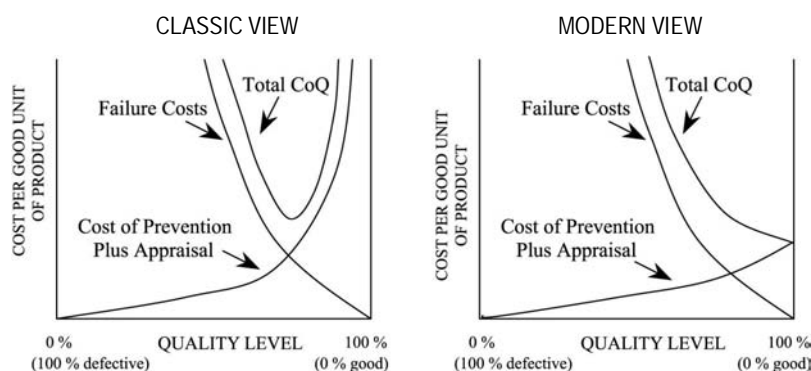
Figure 2.3 – Juran's Classic and Modern View of Quality Costs vs Quality Level
(Reprinted with permission: McGraw-Hill Publishing)

Crosby (1980) popularized quality costs in his bestselling book *Quality is Free* by advancing the concept of "conformance to requirements" as a fundamental definition of quality. Crosby simplified quality costs by combining prevention and appraisal activities into a single grouping that he called the "the cost of conformance," and combined all failure costs into a nemesis category called "the cost of nonconformance" that consisted of the money wasted when work failed to conform to the customer's requirements.

Instead of simplifying the model like Crosby, others extended the model by adding an additional category: cost of lost opportunity, or opportunity costs. External failure quantified customer-related direct losses, such as warranty repair, recalls, or lawsuits; but opportunity costs described a special type of market-related external failure cost which had a direct impact on business performance. (Dale and Plunkett, 1999)

Dale and Plunkett (1999) described a classic opportunity cost as the value of lost profit of a customer who, after experiencing a series of failures, removed his business and gave it to a competitor. Many sources named the cost of lost opportunity as a genuine quality cost. However, there was a conspicuous silence among them regarding actually quantifying the cost of lost opportunity; despite the widespread suspicion that that they could have been quite large. What made computing lost opportunity costs so problematic was that because of "swings and roundabouts of trade, lost opportunity costs derived from a single failure is likely quite small." (Dale and Plunkett, 1999)

While essentially costs of "revenue lost and profits not earned," Sandoval-Chavez (1998) defined lost opportunity more in terms of waste and classified those wastes in one of three categories: "underutilization of installed capacity, inadequate material handling, and poor delivery of service." These three wastes bear striking similarity to Ohno's (2002) "seven wastes" often associated with lean manufacturing.

Freiesleben (2005) defined opportunity cost as the cost of missed opportunity to make and sell all products on time and without error, thus giving up its foregoing profits. Freiesleben described two effects:

- Productivity Perspective – Between two firms with the same installed capacity, the higher quality firm can produce more units because fewer units are lost to poor quality.

- Capacity Perspective – For the same potential sales volume, the capacity of the poor quality firm must be larger in order to produce the same amount of sellable goods as the high quality firm.

This meant not only an increase in the costs of good product, but also a corresponding decrease in sales and the resultant profit, quite likely the most tangible model of opportunity costs.

2.6.1. The Process Cost Model. Part 1 of BS6143: *Guide to the Economics of Quality* described the Process Cost Model (PCM) as process-based, rather than product or activity-based. See Figure 2.4

PCM consists of a cost of conformance (COC), which is the actual process cost of a specified process the first time and to the required standard, and a cost of nonconformance (CONC), which is the cost of failure associated with the specified process not being executed to the required standard. PCM is implemented in four steps:

- (1) Identify all cost elements in a process;
- (2) Classify each of the cost elements as either COC or CONC
- (3) Price the elements
- (4) Continuously compare COC and CONC and seek ways to reduce CONC
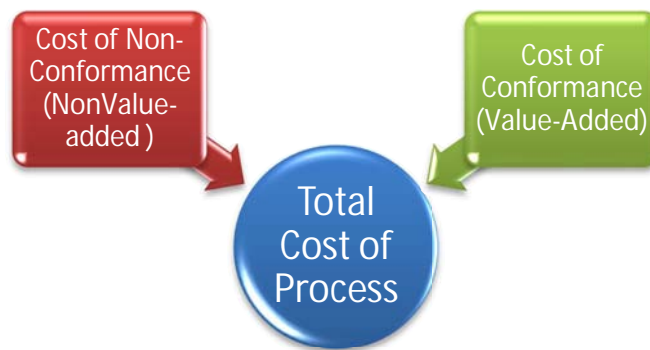
Figure 2.4 – The Process Cost Model

Identifying all elements in a process for PCM is a sizeable procedure involving process flowcharts prepared with the help of the process owners… cutting across multiple activities. Another key characteristic of PCM differentiating it from the PAF model is its major element COC contains only value-added labor and materials; PAF elements contain no value-added activities. What makes PCM similar to the PAF model is its two major components, COC and CONC, work best when they are analyzed together.

The first evidence of PCM used for quality costing was by Marsh (1989) in a case study of a software manufacturing firm. In Marsh's case study, Total Quality Management (TQM) was the quality improvement model. In their survey of CoQ methods, Schiffauerova and Thomson (2006) acknowledged that the use of PCM was far less common than the PAF model but still suggested that PCM was "the preferred method of quality costing within TQM" because of its unique measurement scheme that allowed assignment (and ownership) of CoQ to a process, rather than to an activity or product.

2.6.2. The Quality Loss Model. The PAF model and PCM are both backward-looking tools. They both collect, organize and analyze historical data with an ultimate goal of an historical snapshot. A method of quality costing that is more predictive or forward-looking is the quality loss model (QLM).

The QLM attempts to estimate all losses, tangible and intangible, internal and external. (Campanella, 1999) The QLM, which is most closely associated with Taguchi's (1987) System of Quality Engineering, converts a particular level of variation and estimated losses with the use of Taguchi's parabolic quality loss function (QLF). Taguchi claims the model estimates the total losses to society due to poor quality.

The suitability of the QLF is proportional to the skill of the practitioner in framing the underlying process, product, or service in statistical terms. This suggests that processes with a mix of activities that were predominantly non-repetitive are not particularly suited for the QLM. Still, with the help of a modified design of experiments analysis, the QLF has substantial value in fine tuning product parameters and design of process parameters. (Taguchi, 1987) A more recent modification to the QLF is the warranty loss function. Where the QLF predicts losses due to the quality deviation of a single unit of output, the warranty loss function predicts losses due to the entire statistical population's output expressed in standard deviation and skew. (Ragsdell, 2005)

2.7. COSTS OF QUALITY IN OTHER BUSINESS SECTORS

Most available CoQ literature focused on product manufacturing. However, there have been quite a few sources that discuss CoQ within the context of other business sectors. While no literature was found to concentrate on engineering firms, two business sectors: (1) construction and (2) software development were examined closely.

2.7.1. Construction Sector. Engineering firms are inextricably linked to the construction sector. In most U.S. jurisdictions, all but the simplest construction activity requires architectural and engineering work. As a regulatory requirement, designs that serve construction must be prepared by an architect or engineer that is registered by the state in order to safeguard the public.

Knocke (1992) identified liability risks that arise from the designer of the construction project. Knocke described construction defects as a physical manifestation of errors or omissions, so a design error or omission affecting the initial conception of a construction project made engineer's drawings and specifications the 'carrier' of the defect.

The Construction Industry Institute (CII), an affiliation of the University of Texas, developed a management tool called "Quality Performance Management System" (QPMS) that contained a very good starter list of quality deviations in construction for the purpose of collecting CoQ. The system developed by the CII recognized 15 quality management activities, 11 causes of rework, and four phases of construction. (Burati, 1989; Ledbetter, 1989) Davis, et al. (1989) modified the QPMS from the CII with a coding system made to be more compatible with the construction project's work breakdown structure.

Abdul-Rahman (1996) discussed the use of the PAF model in construction, listing design-related errors as one the major sources of errors. In a construction case study, Abdul-Rahman (1995) identified design-related error as third most costly, behind construction-related and subcontractor-related errors. Abdul-Rahman (1997) also observed that many errors did not affect construction costs, but were found by the owner after the construction project was complete. Low and Yeo (1998) suggested that construction quality cost models advocated by Abdul-Rahman and Davis were not compatible with the European quality system ISO 9000.

Construction quality cost systems by Davis, Abdul-Rahman, and Low were based on the PAF model. Aoieong, et al. (2002) wrote that the PAF model was not compatible with TQM, and could not be used on a limited basis, asserting that the PAF model became incredibly skewed unless all quality activities were included. As an alternative to the PAF model, Aoieong proposed PCM modified for use with construction activities. The advantage of the PCM, according to Aoieong, was that it could be effectively used on small projects segments without corrupting the results. In addition, the PCM had been considered more compatible with TQM.

Love, et al. (1999) and Love and Li (2000) used several construction project case studies to investigate causal factors behind construction rework. Among other factors, their results pointed to a lack of quality focus by design consultants. They advocated a dynamic quality model that uses quality costs as a backdrop that they claimed shifted the paradigm to a "holistic viewpoint."

The treatment of engineering and architecture in literature on quality costs in the construction sector is interesting. Some literature on construction CoQ systems portends traceability of error back to engineering design. In such a system, however, there is no burning incentive to search for the cause of design errors because the engineering design process is not normally an integral part of the construction firm. As such, engineering design firms may not substantially benefit from the intelligence from such a system, except as what might resemble customer feedback; this is especially true of design-bid-build construction projects, where the design firm acts as the Owner's advocate, and there is a somewhat adversarial relationship between the design firm and the construction firm. Even in design-build arrangements, where no such owner advocacy is implied, design firms and construction firms are ordinarily connected only by service contract, partnering agreement, or joint venture, making effective exchange of quality cost data difficult.

While the business relationship to construction firms is close, design firms do not substantially share work processes, work flows, skill sets, or inputs and outputs. Would it be logical that a design firm attain quality awareness more effectively with a CoQ system of its own, rather than to depend solely upon incidental downstream intelligence that it might obtain construction firms?

2.7.2. Professional Sector – Software Development. The dynamic of an engineering firm is peculiar among other business models. Certainly different than product and process manufacturing, the engineering firm model also shares little with construction and highly repeatable services such as shipyards, departments of motor vehicles, or passenger airlines. Instead, engineering firms may share more with non-repeating service firms like law offices and software developers. In their text *Principles of Quality Costs: Principles, Implementation and Use* (Campanella, 1999), the ASQ identified the differences that make software development unique when compared to the manufacturing sector. See Table 2.2.

Table 2.2 – ASQ: Software Sector vs Manufacturing Sector

	Key Differences
1	Software is an intellectual, rather than a physical product, so its development is subject to human and logical constraints, rather than physical laws.
2	One cannot assume that a software specification is stable. Changing requirements is expected behavior in software development.
3	Productivity levels vary widely; more so in individuals than in teams[2].
4	Product defects are results of human misunderstanding and mistakes, not deficient materials.
5	Manufactured goods are valued for their features, but software is also valued for its interactive functionality.
6	The economics of software quality hinges on the process of understanding requirements.
7	The process of understanding requirements, more so than conformance, is commonly responsible for the value of a software product.
8	Statistics cannot be applied to replication, because software products are usually one of a kind.

Replace "software" with "engineering" or "architecture" wherever it appears in Table 2.2 and it is entirely plausible that experienced engineering practitioners would associate these characteristics with their own processes. While each of these

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[2] Variation of productivity is an assertion of the ASQ; comparison of variation between teams and individuals is a postulate by this researcher.

characteristics was written specifically to describe the economics of software development, they bear an uncanny resemblance to an engineering design process.

Jones (1986) conceived of an eight-variable approach to collecting data on software defects. While these variables did not substantially match those described by Ledbetter (1989) for the CII, they implied that success of a CoQ system was substantially related to tailoring of design of data-collection to the particular industry.

Knox (1993) extrapolated data from CoQ models in manufacturing and service industries and applied it to the business of software development. The PAF model was used to describe the cost of software quality (CoSQ) at each of five stages of the Software Engineering Institute (SEI) capability maturity model (CMM) for software "ranging from the chaotic, ad-hoc development environment to the fully-matured and continually-optimizing production-line environment." Knox asserted that software development had process capability analogous to product manufacturing, but was measurable only by special assessments, not continuous monitoring. The model demonstrated that resulting quality costs would diminish as an organization achieved higher levels of maturity. Knox estimated that at CMM level one, some combination of the four PAF CoSQ categories would consume 60 percent of every sales dollar, but only 22 percent of every sales dollar at CMM level five. See Figure 2.5.
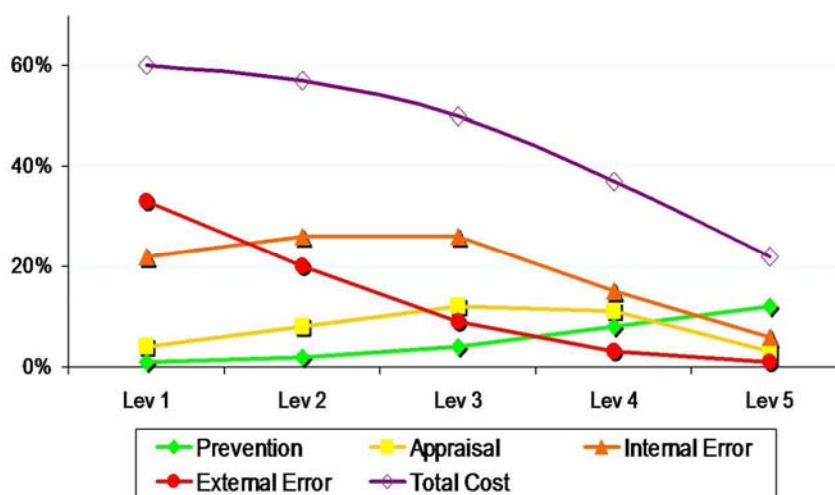
Figure 2.5 – Knox Estimates of Software Quality Costs at Different Quality Levels

The magnitude of CoSQ described by Knox's model is dramatically higher than on even the most pessimistic manufacturing models examined to date. Even Crosby (1980) noted only 25 percent at the lowest level of quality maturity.

Raytheon Electronic Systems (RES) validated the Knox CoSQ model in a quality improvement program where they used the PAF model as a means of measuring progress across 15 projects. Haley (1996) reported that in 1988, RES was at level one, based upon a SEI CMM self-assessment, and had corresponding quality costs tracking at approximately 60 percent of sales. By 1994, RES had surpassed CMM level 4 and had reported a productivity increase of 190 percent.

Houston and Keats (1998) examined the work of Haley and Knox more closely and recognized one benefit from Knox – "justification for quality initiatives" – and added six more benefits (below) that engineering firms might find attractive, except for motivational aspects (discussed in Subsection 2.8) which firms may possibly find to be harmful to the process of collecting CoQ:

- Cost data for motivational purposes
- Basis for budgeting quality activities
- Compare process improvements and identify the most cost effective
- Comparing the success of projects
- Identify quality improvement candidates
- Reduce quality costs by altering the process in a particular project.

2.8. ISSUES RELATED TO SELF-REPORTING DATA

According to Austin (1996), workers are motivated in three ways: (1) workers like being paid, (2) workers dislike work, and (3) workers like making customers happy. With the use of an effective supervision or other performance measurement system, the first motivator (greed) can be used to overcome the second (sloth/apathy). In some cases, if a combination of job factors and the character of the individual worker are compatible, an employer need only depend on the third motivator. In actual practice, employers use some combination of all three.

However, in an environment that relies on self-reporting measurements, Austin (1996) believes workers who perceive that coworkers are exploiting the system of self-

measurement face a dilemma: risk the perception of being low-performing as compared to less honest coworkers, or exploit the system themselves and benefit by appearing to be high- performing as compared to more honest coworkers. A rather large aspect of self-reported CoQ data is not verifiable by other means, so individual's attitudes towards honesty in self-reported CoQ are key concepts. Even if the employee's internal conflict is not as clear cut as the honesty equation described by Austin, there may be a less obvious conflict. Cronbach (1970) summarized the problem as follows:

> "The crucial problem with self-report, if it is to be interpreted as a picture of typical behavior, is honesty... Even when [the respondent] tries to be truthful we cannot expect him to be detached and impartial. His report about himself is certain to be distorted to some degree."

A cost-of-quality system is not immediately intuitive to the ordinary employee and it is reasonable that employees may not instantly understand measurement system rules. Therefore, cognition, or an employee's ability to know the measurement system's rules and apply them correctly is a key concept. According to Crocket, et al. (1987) if extreme precision is required, self-reported data should be considered only if other more objective measurements are not available.

Pace, et al. (1985) provided an interesting examination of a variety of factors that may affect the accuracy of student self-report. Pace concluded their report with this statement: "the quality of questionnaire answers (reliability, validity, credibility) depends most of all on the quality of the questions." Students report data more accurately when asked questions that are clearly worded and unambiguous, and that request information that is generally known by the students. Respondent's ability to function under the measurement system depends on their understanding of the system.

Albeit not firsthand, most workers have been exposed to many different sanctions by management: verbal reprimands, missed promotions, assignments of undesirable tasks, demotions, suspensions, and even discharge. Even high-performing employees who would normally not fear management sanctions at least intellectually understand that an employee that underperforms would be subject to a particular sanction. March and Simon (1958) observe that workers in real organizations are notoriously skeptical about management claims that reported measurements do not affect future sanctions or rewards.

They know that the rate at which widgets are produced matters; that all else being equal, faster production is better than slower production and less error is better than more error. Workers expect, then, that rewards will follow faster and more accurate work, and conversely, performance that is slower and less accurate will be met with unpleasant consequences. Fear of poor performance, or rather self-reporting poor performance is therefore a key concept to consider.

Austin (1996) theorized that the reliability of self-measurement is diminished by motivational factors, regardless of whether positive or negative. This researcher found Abdul-Rahman (1997) as the only source that contemplated discrepancies of quality cost measurement due to an aversion to self-reporting errors.

Integrity of a measurement system relies on a delicate balance of incentives and verification methods. An imbalance of incentive and verification results in "dysfunction" that manifests itself by poor performance, misplaced priorities, or even dishonest measurements. Within discussion of dysfunction associated with self-measurement, Austin (1996) describes "purely informational measurement" as a measurement system that is completely decoupled from personal motivation. In this paradigm, ordinary incentives and verification methods are not required because the nature of the measurement is effectively free of motivational factors. This supposition by Austin plays a substantial role in the CoQ measurement system used in this study.

2.9. CONCLUSION

There is a profusion of quality cost scholarly writing in product and process manufacturing, as well as significant inquiry into CoQ within other business models. Still, writings that relate cost of quality models to the engineering firm model are sparse; at best, nibbling around the edges. No literature on the subject of quality costs has been found that target engineering firms.

With no scholarly writings available that defend, dispute, or even explain the collection or use of CoQ data within an engineering firm, this work lays the groundwork for a serious inquiry. While firms of every type manage quality in some way, engineering firms have not been historically successful, or even willing to collect and exploit quality costs; with this work, that may begin to change.

3. RESEARCH MODEL AND METHODOLOGY

3.1. THE RESEARCH ENVIRONMENT

In order to develop concepts that relate to design engineering firms, this research studied portion of the staff and management of a worldwide engineering and architectural firm (hereinafter referred to as "the Firm"). The Firm is principally an infrastructure engineering firm[3] that performs engineering architecture and engineering design, construction administration, and program management. It employs 14,000 people worldwide, and maintains offices worldwide on six continents and has been in continuous operation for the last 125 years.

The participants of this research include a small sample of staff and management employed by the Firm at one of their local offices located in the Midwest United States. The local office has a diverse mix of administration, professionals and sub-professionals, including transportation and other civil engineering specialties; structural, mechanical, electrical, plumbing, and fire protection engineering specialties; architects, landscape architects, interior designers, and construction administrators.

3.2. THE RESEARCHER'S ROLE

The researcher is employed full-time by the Firm as a supervising engineer at its local office and works closely with the individuals that participated in the study. According to Trochim (2001), one common method for collecting qualitative data is participant observation. While some methodologies involve observers that remain detached from the culture under study, a participant observer immerses in the culture as a member of the group under study. (Denzin, et al., 2005) It is arguable that, as a member of the group, the researcher's objectivity is impaired. However, it is also arguable that conforming to the culture as a member of the research study group imparts insight into the culture's practices and motivations.

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[3] Infrastructure Engineering Firms focus on horizontal construction projects, such as roadways, tunnels, and bridges; light rail and heavy rail transportation; airports, harbors, and other transportation centers, plus other systems such as power systems, e.g. coal, nuclear, hydroelectric, and wind power plants. Vertical construction – buildings – is ordinarily a peripheral specialty within infrastructure firms.

3.3. THE QUALITATIVE PARADIGM

The deductive approach is "top-down" paradigm that begins with a theory and leads ultimately to affirmation or rejection. (Trochim, 2001) It follows a familiar pattern in research where a testable hypothesis is selected from a well-established theory and, through statistically-sound observation, is either confirmed or disproved. See Figure 3.1.

theory → hypothesis → observation → confirmation
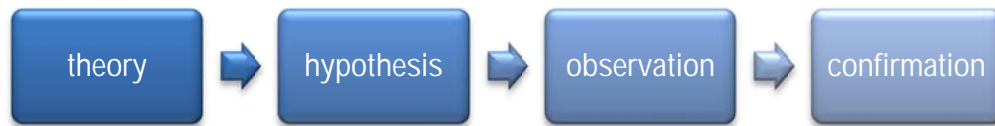
Figure 3.1 – Deductive Research Approach

Statistical models that count, order, and classify lend themselves well to the quantitative methodology and are easily integrated in the deductive approach. With no testable hypothesis from which to proceed, the approach cannot be applied. Alternatively, the inductive paradigm is a "bottom-up" approach that begins with observations, sifts out concepts and assembles patterns, revealing hypotheses, and finally concludes with general theories. See Figure 3.2. It would not be illogical, in fact, to link the two approaches end-to-end into a continuous cycle for a progression of continuing research. (Trochim, 2001)

observation → patterns → tentative hypothesis → theory

Figure 3.2 – Inductive Research Approach

As the literature search in Section 2 suggests, there is little scholarly writing on quality costing related to engineering work within the construction sector and none for

engineering firms as an independent business. With no available scholarly speculation on the human and professional behaviors associated with the use of quality costs, this study has chosen an inductive approach within a qualitative study.

3.4. RESEARCH MODEL

In order to develop credible hypotheses that explain the motivations of engineering firm staff and management regarding the collection and use of CoQ, this study has made use of a phenomenology approach (discussed later in this section). While the firm under study had rudimentary components of a quality management system, personnel had no background in quality costs, nor had they been exposed to CoQ in the course of association with clients, contractors, or other firms. Without an understanding of the subject, examination of staff and management motivations would not have yielded meaningful results regardless of the qualitative approach. In a study about daydreaming, Morely (1998) asked study participants to write about their experience before then examining their experience in more depth during an interview. Morely's rationale for this approach to sensitize participants so as to maximize the "depth of description" during the participant interviews. In order to sensitize participants for interviews in this study, a sensitizing (or awareness) exercise was devised to provide individuals with a minimum level of knowledge and experience so that they might participate more confidently in subsequent inquiry. See the research model in Figure 3.3.

3.4.1. The Awareness Exercise. For management and staff likely to participate in personal interviews, an awareness exercise was devised to impart specific knowledge of the purpose and use of quality costs so that they could recognize and record their own quality costs while performing their ordinary project duties. By way of preparation, the group submitted to an *orientation* consisting of a brief discussion of quality management and a more detailed discussion on the purpose and use of CoQ. At that time, personnel were given a *color guide* containing detailed explanations of the CoQ activities relevant to their own project activities, and were briefed on use of a *recording tool* consisting of a convenient computer application to record CoQ data.
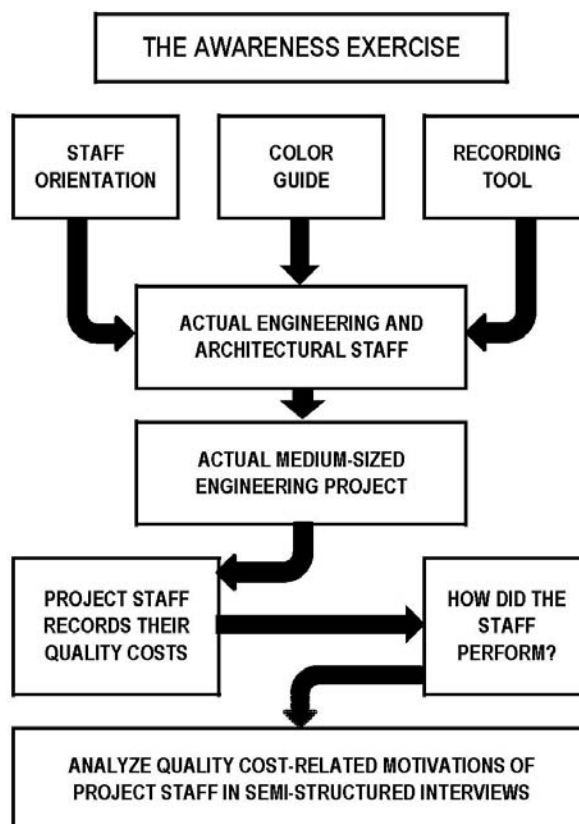
Figure 3.3 – Research Model

The project staff consisted of mechanical, electrical, plumbing, and structural engineers, architects, and landscape architects, designers, and drafters. The exercise used a medium-sized project consisting of a contract to provide E/A services.[4] The client was a local school district (the "District") that required design support from outside consultants for an annual maintenance and renovation program consisting of twelve individual jobs (schools) and contained various technical tasks, such as mechanical system upgrades, roof replacements, and lighting upgrades, and associated electrical modifications.

The District's construction schedules had to accommodate the school year calendar and not interfere with the ordinary classroom activity, consequently, the

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[4] According to Table 1 in the Firm's "Policies and Guidelines for Forms and Checklists," medium-sized projects are defined as having a fee between $250K and $3M. (Parsons-Brinckerhoff, 2001)

project's 14-month master schedule for this year overlapped the school district's master schedules for the previous and following year's annual maintenance and renovation programs. The individual school jobs were staggered across the project's master schedule such that work associated with some of the project work fell outside of the schedule limits of the exercise.

3.4.1.1 Participant orientation. At the launch, the staff of the exercise project attended a 90-minute orientation presenting Feigenbaum CoQ concepts and related quality management concepts. The orientation was crafted to promote the awareness of the Feigenbaum model so as to increase compliance during the exercise when no daily external reminders would be provided. The orientation also outlined elementary features of the exercise, including how staff would record CoQ data and other ground rules. Supervisors and managers not necessarily associated with the project attended as well. Project staff participating in the exercise were given (1) a color guide (See Paragraph 3.2.1.2) that described the CoQ activity recording process, (2) exercise ground rules, and (3) descriptions of 47 CoQ activities against which participants would be logging time. Before data recording commenced, participants were offered a 60-minute tutorial to review the color guide and to answer any questions about the exercise.

3.4.1.2 Color guide. Officially titled "Quality Cost Reporting Project/Meeting Handout," this 21-page booklet was devised and created by this researcher and distributed to the staff participating in the awareness exercise project as a guide to recognizing CoQ activities while performing project duties. See Appendix A. Activities were modeled after CoQ activities found in product manufacturing, then tailored to the engineering firm business model. The color guide contained a basic definition of CoQ and its broad categories, and complete descriptions of individual CoQ activities.

Many of the 47 CoQ activities used in the study were borrowed from manufacturing CoQ models and modified slightly to serve a consulting engineering environment. Individual engineering firm activities not covered by synthesizing existing manufacturing CoQ activities were identified by this researcher and classified under one of the four established Feigenbaum categories (prevention, appraisal, internal, and external error). See Figure 3.4 for the complete list of all 47 CoQ activities.

EXTERNAL ERROR COSTS	APPRAISAL COSTS	PREVENTION COSTS
RFI Redesign from External Error Rework from External Error Post-Delivery External Design Review Post-Delivery Complaints Other Direct External Error Rechecking from External Error Other Indirect External Error	Internal Plan Checking Internal Design Review Customer Design Review Coordination Review Shop Drawing Review Cost Estimates Other Direct Appraisal Costs Evaluate Subcontractors Post Mortem Project Quality Audit Performance Appraisals Time Card/Expense Report Review Other Appraisal Costs	Programming Review Lessons Learned Drafting Planning Design Planning Coordination Planning Scheduling Contract Review Other Prevention Activities

INTERNAL ERROR COSTS		INVESTMENT COSTS
Redesign from Internal Error Rework from Internal Error Waiting Due to Coordination Other Direct Internal Error Rechecking from Internal Error Subcontractor Corrective Action Computer/Copier Problems Correct Time Sheet/Expense Reports Other Indirect Internal Error	47 CoQ Activities	Quality System Standards CADD Standards Technical Standards CADD Training Quality Training Technical Training Education Quality Improvement Costs Other Investment Costs

Figure 3.4 – CoQ Activities Used by Participants during the Awareness Exercise

A fifth category was conceived to differentiate prevention activities that would not normally be paid from the project budget, but from the Firm's overhead budget. For instance, costs related for design planning activities would reasonably be assigned to a project budget. Activities related to the development of technical standards would likely benefit many projects; it would therefore not be equitable for a single project to bear such cost, which could be disproportionately large when compared to the project budget. Both would be considered prevention activities, but the latter could not ultimately be compared to project costs. In this study, prevention activities that were not project-related were categorized as "investment."

The booklet became known as the "color guide" because each CoQ activity was described in detail and color-coded: *external error* (pink), *internal error* (orange), *appraisal* (yellow), *prevention* (green), and *investment* (blue). The color guide had an explanation key (see Page 3 of Appendix A) to assist study participants in reading the description of each activity.

3.4.1.3 Data recording tool. As a way of logging CoQ data, participants were provided with a computer-based recording tool. The recording tool was a network-based relational database application that matched each participant data entry with his/her personal data. The application appeared to each study participant as a pop-up on their computer desktop. The tool created a record with information about the participant's CoQ activity each time the participant logged time. See Table 3.1, below.

Table 3.1 – Information Entered on Recording Tool by Participant

Recording Tool
PARTICIPANT ENTERS MANUALLY
The CoQ broad category
The CoQ activity selected by the participant
The duration of the activity entered by the participant
An indication as to whether the activity included direct expenses, and the dollar amount of those expenses.
SYSTEM TAGS AUTOMATICALLY
The identity of the person recording the CoQ,
The date and time
The dollar value of the activity calculated by multiplying the time duration entered by the participant by the participant's hourly rate.

Although the exercise included only one project, the recording tool was designed to permit the participant to record CoQ data against many different projects. The breadth of the data was sufficient to study behavior of CoQ or to study the behavior of the participant. Participants were briefed on the use of the recording tool was discussed at the exercise orientation; in addition, the color guide provided the participant with an explanation key to assist them in navigating and using the pop-up of the computer-based CoQ recording tool. See pages 4 and 5 in Appendix A for the data recording pop-up explanation key.

3.5. PHENOMENOLOGY

This study involves qualitative research using the phenomenology approach. Per Moustakas (1994), phenomenology is the search for the central and underlying meaning,

or "essence," of the conscious experience of a group related to a phenomenon by determining essential properties and structures of the conscious experience through systematic reflection. The challenge of phenomenology is to describe things as they are, using open observation that is unfettered by prejudgments or presupposition, and to understand meanings and essences using intuition and self-reflection.

Phenomenological research acquires comprehensive descriptions by examining the experiences of persons who "lived" them. (Goulding, 2005) By analyzing these descriptions the essences of the experience can be discovered. These descriptions are acquired as original data through open-ended questions and dialogue. Upon reflection and interpretation of the study participant's responses, a researcher assembles common themes and ultimately captures the essence of the phenomenon.

According to Thompson (1997), the interpretation process must naturally incorporate a broader perspective than just participant interviews for the researcher to arrive at a holistic interpretation. The ultimate explanation will represent a synthesis of the participant interviews and the researcher's frame of reference.

By relying on in-depth interviews and not sophisticated equipment or multi-person team for data collection and analysis, Denscombe (2007) identifies phenomenology as particularly suited for low-budget research where the researcher is the only resource. The process of interviewing of persons that have experienced the phenomenon under study is central to the phenomenology approach.

Phenomenology began with extensive writings of Edmund Husserl, a German mathematician. Husserl's method involved the suspension of judgment while relying on the intuitive grasp of knowledge, free of presuppositions and intellectualizing. Husserl (1970) characterized phenomenology as a method of philosophical inquiry using reflective attentiveness to reveal a person's "lived experience." This methodology relies on a theory of consciousness that Husserl's called "intentionality." Intentionality is known as the "cardinal principle of phenomenology" and originated with German philosopher Franz Brentano. Perhaps an oversimplification, intentionality attempts to recognize reality and the individual's perception of reality as separate and distinct concepts.

3.6. DATA COLLECTION

    3.6.1. Data Sources. This researcher uses many data sources with which to evaluate. Sources include direct observations, semi-structured interviews, and non-technical literature, such as written policies and procedures, meeting notes, and memos prepared in the normal course of business.

    Semi-structured interviews were conducted with many of the original participants of the awareness exercise. These participants received orientation on the subject of quality costs and most actually recorded CoQ time in the awareness exercise. Several management personnel in a position to oppose or support the adoption of a quality cost recording program were also interviewed.

    Existing policies and procedures that govern day-to-day operations at the engineering firm are ordinarily prepared by individuals within the firm who have a significant influence over the firm's attitudes and behaviors. As such, study of policies and procedures were identified as being useful in determining institutional impediments to the understanding and use of quality costs.

    Memos and minutes of meetings in the course of training and day-to-day operations were deemed important sources of data where the subject matter or remarks offered in the meeting reflects opinions, behaviors, attitudes, policies, and procedures reflect on quality or possible barriers to implementation of a cost of quality program.

    3.6.2. Sampling. The study targeted a group employed by an engineering firm assigned to staff an actual design project. Staff was selected by the project manager in order to accommodate a particular mix of skill sets. On the one hand, there was a random aspect to the selection of the group as this researcher had no control over the overall staffing of the design project used in the study. However, sampling must be considered purposeful since this researcher selected the firm, the local office, the project, and the time period.

    Purposeful sampling is appropriate method to select individuals for a study using a phenomenology approach. According to Speziale & Carpenter (2007), sample sizes of up to 15 participants are sufficient to provide rich descriptions of the phenomenon. Confining the study participants to persons with particular skills and experiences helps focus inquiry to those with an enhanced understanding of the phenomena in question.

According to Morse (1991), Participants in a purposeful sample should be selected according to the needs of the study. For example, a researcher may seek to interview persons with broad knowledge of subject matter, but later alter the selection criteria to accommodate an evolving need for individuals with more specific knowledge or experience. Using purposive sampling, the researcher selects persons to participate in the study based on their particular knowledge of a phenomenon for the purpose of sharing that knowledge.

3.6.3. Interview Transcripts. Among the proposed guidelines from Hycner (1985) for phenomenology, the researcher must transcribe participant interviews to accommodate subsequent coding analysis.

In this study, participant interviews were conducted in private, recorded and transcribed. Transcriptions were performed by an independent transcriptionist not affiliated with the Firm. Once transcribed, this researcher corrected spelling and other interpretive errors made by the transcriptionist by reading each transcript while listening to its corresponding recording. Corrections were made only by the researcher; interviewees were not permitted to correct, or even review his/her transcript.

3.6.4. Institutional Review Board. As the culture is a working engineering firm, there are realities that cannot be ignored. Participants in the study are called upon to provide frank conversation on potentially uncomfortable subject matter. In recognition of the special risks associated with human subjects in research, Missouri University of Science and Technology maintains an independent Institutional Review Board (IRB) to oversee research involving human subjects. In the United States, IRBs are governed by the U.S. Code of Federal Regulations (CFR) Title 45, Part 46. While this research does not qualify for exemption under the CFR, it has been considered by the IRB to be of minimal risk. Nevertheless, the following safeguards have been put into place to protect study participants who submit to a recorded interview:

- The interviewee signed a written IRB agreement that identified the research, warned the interviewee that remarks were being recorded and transcribed, informed the interviewee that the interview was strictly voluntary and could be terminated at any time, and provided the interviewee with the contact information of the University's IRB office should there have been any misconduct to report.

- The interviewee's verbal affirmations of the same caveats as written on the IRB agreement were included in the recorded interview.

- Voice recordings were transcribed by a third party not affiliated with the engineering firm. Those recordings and transcripts were stored under a coded name. See Appendix D for the transcripts from Group 1 interviews. The key code was kept separate from the voice and transcribed files.

- The interviewee identified him/herself on the recording by name, but such identifying information was redacted from the written transcript. After the research is accepted, the recordings will be destroyed. Only the redacted transcripts will be retained.

- The transcriptionist submitted to a non-disclosure pact and signed a non-disclosure agreement.

As information from all data sources is discovered, memos are prepared in order to make sense of information and support the coding process.

3.7. DATA ANALYSIS

A key exercise of data analysis in qualitative research is the coding process. Per Strauss and Corbin (1990) and Corbin, et al. (1998), this involves breaking down data into discrete parts, closely examined, and compared for similarities and differences. Concepts are then grouped or organized into categories, and the categories are named, based on what seems the most logically related to the data it represents.

It is interesting that Hycner (1985) cautions against use of the term "data analysis" which implies "breaking into parts"; Instead, he favors the term "explication of data" which implies exploration of the components of a whole phenomenon. Colaizzi (1978) proposed a seven-step "explication" process for phenomenology research. See Figure 3.5 for a summary of Colaizzi's data analysis process.

This study also addressed certain quality issues associated with qualitative research. An intercoder agreement exercise was used to demonstrate reliability within the coding process and a member-checking survey of the study participants was devised to demonstrate credibility in the concepts that were developed.
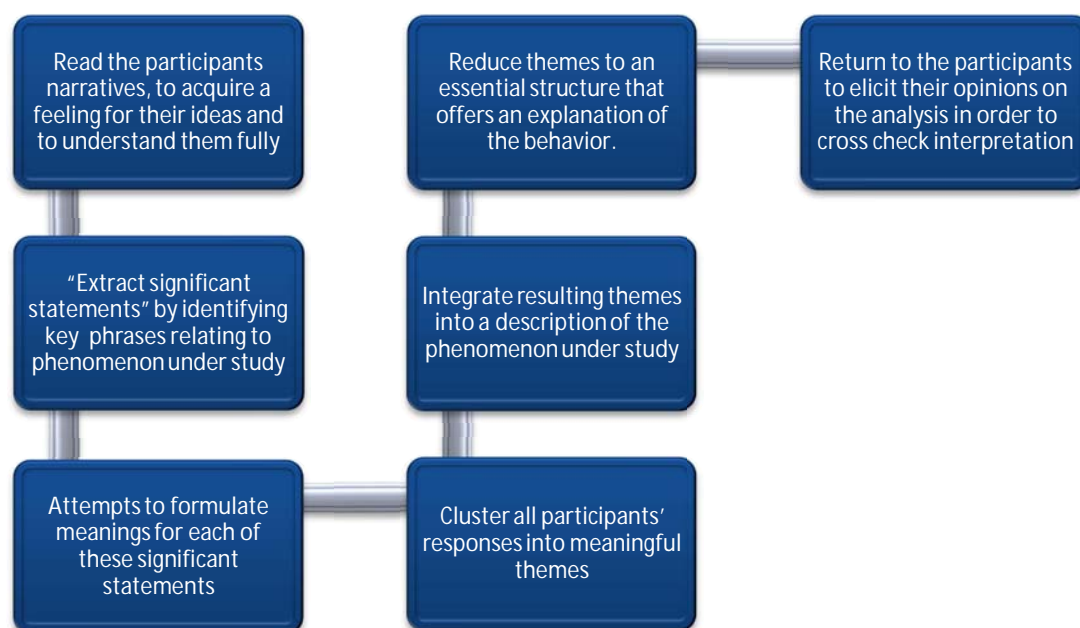
Figure 3.5 – Data Analysis in Phenomenology

3.7.1. Coding. Cresswell (1998) describes phenomenological data analysis as process of reduction involving evaluation of statements and themes by the researcher for all possible meanings. Denzin (1989) recommends a protocol to researchers, beginning with a full description of his/her own experience of the phenomenon. As each statement is treated dispassionately, non-repetitive statements from among significant statements from participant interviews are then cataloged.

With this catalog of statements Denzin (1989) recommends that the researcher develop an overarching description of the essence of the experience of all participants with the help of an objective look at description of the experiences from all possible meanings and divergent perspectives.

In order to focus data collection and analysis, this study makes use of preselected codes: *cognition*, *fear*, *veracity*, *apathy*, and *quality awareness*. While there is an element of conjecture associated with knowing codes in advance of the coding process, there is a basis for applying these codes that is found in literature on measurement systems and biases associated with self-reporting data.

When discussing data that is self-reported by students, Pace, et al. (1985) identifies the student's understanding – or *cognition* – of the system. A system that is understandable to the respondent and free of ambiguities is the determining factor of the quality of the respondent data. According to Crocket, et al. (1987) if extreme precision is required, self-reported data should be considered only if other more objective measurements are unavailable.

Fear of poor performance, or rather self-reporting poor performance is a key concept to consider. In their work on organizational behavior, March and Simon (1958) observed that workers in real organizations are notoriously skeptical – or *fearful* – of management's claims that future reward or punishment are unaffected by measurements reported by workers. Workers understandably believe that those workers who perform faster and more accurately will be rewarded and, conversely, those workers that are slower and less accurate will be disciplined.

A rather large aspect of self-reported CoQ data is not verifiable by other means, so individual's attitudes towards honesty in self-reported CoQ are key concepts. Cronbach (1970) recognized honesty – or *veracity* – as the central problem of self-reported data in psychological testing. A respondent will distort self-reported data to some degree, even with honest intentions, because he/she cannot be expected to impartial when reporting about him/herself.

Per Austin (1996), workers are governed by slothfulness, greediness, and internal motivation, (a satisfaction gained by making customers happy). When designing a management system, an employer can use some combination of all three of these impulses. With monetary incentives, an employer can control an employee's slothfulness – or *apathy* – by appealing to his/her greediness. In order for that combination to work, an effective supervision or measurement system is required. In our system of collecting CoQ, data is self-reported. As such, no system of measurement can verify a worker's diligent and persistent use of the CoQ data collection system as currently designed.

While Crosby (1980) and (1995) uses *quality awareness* in two separate contexts; the first in his "14-steps to improvement" relating to the common worker's attention to quality in his own work; and the second, as a scale of progress along his "Quality Management Maturity Grid" referring to a management attitude towards a systems'

perspective on quality. The second context is the key to this analogy. Since a CoQ system is intended to promote a systems' perspective, it is useful to search for clues from respondents that suggest an acceptance, or at least an understanding of that concept.

Table 3.2 identifies these codes and offers a question for each code used to analyze the interview transcripts.

Table 3.2 – Codes Used in Coding Group 1 Interviews

Code	Coder Question	Source
Cognition	Did the respondent come to know the 47 cost of quality activities found in the color guide and properly apply them to their own activity?	Pace, et al. (1985), Crocket, et el. (1987)
Fear	Did the respondent experience trepidation or feel suspicious of the motives behind a system to record quality costs?	March & Simon (1958)
Veracity	Did the respondent conceal or exaggerate when logging cost of quality data?	Cronbach (1970)
Apathy	Did the respondent persist in applying knowledge of the cost of quality and faithfully record cost of quality activities?	Austin (1996)
Quality Awareness	Did the respondent exhibit an underlying receptiveness to quality principles that a cost of quality system is designed to promote?	Crosby (1980)

3.7.2. Reliability: Intercoder Agreement. It is possible that one coder can disagree with another about the categorization of the same segment of data. Because of individual bias and even slightly different mental processes, coders may not reach identical conclusions. Assigning multiple coders is one way that a research project can neutralize this effect. By independently coding the same segments of data, multiple coders can collaborate and obtain consensus. In this way, validity can be enhanced by reducing inter-coder variations.

While ideal, consensus of multiple coders for each segment of data was not available due to this study's limited resources. Alternatively, this study addresses validity by auditing a sampling of data segments that were coded by the principle investigator and then re-coded by several independent and specially-trained individuals.

The study enlisted the assistance of two volunteers, each on the staff of the same engineering office as the exercise participants, but detached from the awareness exercise. Neither volunteer was an employee in the same cost center, nor employed by the Firm at the time of the awareness exercise.

Both volunteers submitted to a short training session – approximately one hour – in order to familiarize them with the cognitive tools they needed to apply the codes previously used by the principle investigator. These tools included a cursory overview of the costs of quality as an accounting tool, and a brief history of the awareness exercise that preceded the interviews. After reading the subject interview transcript once through, volunteers were instructed to examine each interviewee's response and compare it with the codes in Table 3.2.

Volunteers were instructed to mark the transcript with a corresponding code if they found that the interviewee's response tended to answer any of the coding questions, even if the answer could be regarded as negative. In addition, volunteers were instructed that more than one code could be applied to each response, but that multiple codes should be avoided if additional coding questions had only a weak correlation.

Transcripts were further redacted so that no portions of the transcript could be traced by the volunteers to a particular study participant. Nonetheless, each volunteer signed a confidentiality agreement not to discuss the contents of the transcripts outside of the coding process.

Volunteers obtained an interview transcript by blind selection from among the Group 1 interviews. One volunteer requested and was given two transcripts to code. No time limit was imposed on their work, but volunteers were offered a gentle telephone reminder after two days. Volunteers were free to ask questions during the coding process; however, answers were limited to clarification of the initial instructions. To retain a level of consistency, answers provided were delivered to both volunteers.

The degree of agreement between the results of the independent coders and the principle investigator understandably varied with the individual code, coder, and interviewee.

In some literature, inter-rater reliability, inter-coder reliability, and inter-rater agreement appear to be interchangeable terms. There are distinctions between

'reliability' and 'agreement'. Tinsley & Weiss (1975) defines 'reliability' as the degree of proportionality between coders when compared to their mean, and 'agreement' describes the extent to which coders make exactly the same judgments. Since coding in this case requires binary judgments, agreement is the more appropriate measure.

Trochim (2001) recommends testing agreement by joint-probability, or percent agreement. This method is simply the number of times coders agree divided by the number of opportunities for agreement. While the easiest measurement may be the simple percent agreement, Lombard, et al. (2002) suggests that it should not be the only measurement. Percent-agreement is a weak measure of conformity because it does not account for agreement that may occur solely by chance.

There are different methods available to calculate agreement while at the same time correcting for chance agreement. Krippendorff's Alpha is a method that has been used with variable data and among multiple coders. (Hayes & Krippendorff, 2007) Cohen's (1960) Kappa, a simpler statistics than Krippendorff's Alpha, is useful only for binary data and to compare only two coders. Several enhancements to Cohen's original Kappa statistic have been made available. Cohen (1968) created a weighted Kappa to evaluate ordered data, and Fleiss (1971) enhanced the Kappa statistic to accommodate multiple coders.

Coding in this study consists of multiple responses that are marked, or not marked, with a particular a priori code. Coding data, therefore, can be characterized as binary data. This inter-coder agreement exercise requires only comparison of two coders for one of three interview transcripts and, thus, can demonstrate validity with Cohen's original Kappa statistic as a basis of comparison. Methodology and calculations can be found in Appendix G.

3.7.3. Credibility: Member Checking. Another quality issue associated with qualitative research is credibility. Trochim (2001) defines credibility criteria as:

> "…establishing that the results of qualitative research are credible or believable from the perspective of the participant in the research."

Qualitative research purports an understanding of a particular area of interest from the perspective of the study participant; it is therefore not unreasonable to obtain some measure of consensus from among the study participants as to the credibility of that

perspective. Among other criteria, Lincoln and Guba (1985) proposed that qualitative research be judged in exactly this way. One of several strategies by Streubert-Speziale (2007) for demonstrating credibility involves "member checking"; that is, engaging the study participants in some way so as to determine if data and analysis reflects their view of the phenomenon or experiences related to the phenomenon.

This study uses a credibility criterion that proposes to demonstrate that concepts obtained from the data are credible and believable from the perspective of the study participant.

A survey was devised to allow study participants the opportunity to examine concepts that were developed from the interviews and, from their own perspective, gauge their confidence in those concepts. The survey population was deliberately confined to the original participants of the awareness exercise because of their unique experience they obtained while recording CoQ data.

Participants were asked to examine 98 statements organized within eleven broad categories. Each statement was crafted from a key concept selected from among all concepts accumulated during the coding analysis that was performed on the interview transcripts. After reading each statement, participants were asked to respond with their level of agreement across a five-point scale: (1) *strongly agree*, (2) *somewhat agree*, (3) *neither agree nor disagree*, (4) *somewhat disagree*, or (5) *strongly disagree*. In addition, there was a "*not applicable*" selection that was made available for all statements. The survey was designed and deployed through Zoomerang Online Surveys and Polls.[5]

In preparation of general survey deployment, one employee was selected to test the survey in order to uncover ambiguity and unnecessary repetition. Permission was obtained from each participant before being included in the survey phase. Each participant who consented was provided with a copy of the basic study materials so as to refresh his/her recollection of key parts of the Awareness Exercise.

Participants were instructed to use the "not applicable" button only for statements for which they could not render an opinion. This investigator was careful to explain to participants that the "not applicable" selection was to be used sparingly. This distinction

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[5] Online Survey Software Tool - Create Free Online Surveys - Zoomerang. MarketTools Company, San Francisco, http://www.zoomerang.com/free-account/, 2011.

was important because a response marked in this way was excluded from the statistics calculations. Statements for which the participant merely had no opinion were to be marked "(3) neither agree nor disagree." Responses with no opinion were not excluded from the statistics calculations and given a neutral score of "3" for that response.

There were no IRB issues to consider as participants had previously signed an IRB agreement. Confidentiality in the form of coded identities that began in the awareness exercise was continued through the survey. The survey website solicited each participant individually; in this way, each participant could control their environment while completing the survey and determine their own desired level of privacy. The survey was design so that participants would not have access to results.

Statements were examined separately, but responses by participants to each statement were tested together. Examination of each statement involved rating of a single target by multiple respondents across the five-point agreement scale.

In order to evaluate the error of the mean rating assessed by all respondents in this type of assessment, Schmidt and Hunter (1989) recommends the standard deviation of all ratings in a population and the standard error of their mean rating. The standard deviation (SD) proposes to index agreement among respondents, while use of the standard error (SE) proposes to establish 95 percent confidence intervals around the mean rating. Burke, et al. (1999) recognized the sensitivity of SE to sample size and suggested that a more practical index of agreement: the average deviation index (AD). As with the Schmidt and Hunter indices, it estimates agreement of the rating of multiple respondents across an interval scale of measurement. This exercise uses the simpler SE calculation.

Survey results for each concept statement were individually analyzed and the mean response, the standard deviation, and the standard error were calculated. Because of the context of a portion of the statements, some participants did not respond with a rating to every statement. The population used in the calculation did not reflect "not applicable" responses, therefore, the population varied across the calculations of all statements. Results are integrated in the Research Discussion in the next Section.

4. RESEARCH DISCUSSION

4.1. THE AWARENESS EXERCISE

In human terms, the awareness exercise involved 16 study participants recording CoQ data over a period of approximately 50 calendar weeks; during that time, project staff expended nearly 6,800 professional hours and simultaneously recorded 1,447 of those hours as CoQ activities. Collectively, the staff found and recorded 34 different CoQ activities during the exercise from among the 47 CoQ activities (see Figure 3.4) published in the color guide. Refer to Appendix A for the color guide itself.

Work of engineering and architectural staff frequently involves managing more than one project. During the active phase of the exercise project, no single participant worked exclusively on the project under study, but had varying degrees of involvement. Contribution of CoQ data by exercise participants was not supervised during the exercise period. Except for the prompting by the CoQ recording tool that activated on their computer desktop when logging in each day (see Paragraph 3.4.1.3), study participants received no regular reminders on the ongoing awareness exercise.

Appendix B shows the data collected by the staff during the study period collated in several different ways. Washing this data several times as an excel pivot table illustrates different aspects of the staff's level of participation which can only be described as mixed. See table on page 1 of Appendix B. From the entire record of data, the table shows:

- How many different CoQ activities the participant identified in his/her own work during the exercise period,
- How long the participant remained active after their first log entry,
- How many log entries the participant actually made over the course of the exercise period, and
- How many actual hours the exercise participant logged during the exercise.
- Participants had varying responsibilities, so the table also lists
- Participants' project involvement, in hours, and
- Participants' ratio of CoQ hours to total hours.

Some found it difficult to stay focused during the exercise period. More than half of participants continued logging activity for more than 20 weeks after they began logging CoQ data. Unfortunately, a full third discontinued activity less than a week after their first log entry.

Opportunities to record CoQ data were not evenly divided among all exercise participants due to varying responsibilities and degrees of involvement. Even so, some found it difficult to remain diligent during the time period that the study was active. More than a third of participants made four or fewer log entries over the 50-week exercise period, while nearly half of the group made more than 30 CoQ-activity log entries during the exercise.

Not all participants found it easy navigate and identify a particular activity from among the 47 distinct CoQ activities. Regrettably, nearly half of participants were not able to distinguish but three or fewer different CoQ activities during the entire exercise period. At the same time, an equal number of the participants logged time against at least ten different CoQ activities. One participant recognized as many as 18 different activities during the exercise period.

Lastly, each participant logged, on average, 90 total hours of time against quality cost activities during the exercise period. Not every participant was active, though; at least four individuals logged eight hours or less.

In order for a CoQ system to become useful tool for tracking quality in engineering firms, the shortcomings of the system of identifying and recording CoQ needed to be examined. The statistics identified participants who logged very few hours, made very few log entries, operated within a very narrow range of different CoQ activities, and participated in the awareness exercise for only a very short time.

Without speculating as to the individual motivations of each study participant during the awareness exercise, the following preliminary observations are a first step in explaining participant behavior that led to some of the weaknesses described above:

- Participants were suspicious of the motives behind the study, or the CoQ system.
- Participants lost interest in the CoQ system.
- Participants failed to log time during the course of their work because they forgot to consider CoQ activities.

- Participants became confused with the system or its purpose.
- Participants become embarrassed by mistakes or missed opportunities.

4.2. GROUP 1 INTERVIEWS

In order to provide additional clarity, some members of the staff who participated in the awareness exercise were interviewed. Because of issues related to the participant's availability, seven of the 16 participants were interviewed. Among those participants not interviewed, some were not available; others flatly declined to submit to a recorded interview.

The interviews were semi-structured (see Interview Guide in Appendix C) and were designed to elicit discussion on the concepts identified in Table 3.2. This researcher speculated that respondents considered some issues to reflect poorly on themselves in some way. For instance, it did not seem plausible that respondents, even in a private, non-judgmental setting would admit that they may have been less than honest when recording data; it was more likely that respondents would harbor some doubt that their admission would remain secret. To neutralize this possibility, some questioning solicited speculation from the respondent regarding the behavior or opinion of others on the same or similar concept. Speculating about how others think or behave with respect to a delicate issue may not totally remove threatening implications for some respondents, but it was expected that the strategy would at least elicit a more candid response. Discussing behavior of others may be an effective surrogate to probing of the same behavior in ourselves.

4.2.1. Coding Group 1 Interviews. At the conclusion of each of the recorded Group 1 interviews, voice files were transcribed and redacted to remove personal and company specific information. Each participant was assigned a random code; the only means of identifying a transcript is with the use of a separate respondent key. Interview transcript field notes can be found in Appendix D. Once transcribed, each interview was coded for the concepts identified in Table 3.2. A coding memo from each transcript was prepared that arranged responses by concept. See Appendix H for each coding memo.

4.2.2. Inter-Coder Reliability. Coding results from the volunteer coders were tabulated and compared to the principle investigator's coding of the same transcript. Each interviewee response was examined for each code for agreement between the principle investigator and the volunteer. With the possibility of five codes, binary choices were compared for each of five codes between the two coders. For each interviewee response, there were four possible outcomes for each code: (1) both agreed that the code applied, (2) the principle investigator agreed and the volunteer disagreed, (3) the principle investigator disagreed and volunteer agreed, and (4) neither agreed that the code applied. The outcomes from all responses of the interviewee related to a particular code were totaled and compared with the original coding. Figures 4.1, 4.2, and 4-3 represent the results of reliability in terms of percent agreement and Cohen's Kappa for each of three interviews, for each of five different codes. See Appendix G for the complete data and calculations.
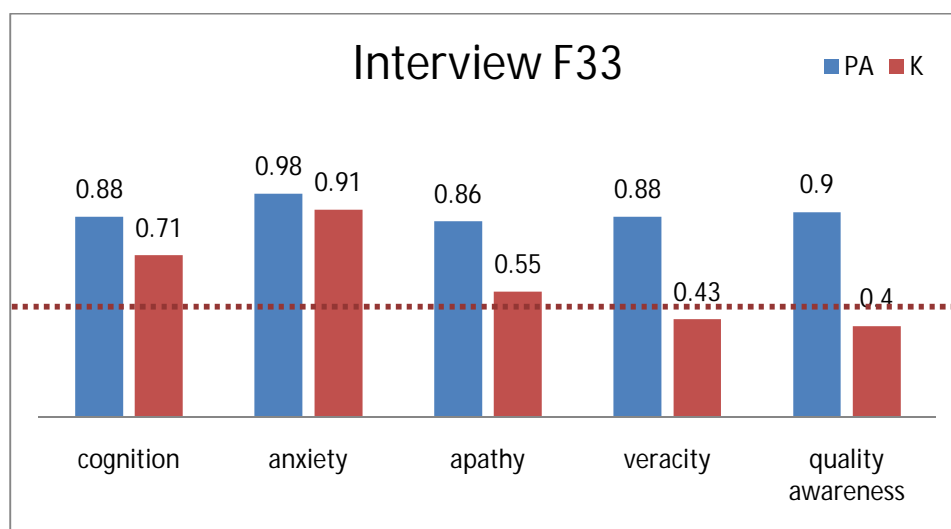
Figure 4.1 – Inter-Coder Agreement for Respondent F33
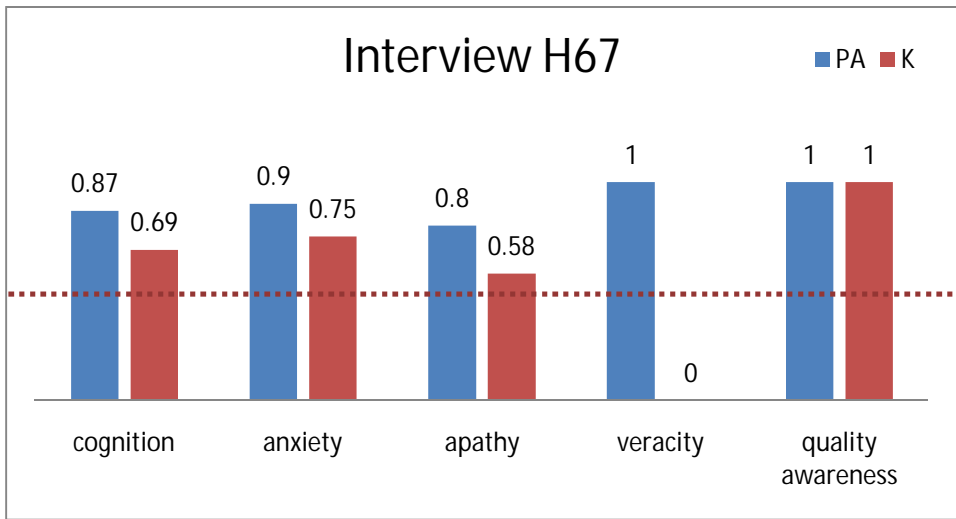
Figure 4.2 – Inter-Coder Agreement for Respondent H67
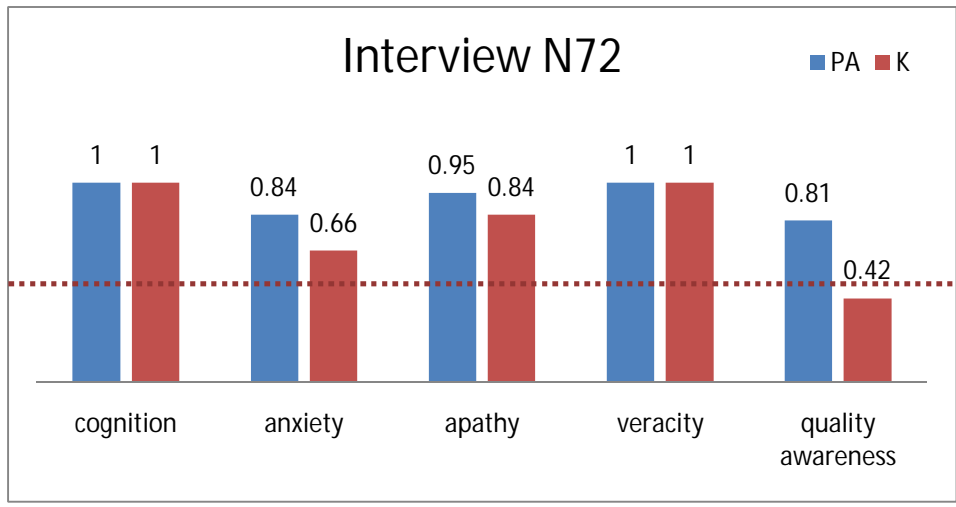
Figure 4.3 – Inter-Coder Agreement for Respondent N72

LeBreton, et al. (2008) suggests that the traditional 0.7 cutoff of Cohen's Kappa may be too high and that a value of 0.5 should be considered as a more suitable lower limit to signal weak agreement. The results of the audited sample interviews reflect agreement in the coding process for cognition, anxiety, and apathy codes. Conversely, independent audits related to veracity and quality awareness codes failed to achieve a minimum standard of agreement, at least in terms of Cohen's Kappa. Mathematically,

the relative few codes in this area by either the principle investigator or the volunteer coders contributed significantly to the weak agreement. Still, it suggests that this might be an area where the volunteers' understanding of the intent of these two codes diverges, suggesting a weakness in reliability in this area.

4.2.3. Data Analysis. The responses from all code memos were analyzed for significant statements and sub-concepts. Those statements and sub-concepts were sorted and arranged to prepare a themes reduction memo. See Appendix J for the themes reduction notes for each concept from the Group 1 interviews. Once significant statements were arranged, a clustering memo was prepared to discuss preliminary "essences" related to each of the sub-categories. Clustering notes for each of the concepts can be found in Appendix K.

Ultimately, statements found to be significant to the problem statement were used in the discussion in the following subsections. Once a sub-concept is identified in this way, only the response quotation deemed most relevant is used in the narrative.

4.2.4. Data Confirmation. While many of the significant statements accumulated in the coding process were synthesized from among similar statements of several respondents, interviews were only semi-structured, so it was possible to obtain a significant statement that could be attributed to only one respondent. The survey organized each of 98 significant statements accumulated during the coding process into theme groups; then presented them in a structured manner to the original study participants to indicate consensus.

Each survey respondent could indicate a level of agreement with significant statement across a five-point scale from (1) *strongly agree* through (5) *strongly disagree*. Mean and SE were calculated for each statement in order to assess agreement among the respondents. See Appendix L for complete data and calculations.

4.2.5. Theme: Anxiety. The CoQ system as presented to the study participants purports to accumulate data related to several key factors. At some level, these key factors are associated with both good behavior and bad behavior. Time recorded to internal error suggests bad behavior and time recorded to external error suggests really bad behavior. Conversely, time recorded to appraisal and prevention represents good behavior.

Before the awareness exercise began, this researcher promised all project participants that personally-recorded CoQ data would never be disclosed, except as part of a larger, aggregated report that would make individual data indistinguishable from the rest of the report. The justification for this non-discloser pledge was to separate the motivational component from measuring CoQ activities, at least in the participant's mind. Based upon Austin's (1996) principles of performance measurement, purely informational data (data with no motivational value) should have a lower bias when compared to data submitted by individual who may personally suffer or benefit from the use of that data.   However, March and Simon (1958) recognized that workers are skeptical of management claims that future rewards or punishments are unaffected by measurements reported by workers: workers make the understandable linkage that the faster and more accurate work is be rewarded and slower and less accurate work is punished.

See Tables 4.1 and 4.2 for significant statements related to participant's anxiety related to recording personal CoQ data.

Table 4.1 – Consensus of Significant Statements Related to Anxiety

	Significant Statement	Consensus	$\bar{x}$	SE_x
29	I'm not worried because I don't think that my personally-recorded data, or the cost-of-quality system, would have any value	disagree	3.6	0.2
30	As a supervisor, I believe that disclosing personally-recorded data would undermine the cost-of-quality system and, ultimately, do more harm than good	disagree	3.8	0.3
31	As a supervisor, I would find personally-recorded cost-of-quality data to be useful as I process performance reviews for my subordinates	agree	2.4	0.3
32	As a supervisor, I believe that personally-recorded data is a critical component of cost-of-quality system and I believe that protecting the anonymity of the individual staff member that records his/her activities serves that purpose	weak disagree	3.3	0.4
33	As a supervisor, I believe that disclosure of personally-recorded cost-of-quality data might cause unnecessary conflicts over ownership of errors	agree	1.7	0.2
34	As a supervisor, I know that there are more effective means to rank employees than using their personally-recorded cost-of-quality data	agree	2.3	0.4
35	As a supervisor, I believe that aggregated data (data collected from many individuals) would be considerably more useful than personally-recorded data that is traceable to a single individual	agree	1.9	0.3
36	Since I only normally only check plans, I didn't report any time to error activities	agree	1.9	0.3

(See Appendix L for complete survey data and calculations)

In general, study participants felt that personally-recorded CoQ data was important enough to take seriously. While participants do not view personally-recorded data as a challenge to professional competence, there is a general suspicion that personally-recorded data could be somehow abused. Yet, it is believed that disclosure of personally-recorded data could be used to help other avoid mistakes. If the Firm would declare a clear purpose regarding the CoQ system in general and personally-recorded data in particular, it could alleviate suspicion.

Table 4.2 – Consensus of Significant Statements Related to Anxiety

	Significant Statement	Consensus	$\bar{x}$	SE_x
37	Everyone makes mistakes; my personally-recorded data should not be a cause for concern	agree	2.5	0.3
38	I'm not concerned at all because I don't think that it's possible to abuse my personally-recorded data	disagree	3.6	0.3
39	If my personally-recorded error activities were disclosed, it might help others avoid my mistakes	agree	2.5	0.3
40	I fear that personally-recorded data might reveal the magnitude of a major mistake for which I was responsible	disagree	3.7	0.2
41	Mistakes are made every day; as long as it's not an extremely expensive mistake, it's not a big deal	disagree	3.6	0.3
42	I suspect that my personally-recorded data could somehow be abused	agree	2.6	0.2
43	I believe that management would use personally-recorded cost-of-quality data to rate and rank employees during the salary review process	weak agree	2.9	0.3
44	We should all be able to admit our own mistakes, but I might, on occasion, have trouble owning up to my own errors	disagree	3.5	0.3
45	I believe that disclosure of personally-recorded cost-of-quality data would be viewed as a direct challenge to my professional competence	disagree	3.8	0.3
46	Since many of the errors that I correct are out of my control, I should not be stigmatized if I report error activities	agree	1.8	0.2
47	I believe that personally-recorded cost-of-quality data would be used as a "whipping tool" to control employee behavior	disagree	4.0	0.3
48	I would be much more candid in recording cost-of-quality activities if my personal data remained anonymous	agree	2.4	0.3
49	I might be considerably less suspicious that someone might misuse my personally-recorded data if the company made the purpose of the cost-of-quality system very clear	agree	1.8	0.2
50	Since many of the errors that I correct are out of my control, my personally-recorded error activities might be misunderstood if they were disclosed to management	agree	2.4	0.2

(See Appendix L for complete survey data and calculations)

Participants recognized from the awareness exercise that some CoQ activities, error activities in particularly, could be associated with circumstances that are beyond a worker's control. For example, a mechanical engineer may be called upon to reconfigure ductwork due to changes in room adjacencies. Architecture would be responsible, but the mechanical engineer and his/her drafter would be tasked with performing the resulting redesign and rework and record the work as an error activity.

> "The reason management would gather the information would be to compare employees… and one employee might have more of an opportunity to be the one to correct errors or be the one to prevent errors, so they have more opportunity to spend quality costs, where another might not…" (Respondent F33)

If management was not aware of the possible inequity associated with the realities of CoQ measurement, a worker would understandably suspect that he/she might be singled out for unfair criticism. However, participants believed that management is generally tolerant of mistakes and would come to be aware of the true character of personally-recorded CoQ data.

Participants disagreed that disclosure of personally-recorded data would tend to undermine the CoQ data recording system. Supervisors also generally disagreed that such disclosure would compromise the integrity of the system, but recognized that tracking personally-recorded CoQ data could give rise to conflicts between groups over ownership of errors. Even so, all participants still preferred anonymity when recording personal CoQ data.

Participants were generally split on whether management might make use of personally-recorded data to rate and rank workers for salary and performance reviews. While supervisors felt that a record that included a worker's personally-recorded CoQ data history could be useful at performance reviews, they generally agreed that there were more effective measurements and observations for that purpose. In fact, supervisors considered aggregated data more interesting than personally-recorded CoQ data.

> "… as a manager, I would think seeing the entire group's [CoQ] time would be more interesting than an individual's." (Respondent N72)

4.2.6. Theme: Cognition. In a system that relies on self-reported data, Pace, et al. (1985) acknowledged that a respondent's understanding of the system is a key element of the quality of the respondent's data. Quality demands that the system be understandable to the respondent and be reasonably free of ambiguities. Crocket, et al. (1987) disagrees that self-reported data should be considered at all where extreme precision is required, unless more objective measurements are unavailable. In this system of recording CoQ data, how a participant understands the principles behind quality costs and remembers enough about individual CoQ activities and broad categories determines whether he/she can consistently recognizes CoQ activities and correctly match them to the pre-defined activities within the color guide reference.

While the diversity of different CoQ activities available in this study is substantial, it is not large when compared to CoQ used in manufacturing Firms. Still, comprehending all 47 CoQ activities during the awareness exercise may have been overreaching. Based on the data accumulated during the awareness exercise, there was a wide disparity among participants regarding the perceived understanding of the different activities. Nearly half of all participants in the exercise did not recognize more than three CoQ activities, compared to an equal number that each recognized more than ten in their project activities. This ability or willingness by participants to learn to recognize many different activities becomes an important issue.

See Tables 4.3, 4.4, and 4.5 for significant statements related to participant's cognition of activities and methods related to recording personal CoQ data.

Participants said that they found the orientation and training sessions helpful and disagreed when asked if they later forgot knowledge that they acquired during training when called upon to apply it to their own activities during the awareness exercise.

The color guide was previously described as a full-color booklet containing complete descriptions of the 47 CoQ activities, each classified under one of five broad categories. While participants were not generally intimidated by the 47 CoQ activities themselves, they were generally worried that there were too many CoQ activities for the average designer to understand. Participants found the five broad categories of quality costs contained in the color guide to be easier to understand than the 47 activities. However, they also found that the descriptions found in the 47 individual activities to be

valuable as a tool to correctly classify an activity within one of the five broad categories. In other words, participants believed that they understood the concepts represented by the five broad categories but not well enough to use them without the help of the instructions found in the color guide for each of the individual CoQ activities. This suggests that participants recognize that while the five broad categories are understandable concepts, they are too abstract, or perhaps too impractical to apply to everyday complexities of their daily work.

Table 4.3 – Consensus of Significant Statements Related to the 47 CoQ Activities

	Significant Statement	Consensus	$\bar{x}$	SE_x
1	I found the activity descriptions to be confusing at first, but the orientation session was helpful and clarified many of my concerns	agree	2.1	0.2
2	I found that the 5 broad categories were easy to understand, but there were too many individual cost-of-quality activities for me to comprehend	weak agree	2.8	0.3
3	I found the activity descriptions to be confusing at first, but the orientation session was helpful and clarified many of my concerns	weak agree	2.7	0.3
4	The 5 broad categories were easier to understand	agree	1.4	0.2
5	I was not intimidated by the 48 individual cost-of-quality activities because I only needed to focus a few of them	agree	2.3	0.2
6	I found some of the activity descriptions were confusing because only small nuances separated one description from another so how an activity would be classified would vary between individuals	weak agree	2.9	0.3
7	With a short grace period, I think that I could learn all I needed to know about applying the cost-of-quality activities to my own work	agree	2.1	0.3
8	I ended up reporting only a few of the 48 available activities	agree	2.1	0.3
9	It was difficult to correctly classify my activities because it was not always clear to me whether my rework was due to an internal or external mistake	weak disagree	3.3	0.3
10	By the time I got to where I thought I should be reporting cost-of-quality activities, I remembered very little about what I learned in the orientation session	disagree	3.7	0.3
11	On balance, I correctly identified and reported more than half of my activities that matched one or more of the listed cost-of-quality activities	agree	2.5	0.4
12	Since I only normally only check plans, I didn't report any time to error activities	disagree	4.0	0.3

(See Appendix L for complete survey data and calculations)

Participants were provided with a cheat sheet handout during the orientation and training that compared all CoQ activities with staff jobs and listed when and if the staff job would be called upon to engage in that activity. It helped participants ignore CoQ

activities from the color guide that were unrelated to their project work and focus only on those activities that they would most likely encounter.

Table 4.4 – Consensus of Significant Statements Related to the Color Guide

	Significant Statement	Consensus	$\bar{x}$	SE_x
13	Explanations under each activity in the color guide made classifying my own work much easier	Agree	2.1	0.2
14	I referred to the cheat sheet to help me focus only on the activities that would affect me during the project	Agree	2.3	0.3
15	The descriptions of the activities in the color guide were instructive and helped me select the correct activity	Agree	1.8	0.2
16	Without the color guide's descriptions of the individual activities, I may not have been able to correctly select the correct category from among the 5 broad categories.	Agree	1.8	0.2

(See Appendix L for complete survey data and calculations)

While there was some minor opposition, participants found the time recording tool designed for use during the awareness exercise to be convenient, intuitive, and superior to the Firm's official timesheet.

> "It seemed to be an efficient way to record the data that was asked for and it was probably the least burdensome way I can imagine… it was easy for me to use…" (Respondent F33)

Participants agreed that there were certain realities associated with official timesheets that would make them inappropriate for recording CoQ data. They believed that in a timesheet recording process, some activities might go unreported for two reasons: (1) official timesheets are linked to the payroll process and are, therefore, required to be completed before the end of the timesheet period, and (2) Project managers sometimes close chargeable tasks and leave project staff to record time to overhead. Also, supervisors agreed that CoQ activity records could become public knowledge because timesheet records are ordinarily open to clients. Each of these circumstances could cause, or at least influence some CoQ activities to go unreported.

4.2.7. Theme: Apathy. Based on the data accumulated during the awareness exercise, there was a wide disparity among participants regarding the data reporting

activity. While it was expected that participants have varying involvement in the project in the awareness exercise, proportion of hours recorded as CoQ activity to project hours were significantly less for some participants.

Austin (1996) recognized that workers are governed by slothfulness, greediness, and an internal motivation to make customers happy; and that the key to managing worker performance is to devise a supervision or measurement system that, in some proportion, accounts for all three motivations. Sloth, or apathy, is a key component in Austin's worker performance management equation. In this study, the measurement system devised to obtain CoQ data relies wholly on voluntary compliance. As such, apathy among participants must be examined in any serious inquiry.

Table 4.5 – Consensus of Significant Statements Related to the Recording Tool

	Significant Statement	Consensus	$\bar{x}$	SE_x
17	I found the separate recording tool to be useful for selecting and recording cost-of-quality activities	Agree	1.7	0.2
18	The recording tool was too complicated… too many buttons and too many steps	Disagree	3.9	0.3
19	If I had to record cost-of-quality activities on the company timesheet, some activities might not have been reported because some project tasks close before work was complete	Agree	1.7	0.2
20	Recording tool was easy to use, convenient, and fairly intuitive	Agree	1.8	0.2
21	If I had to record cost-of-quality activities on the company timesheet, some activities might not have been reported because I have to complete the company timesheet before the end of the timesheet period	Agree	1.7	0.2
22	I recorded my cost-of-quality activities down to the minute	Disagree	3.7	0.3
23	My learning curve for using the recording tool was very short	Agree	2.0	0.2
24	Using the recording tool took very little time	Agree	1.8	0.2
25	Using the recording tool for the first time was way too time consuming	Disagree	3.4	0.3
26	Recording time on the separate recording tool was easier because the company timesheet is not particularly user-friendly	Agree	2.3	0.3
27	If I didn't have the separate recording tool, I think that recording cost-of-quality activities on my company timesheet would be very messy	Agree	1.7	0.3
28	As a supervisor, I know that time charged to cost-of-quality activities might cause a problem if clients saw them on timesheet records that are seen by clients	Agree	2.3	0.5

(See Appendix L for complete survey data and calculations)

Participants believed that they accurately recorded their CoQ time, but they admitted that they could not catch every recording opportunity. They say that they recorded short activities immediately, but admitted that they were less accurate the longer they waited to record an activity. Still, participants disagreed that their CoQ activities were forgotten by the end of the day. Participants did not use physical reminders like sticky notes, nor did they rely on opportunities to enter time on official timesheets to prompt them to record CoQ time; this is probably accurate because few employees of the Firm record their time on the official timesheet multiple times throughout the day.

Table 4.6 – Consensus of Significant Statements Related to Apathy

	Significant Statement	Consensus	$\bar{x}$	SE_x
51	I tried, but I couldn't catch every cost-of-quality activity	Agree	1.8	0.2
52	My accuracy went down the longer it took me to record my cost-of-quality activities	Agree	2.6	0.4
53	I reminded others to record time when I found a cost-of-quality activity that affected more than just me	Disagree	3.7	0.4
54	I forgot to record data sometimes	Agree	2.4	0.4
55	When I forgot to record an activity immediately, I would sometimes go back and reconstruct the information on my cost-of-quality from memory	Agree	2.5	0.3
56	Writing notes to myself helped me to remember to record the activity later	Weak Disagree	3.0	0.4
57	I mentally tracked my cost-of-quality activities and recorded them at the end of the day	Weak Disagree	3.1	0.3
58	By the end of the day I forgot most of my cost-of-quality activities	Disagree	3.6	0.4
59	I recorded short activities almost immediately	Agree	2.6	0.3
60	I recorded my activities on the recording tool at the same time as I made entries onto the company timesheet	Weak Disagree	3.1	0.4
61	The description of the 5 broad categories jogged my memory more so than descriptions of individual cost-of-quality activities	Agree	2.7	0.3

(See Appendix L for complete survey data and calculations)

While participants were not warm to the idea of a company mandate that workers record CoQ data in this way, they found that the system was manageable. Many workers have already experienced clients who required separate means of recording time in addition to official timesheets. The practice often entails time classifications that are different from the classifications workers see of their official timesheets, but must always

match, hour-for-hour. The added burden is not popular, but compliance among workers in the Firm is nearly the same as official timesheets. While most disagreed, one participant believed that the separate CoQ recording process took too much time at the end of the day. Both employee and supervisor participants predicted that other employees would feel burdened by the CoQ recording system, at least at first.

Table 4.7 – Consensus of Significant Statements Related to Apathy

	Significant Statement	Consensus	$\bar{x}$	SE_x
62	I classified and recorded my time very accurately	Agree	2.5	0.3
63	I found that the system was very manageable. 30 seconds to record data won't kill you	Agree	2.2	0.3
64	I think that, at least initially, everyone will feel more burdened	Agree	1.9	0.2
65	I found that it was taking way too much time at the end of the day to record my cost-of-quality activities	Disagree	3.8	0.3
66	As a someone who supervises others, I think that recording cost-of-quality activities will initially be seen as a burden	Agree	2.5	0.3
67	I wouldn't like it if the company forced the system on me, but I would get used to it.	Agree	2.6	0.3

(See Appendix L for complete survey data and calculations)

In general, participants admitted that they could not gauge compliance among other employees, but they could see others might avoid using the system because they lacked understanding of the system itself or how it would be applied. Participants want to see the Firm publish CoQ data, not just as a final report at post mortem, but in a regular, ongoing report. Seeing CoQ data in near real-time might encourage compliance. While timesheets enjoy near perfect compliance, participants did not agree that use of official timesheets for collection of CoQ data would serve to improve compliance, despite the perceived "payroll" incentive associated with its use.

4.2.8. Theme: Veracity. The system devised for recording CoQ in the awareness exercise relied on data that was self-reported and, as such, unverifiable. There was no objective measure of a participant's honesty during the exercise, or a credible technique for auditing the veracity of a participant's personal data log at the conclusion of the exercise. According to Cronbach (1970), a respondent in psychological testing will tend

to distort self-reported data to some degree. Even without deceitful intentions, respondents cannot be expected to be impartial when reporting about themselves; so honesty – or veracity – is the key issue when using self-reported data.

Table 4.8 – Consensus of Significant Statements Related to Apathy

	Significant Statement	Consensus	$\bar{x}$	SE$_x$
68	Staff will tend to avoid using the cost-of-quality system because they don't understand it or its benefits	Agree	2.5	0.3
69	The staff would tend to be more complaint if they saw regular reports that included cost-of-quality data, not just a single report at post mortem time	Agree	2.1	0.2
70	I have no sense of the compliance level of others on the staff	Agree	2.6	0.3
71	I believe that it would be difficult for the company to track my compliance	Weak Disagree	3.1	0.3
72	I would be more diligent in recording cost-of-quality data if I had to report it on my company timesheet	Disagree	3.4	0.3
73	Since the company cannot track when I don't use the system, I am more likely to ignore legitamate opportunities to report cost-of-quality activities	Weak Disagree	3.0	0.3
74	Of course I can always find time to record my time on the company timesheet, but I have little or no time to record activities on a separate recording tool	Disagree	3.5	0.2

(See Appendix L for complete survey data and calculations)

Discussing honesty during participant interviews was a particularly troubling notion. Approaching the topic of concealing or exaggerating by exercise participants required great care. Although interviews were private and freshly-signed nondisclosure agreements were in hand, complete candor was not expected from interviewees if their honesty were questioned directly. Instead, this researcher chose to explore the interviewee's perspective of honesty among other members of the staff.

Participants agree that other workers will under-report or avoid reporting CoQ data that they perceive would attract criticism, or worse. Participants disagree, however, that workers will exaggerate CoQ data in order to call attention to the carelessness or negligence of others.

> "People do things to increase pleasure and decrease pain. So, in doing so,
> I think that others may tend to seek something that would detour blame or
> detour the mistake and see if there was another method of placing
> elsewhere instead of themselves" (Participant Q53)

In a CoQ data report, it is reasonable to believe that higher reported CoQ error costs can focus harsh criticism on a mistake, and likewise, the persons or group associated with the mistake. The survey question connected with this concept was inadvertently phrased in the first person; it is possible that this particular concept would have attracted more support if the corresponding survey question was phrased so as to refer to behavior of other workers.

On the other hand, participants consider themselves to be innately honest and believe that they would not conceal or exaggerate CoQ data when reporting their own activities, even if confronted with embarrassing errors; they would not conceal their personal error activities when reporting CoQ data. The comparison of participant's perspective of their own personal honesty verses the honesty of other workers suggests a suspicion of the motives of others and dovetails neatly into Cronbach (1970) suggestion that self-reporting respondents cannot be expected to be impartial.

Table 4.9 – Consensus of Significant Statements Related to Veracity

	Significant Statement	Consensus	$\bar{x}$	SE_x
75	It is human nature to increase pleasure and decrease pain; employees will slant data to avoid blame or to make themselves look good	Agree	2.3	0.2
76	I would not conceal or exaggerate my personally-recorded data because I'm inherently honest	Agree	1.7	0.2
77	Embarrassing errors might induce me to conceal some or all of my personal error activities	Disagree	3.9	0.2
78	I would be more inclined to report my personally-recorded data honestly if it would remain anonymous	Agree	2.6	0.3
79	If I had to personally correct my own work due to the negligence or carelessness of others, I might exaggerate my personally-recorded error activities in order to call attention their mistake	Disagree	3.4	0.3

(See Appendix L for complete survey data and calculations)

There was interesting observation from the interviews that was not reflected in the participant survey, but is worth noting and exploring further: individuals who can recognize mistakes by others with unmistakable clarity but appear to be blinded by their own mistakes. It is not clear whether this observation describes a deliberate deception or an example of self-delusion.

Consider an engineer respondent describing CoQ activities associated with checking the work of a drafter. Ordinarily, an engineer will prepare a solution to an engineering problem and then refer the solution to a drafter to incorporate the solution graphically in an engineering drawing. Whether the engineer faithfully represents the engineering ideas on a set of plans is often a subjective exercise. After receiving instructions from the engineer, the drafter can deliver three fundamental types of error: (1) incorrectly interpreting instructions from the engineer that were technically-accurate, (2) correctly interpreting instructions from the engineer that were technically-inaccurate, and (3) failing to follow accepted graphic standards.

In the example, the engineer believes that the only errors that drafters deliver are error types (1) and (3). Consider the position of the following participant engineer: despite providing technical instruction and guidance to drafters and designers during the checking process, she recorded no time against error activities because, according to her, she only "checked" the plans:

> "I didn't use the ones for correcting errors because I was usually doing the checking." (Participant Q60)

She believed that her plan-checking activity resulted in exposing errors made by the drafter – error types (1) and (3) – but not to repair an error made by her – error type (2). In this example, plan-checking was unquestionably an appraisal activity. However, the system requires that if the plan-checking revealed engineering errors, correcting those errors would have been considered redesign; and the engineering would be obliged to report the redesign as an error activity.

Contrast that with a drafter's belief that his work only reflected errors made by others – error type (2). One participant drafter had this to say about plan-checking comments he received from the engineer regarding his drafting work:

> "It was a back-check thing; changes that the architect would make that would cause us to change our plans… or just plain mistakes that the engineer had to redo which there I had to redo." (Participant B11)

In this isolated observation, the engineer characterizes her work, in part, to remain vigilant against mistakes made by drafters. By contrast, the drafter characterizes his work, in part, to repair mistakes made by architects and engineers.

4.2.9. Theme: Quality Awareness. The staff of the Firm's local office occasionally receives compliments and commendations from clients and other offices within the Firm for their role in successful projects. For example, the New Jersey Concrete and Aggregate Association honored the architects of a 100,000 square-foot communications station with a design award. Despite technical successes, participants recognized that the Firm's processes have issues with quality**:**

> "I would say we, as a company, do not pay attention to quality in projects generally because we have lots of construction administration issues on a number of projects; those would be significantly smaller, in my opinion, if we had paid a little more attention to the quality in the first place. It doesn't mean that we do sloppy work; it just means that we certainly could be do a lot better work." (Participant N72)

Table 4.10 – Consensus of Significant Statements Related to Quality Awareness

	Significant Statement	Consensus	$\bar{x}$	SE_x
80	Recording our time against cost-of-quality activities would promote good quality awareness in the office	Agree	1.7	0.1
81	If I had to specifically record time spent correcting errors, I would be more inclined to perform work correctly in the future	Agree	2.4	0.3
82	Time spent performing cost-of-quality activities demonstrates the old adage, "there is never enough time to do it right, but there is always enough time to do it over"	Weak Agree	2.9	0.4
83	Monitoring cost-of-quality activities can help maximize efficiency	Agree	2.1	0.2
84	Engineering work cannot be evaluated with tools that are used in manufacturing firms, such as time-and-motion studies	Agree	2.7	0.2
85	The principle behind a cost-of-quality system is not realistic, at least as it relates to projects on which I work	Disagree	3.8	0.3
86	I believe that excessive costs-of-quality on a project suggests that clients are likely to experience added costs after plans are delivered	Weak Agree	2.9	0.3
87	Cost-of-quality accounting might be useful in identifying expensive areas or activities	Agree	2.1	0.2
88	As a supervisor, I think that historical cost-of-quality data could be useful for fee estimates	Agree	1.9	0.1

(See Appendix L for complete survey data and calculations)

The Firm occasionally uses construction administration issues as a measure of quality of engineering work. Higher quality engineering work tends to minimize construction administration issues, such as change orders, requests for information, and disputed product submittals. In the experience of this researcher, construction

administration issues have been known to degrade an engineering firm's reputation and cost money in terms of extra work, charge-back[6] expense, and lawsuits. There appears to be more than a passing level of annoyance among participants and other staff related to internal quality issues:

> "I do find that people actually are more frustrated when doing things more than once for any number of reasons. So for doing one thing correctly the first time is much more pleasing to everybody." (Participant N72)

Discussion of symptoms of quality problems in participant interviews appear to be related to shortcomings within (1) *communications* and *coordination*, and (2) *standards*, which are discussed below. These issues are not trivial, and influence the common worker's day-to-day activities.

Communications and coordination are issues that are linked. Design decisions by engineers and architects affecting other technical disciplines in the design process are common. From personal experience as a design engineer, this researcher knows that communications issues arise when one individual or group withholds information, usually by ignorance or neglect, that other individuals or groups would find valuable in order to avoid mistakes or unnecessary work. Coordination, on the other hand, refers to collaborative, two-way communication between individuals or groups needed to efficiently address design issues. Communication and coordination among the disciplines avoids potentially embarrassing and costly conflicts that affect budget, schedule, and quality.

This researcher has recognized in daily work that many participants in staff and management have, at one time or other, pressed for standards to guide the production of engineering and architectural plans. Since the Firm maintains multiple disciplines, adherence to uniform drafting standards would promote professional-looking plans and allow project's CADD work to run smoothly. Drafting standards encompass multiple aspects of drafting work. Very briefly, they include:

---

[6] An extra cost recognized by the Client that is known to have been caused by an architect/engineer's error or omission is frequently deducted, or "charged-back" to the architect/engineer by reducing payment of engineering fees due by the extra cost.

- *Standardizing software settings* - In order to be flexible for many types of drafting, CADD software developers build in hundreds of software settings that allow drafters to fine-tune their work environment, and to control the look and feel of the final product. With so many settings, variability among the different drafters results in coordination issues, printing problems, and annoying quirks in the operation of the software that cause delays and taxes productivity.

- *Standardizing graphic details* – Publications such as *The Architectural Graphic Standards* (Sleeper, et al., 2007) provide guidance to drafters on style and format issues. However, some disciplines are more rigorous than others in their approach to graphic details. This disparity wastes time and makes it difficult for a project to maintain consistency required for plans with a uniform and professional appearance.

Table 4.11 – Consensus of Significant Statements Related to Quality Awareness

	Significant Statement	Consensus	$\bar{x}$	SE$_x$
89	If you don't check plans and specifications, you're in trouble	Agree	1.4	0.2
90	The first plan check is designed to reveal 70% of the problems, the second check reveals another 20%, and the third check reveals yet another 5%; the remaining 5% of error is beyond the capability of most processes	Agree	2.1	0.3
91	There is a value to a "systems" approach to quality that relies more heavily on preventing errors rather than finding and fixing errors through a plan checking/design review process	Agree	2.0	0.2
92	I believe that the performance of a work system is not the same as the overall performance of all employees that work in the work system	Agree	2.4	0.3
93	While there are certain activities that are repetitive, engineering and architecture projects are all unique and, thus, more prone to error	Agree	1.9	0.2
94	A plan checker rarely has the specific knowledge of project conditions to perform a thorough review	Weak Agree	2.8	0.3
95	It is my job to check my own work in order for the checking process to be effective	Agree	1.3	0.2
96	Quality audits never distinguish high or low quality projects, only whether the staff conformed to the quality process	Agree	2.3	0.3
97	Project managers don't share with the staff information they obtain from construction administrators regarding lessons learned	Agree	2.4	0.3
98	Principle disciplines should communicate when the design is in the early stages before there is a large commitment in drafting and design time	Agree	1.1	0.1

(See Appendix L for complete survey data and calculations)

Communication, coordination, and standards issues are not trivial. They affect workers directly and daily, but are concepts that are not necessarily associated with quality management. However, there are larger, attitudinal issues that relate to quality awareness that appear to be embedded in the Firm's management culture. These issues are discussed in the following subsection.

4.3. THE FIRM'S QUALITY SYSTEM

As participant interviews progressed, this researcher increasingly perceived a fundamental gap between perspectives of supervisors and staff participants towards quality management verses quality management principles that a CoQ system was designed to promote.

Crosby (1980) was a strong advocate of CoQ as part of a quality system, and he measured quality awareness on a progressive scale known as his "Quality Management Maturity Grid." In the context of that Grid, quality awareness is a management attitude that appreciates quality from a systems perspective. Since a CoQ system is intended to promote a systems' perspective, it is useful to search for clues from respondents that suggest an acceptance, or at least an understanding of that concept.

In addition to participant interviews, this researcher gathered other data, in the form of meeting notes, memos, and procedure manuals so as to better understand the Firm's position on some of the more basic principles of quality management and to explore whether certain perspectives of quality thinking entrenched in the Firm's culture tends to obstruct support of a CoQ system.

The Firm is not without its share of critics. This researcher believes that its harshest critics on the subject of quality are internal. However, there are those who defend the Firm's quality system:

> "…keep in mind that what we do here is not a kind of manufacturing, which is what a lot of the time quality work studies are done. Everything we do here is unique and we do use the same processes over and over again… but every project was unique, created on a whole new cloth… which means its ripe for error for people who don't apply the system correctly, or didn't know the system in the first place, or too busy to apply the system… it's not like the assembly line process that by the time you work out the kinks you get a quality product in the end." (Participant P54)

"The system" to which the participant was referring is the Firm's quality system. While this system is not consolidated in a single manual, it has received corporate-wide exposure through a presentation in 2006. In that presentation, the Firm's corporate quality director identified three major components (Crawford, 2006): (1) the quality plan, (2) engineering calculation and plan reviews, and (3) quality audits. As the description of these components will reveal, the Firm's quality system is heavily biased towards activities that the CoQ philosophy would consider "appraisal" activities.

Quality System at the Firm
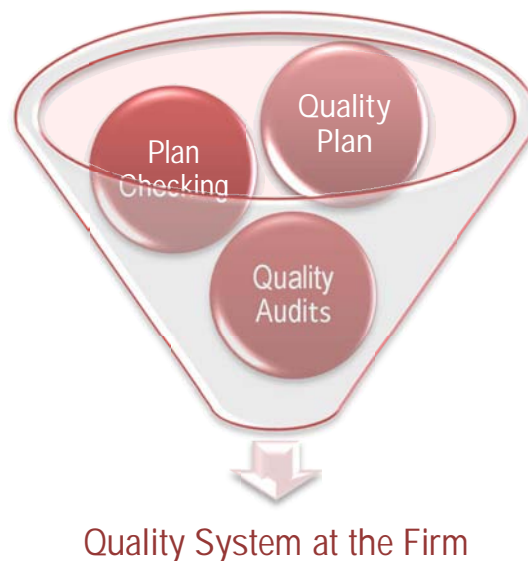
Figure 4.4 – The Firm's Quality System

First, the Firm's system requires a *quality plan* for all new projects and requires that it consolidate key information and planned activities deemed important to achieving client's quality expectations in the project. This includes the project requirements, key members of the project team – especially identifying project quality reviewers, and the level and schedule of document reviews. The Firm codifies the quality plan in the "Project Quality Control and Assurance Plan," a procedure found in the "kick-off" section of the *Firm's Project Management Policies and Procedures Manual.* (Parsons-Brinckerhoff, 2001)

Another key component of the quality system is *plan and engineering calculation reviews*. Review of plans or *plan-checking* is a process by which the Firm's final product, engineering and architectural plans, are reviewed and verified before they are published. Participants believe that plan-checking activities make up the centerpiece of the Firm's quality system. It is interesting that participants acknowledge that plan-checking is a process that is far from perfect and compare it to a sieve or sifting process that filters out errors with a finite efficiency.

"…My understanding is that the first check will get rid of 75 percent of the problems; the recheck will get rid of the next 20 percent of. The next 5 percent is beyond most processes…" (Participant P54)

Participants also know that plan-checking involves multiple iterations, each consisting of plan-checking, rework, and redesign activity; and believe that it is only after the third iteration that the process becomes uneconomic.

The checking process is arguably the single most recognized activity by the staff that is related to quality assurance and it is not known to be simple. Figure 4.5 explains the necessary steps for checking of design drawings from the quality director's 2004 presentation on the quality system. In addition, the Firm also codified plan-checking in several of its procedures. Two of these published internal corporate documents include:

Design Drawing Checking Flowchart
QP Procedure 6.6

Designer and CADD Operator Develop Drawings

Drawings Reviewed by Task Leader

For Project Milestones Drawing is sent to Checker for Review with check-print stamp

Checker marks up drawing in red with corrections and sends back to Designer - CADD Operator

If there is any disagreement between the Designer and checker, the task leader shall resolve all open issues

Designer - CADD Operator makes the corrections and the Checker verifies that the changes were made by using yellow color

Revised print of drawing is produced and signed "corrected by" Designer -CADD Operator

If checker is satisfied that all corrections are completed, he signs the check print stamp. If not the drawing is sent back to the Designer - CADD Operator or task leader.

Revised print with corrections is sent back to checker for Back-checking

Figure 4.5 – Checking Procedure for Plans from the Firm's Quality Director
(Reprinted with permission: Ray Crawford, PB Americas, Inc.)

- (1) "PD 206: Technical Reviews and Project Verifications," a guideline on when to perform plan-checking, and other appraisal activities, such as design reviews, project audits, and

- (2) "TEC 301: Checking of Design Deliverables," a procedure checking design work. It discusses, step-by-step, the process of plan-checking.

The *quality audit* was less understood among participants. Mentioned in only one participant interview, the quality audit was described by the participant in terms of the duties of the project quality auditor:

> "A project auditor tries to confirm that the quality process has been applied to a project… that the files are kept the way they are supposed to be kept, the checking is done the way it is supposed to be done, and as part of our renewal of ISO9000 certification, that we conduct internal audit summaries annually, and that there is also a UL [Underwriter Laboratory] third-party auditor that comes in and does the same thing. Basically, [the Firm] has a published quality program. The audits are to determine if we follow our own program." (Participant P54)

Some members of the staff perceive that audit findings are a practical measure of quality. At one of the participant orientations, an architect attempted to minimize the necessity for a CoQ system as a means for tracking quality. Paraphrased, she said:

> "[The Firm] does have a measure for quantifying quality… when we look at audit findings and we can gauge quality level by the number of adverse findings."

Participant P54, who described the quality audit (see above), and served as an ISO 9000 quality auditor, was not convinced that the auditing process was designed to demonstrate a project's level of quality:

> "It just says 'do you have the files?' 'Do you have the records?' 'Do you have copies of the checked sets?' 'Is the project manager planning?' 'Who are the people on the project manager's plan?' 'Is there evidence that you are following the process?' In the files, it doesn't say 'was this a good project or a bad one?'… It never says that." (Participant P54)

Participants agree that quality audits are not an effective means of measuring project quality, but merely a verification of compliance with the prescribed quality system.

As components parts of the Firm's quality system, the quality plan, plan review, and the quality audits begin to clarify the Firm management's predisposition towards two main weaknesses: (1) a reliance on inspection and other appraisal activities, and (2) a reliance on personal accountability.

4.3.1. Reliance on Inspection and Other Appraisal Activities. Previous discussion on plan-checking focused collectively on worker perceptions. However, this researcher has observed examples of management behavior that suggests a strong reliance on verifying quality at the end of a process as a means of ensuring quality rather than focusing on steps taken before the process to prevent poor quality. While not an advocate of quality costing, Deming (2002) lectured companies not to rely on appraisal activities. He provocatively portrayed the practice of sifting through the factory's production and removing the defectives as "you burn the toast and I'll scrape." One of Deming's 14-points includes the admonition:

> "Cease dependence on inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place."

Deming (2000) explained that there were two ways to make conforming products: (1) separate the bad from the good by careful inspection, or (2) adjust the production processes to shrink variation. The Feigenbaum CoQ methodology presupposes that a firm guided by the CoQ improvement model would undertake critical self-assessments and realign its thinking, resulting in a fundamental shift away from a reliance on appraisal to a prevention-based approach. The risk posed by entrenched attitudes towards appraisal in quality management by the Firm's management is worth exploring. In addition to personal observations, a subsequent round of interviews was conducted that examined management perception of quality.

This researcher's first observation was at a technical leadership training session held at the Firm's local office and involved the topic of quality reviews. Leadership training sessions are conducted regularly on a variety of topics of interest to new and prospective project managers and are normally scheduled during lunch so attendance is always voluntary. At least one senior manager can be found in attendance to either deliver the presentation or to merely offer guidance. The subject matter of this session

apparently resonated with many individuals because it attracted a healthy crowd, including senior engineers and architects, drafters and designers, and at least a half dozen senior managers.

The presentation by the session coordinator's centered on the formal plan-checking process, which he characterized as the key means of ensuring quality of plans and specifications. With so many managers and supervisors in attendance, the session quickly evolved into an open discussion, becoming an excellent opportunity to obtain the perspectives of so many managers in one place about the topic.

Most managers in attendance offered anecdotes related in some way to a personal quality horror story. The tenor of the conversation firmly expressed the consensus among managers present that quality issues were the direct result of failure to apply the plan-checking process. The discussion seemed to include every angle of plan-checking, including the importance of:

- Submitting plans to a checking process before delivery to the client.
- Budgeting for checking activities in project planning.
- Scheduling sufficient time for plan-checking activities.
- Ensuring that checking of plans and specifications conforms to established procedures.
- Ensuring that individuals check their own work before official plan-checking activities.

While it was understandable that the session focus on plan checking, it was not reasonable that there would be no mention of prevention-based quality activities, especially with so many senior managers present. In fact, one senior manager in attendance took the opportunity to propose a revised quality management procedure. See Figure 4.6 for a summary of the plan-check process described in the memorandum distributed at that session and see also Appendix M for a copy of memo itself. Focused on the plan-checking process, the memo suggested that the Firm places a high priority on plan-checking as a component part of the quality process:

> "… this quality management procedure addresses the minimum
> requirements for activities that are critical to delivering quality
> architectural services to our clients and internal customers."

CHECKING	BACK-CHECKING	CORRECTING	VERIFICATION
• completed plans checked for accuracy and forwarded to a back-checker	• checked plans re-reviewed by the originator and forwarded to a corrector	• combined comments from the checker and back-checker incorporated in the plans and forwarded to a verifier	• corrected plans are compared to the mark-ups from the check and back-check steps.
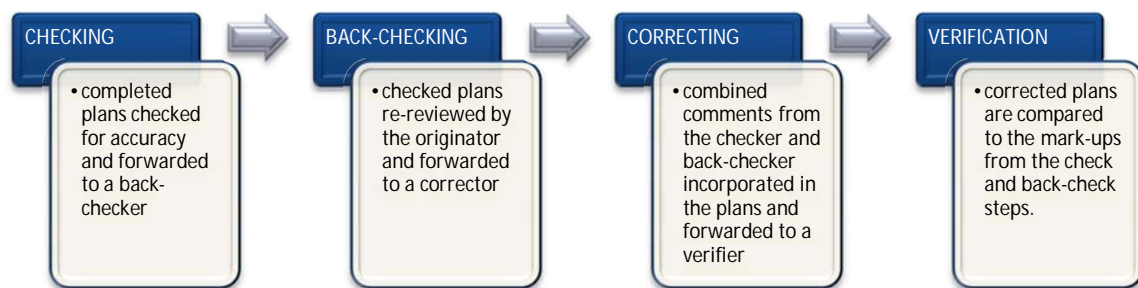
Figure 4.6 – Summary of Proposed Checking Procedure in the Manager's Memo

The procedure described in that memo added complexity to the process described in the Firm's directive entitled "TEC 301: Checking of Design Deliverables." (Parsons Brinckerhoff, 2009) See Figure 4.7 for a summary of the plan-check process described in the directive.

CHECKING	BACK-CHECKING	APPROVAL
• completed plans checked for accuracy and returned to the designer to incorporate corrections	• corrections from checker incorporated and corrected plans submitted for approval	• checker or another person verifies the corrections and approves the corrected plan
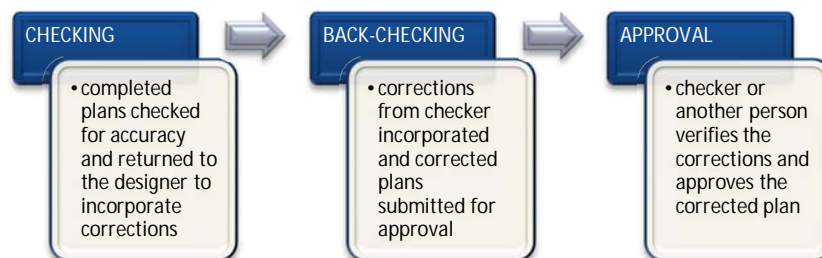
Figure 4.7 – Summary of Checking Procedure in the Firm's Existing Directive

Since a Firm directive explaining the plan-checking procedure already exists, a new memo that expands the procedure, introduced and accepted among a large gathering of managers, demonstrates a management preference to address quality issues with more appraisal activity, rather than devise prevention-based solutions,

Management and supervisory participants admit that there are weaknesses to the plan-checking and quality audit processes, but it has a long history. Mandatory or not,

participants agree that all ethically-conscientious project managers apply some form of plan-checking to final deliverables.

Table 4.12 – Consensus of Significant Statements Related to Appraisal

|	Significant Statement	Consensus	$\bar{x}$	SE_x
99	This quality management procedure addresses the minimum requirements for activities that are critical to delivering quality architectural services to our clients and internal customers	Agree	2.1	0.4
100	It has the ability to improve the product quality at the end level. It does not verify that everything shown on the drawing is correct, but that it does coordinate	Agree	2.2	0.2
101	It only injects quality into the format of the end product. It does not look at the quality of the input to the end product and it does not evaluate whether all of the decisions that lead up to what's reflected in that end product were appropriate decisions. It only reflects an evaluation of the document itself	Agree	1.4	0.2
102	In one version or another, it's been in effect since I've been here. They've changed it… periodically revise it… but it's basically the same…. First of all, it's very hard to implement on a fast moving project and on a project where you don't have a lot of money to spend on getting it done	Agree	2.3	0.4
103	Certain tasks shown in here are done almost automatically by any ethically conscientious project manager	Agree	1.7	0.2
104	As this form exists, there is no verification of any of these certifications. It's just a statement that 'yes, I did this... or we did this.' As such, I think the form as you presented it does nothing to improve quality. It's just a statement that says 'we did something'	Agree	1.8	0.3

(Statements 99 thru 103 refer to the manager's memo *quality management procedures* and statement 104 refers to the form *project quality certification;* see Appendix L for complete survey data and calculations)

The plan-checking process does not have the ability to verify that contents on the drawings are correct; participants believe that it is because the checking process cannot ordinarily evaluate all of the designer's decisions that contributed to the final design. Supervisory and management participants agree that a comprehensive plan-checking process plan is difficult to implement well on certain fast-moving and low-budget projects, and plan checkers rarely have knowledge of important factors related to the project. On the plus side, participants believe that a careful checking process can inject some level of quality at the end of the process, such as drawing format and issues related to coordination among the different disciplines working on the project.

4.3.2. Reliance on Individual Accountability. Engineering and architectural work documents have historically disclosed the identity of key persons involved in the preparation and review of engineering and architectural plans, reports, and calculations. The U. S. Department of Defense (1997) actually mandates that engineering professionals display this information in this way. Engineers and architects use an inked stamp or embossed seal issued by a state licensing board to "certify" calculations, reports, plans, and specifications (See Figure 1.2) indicating that they are individually liable for their integrity, competence, and due diligence. As such, government agencies and other entities will accept the certification of a professional engineer as evidence that a shackle can safely carry a loaded shipping container, a bridge can be safely crossed by heavy trucking, or a school can be safely occupied by students and faculty. The public expects personal accountability from engineering professions.

In addition to the public perception, professional training of engineers and architects tends to reinforce the attitude of "lone practitioner." A participant manager described the nature architectural education in general:

> "An architect's schooling doesn't really provide much background in teamwork and collaboration. It's more individuals working as an individual on projects so you don't have an overall project leadership and management training in academics." (Participant F2)

Not only are architects not trained in teamwork and collaboration, their testing reflects the heavy weight of individual performance. A description below explains a portion of the multi-day exam required by the state for licensure as an architect. As with any exam, successful completion is an individual effort, but the account of the design portion of the exam was significant in that it tested knowledge of the design process, start-to-finish:

> "One day was solving a design problem, given a program at seven in the morning, given till something like four or five in the afternoon to come up with a design solution and to document it with plans, elevations, sections, and such. The object there was to be able to delineate your understanding of the building codes, have the ability to satisfy spatial relationships, to conceptually design the building systems: structural, mechanical, electrical, and such, and to illustrate a building envelope and lend architectural character to it all." (Participant F2)

In actual practice, it is unlikely that an architect (or engineer) works in a solitary environment such as this. However, the intense, day-long ordeal speaks to the role of personal accountability in architectural training and the achievement of professional credentials.

In the technical leadership training session described in Subsection 4.3.1, this researcher also observed the discussion of another key point: the individual responsibility of workers to check their work before submitting to plan reviewers for official plan-checking activities. It is undeniable that self-checking is an important step, however, in this forum dominated by supervisors and managers, the mention of orientation, training, coordination or coordination activities, or any other process or activity that might reasonably be construed as a management function was conspicuously absent from the discussion. The conversation among these managers was clearly focused on holding employees individually accountable.

One exhibit distributed by the coordinator of the session was a form, entitled "Quality Assurance Review Certification." (See Appendix N) Properly applied, the form required the project manager, task managers, and all persons assigned to perform plan-checking to sign and date that certified the following affirmation:

> "A Quality Assurance Review has been completed by the QA reviewers indicated below. The specific project document(s) and/or task(s) stated above were reviewed with the intention that the design and associated tasks regarding this project were undertaken in accordance with accepted engineering practices and requirements set forth by the Client. All work has been reviewed in regards to its technical soundness, ethical content, and cost effectiveness."

Among most participant managers and supervisors, this form does not provide any assurance that the certified plan-checking reflects an acceptable level of "technical soundness, ethical content, and cost effectiveness" and, thus, does nothing to improve quality. Why, then is it used?

In this researcher's experience with manufacturing, certifications have been required of suppliers by some firms as a verification tool where other appraisal methods, such as demonstration or testing, were not available, or were deemed too impractical or unnecessarily expensive. Such a certification consisted of a statement of affirmation that

calls attention to certain key requirements of the goods or services delivered. As a certification, it is required to be signed and notarized by one or more of the supplier's key employees. A common certification might be:

> Company ABC certifies that all electrical materials delivered under project X have been made in the U.S.A.

> Or…

> Company XYZ certifies that product contains 50 percent of post-consumer recycled content.

As a verification tool for supplier goods, a product certification (1) provides a ready-made legal tool to take legal action against non-conforming suppliers, and (2) focuses the supplier's key employee attention on the requirement. As a tool to verify certain internal quality activities, its value appears to be less apparent. It may plausible that the certification could be used to put those employees acting as quality reviewers on notice to be particularly attentive to quality issues described on the printed affirmation. It is not plausible that the certification could be used by a firm to sue one of its own employees. If, in the judgment of management, the document under review did not receive a thorough review with respect to, say, "ethical content" (see the quotation above) would it be necessary to have such a form in order to begin disciplinary action against the employee? The requirements such as technical soundness, cost effectiveness, ethical content listed in the affirmation are arguably elements that should be "managed" rather than simply "affirmed." Does this form indicate a management reliance on personal accountability?

One of Deming's 14-points of management, "Eliminate Slogans" directly addresses this issue. (Gabor, 1992) Deming discouraged slogans and exhortations. He advocated that employees do not make mistakes, but merely deliver mistakes embedded in the process; preaching to workers without corresponding improvements in the processes that they use was counter-productive. In the following discussion, the Firm has placed placards at strategic locations around the office for viewing by workers. Some participants report that the signs appear to workers accountable for issues that are beyond their control.

In the drafter group meeting, this researcher observed a forum on drafting standards that included several supervisors and most drafters in the office. The meeting was a management inquiry of drafting problems and could be characterized as complaint session. One grievance expressed by several drafters involved a perception that drafters were being held accountable for the quality and appearance of engineering and architectural plans, and that due to issues related to drafting standards (or more accurately, the lack of drafting standards) there were certain quality issues that were beyond their control. She objected that posters hung at strategic points around the office (See Figure 4.8) added to the frustration because they suggested that "we're too lazy or we just don't care" enough to produce neat, consistent, and coordinated work. She explained that drafters want to produce quality work, but the lack of coordination, lack of direction, and lack of standards stands in the way.

Figure 4.8 – Posters Exhorting Quality Messages in the Local Office

5. CONCLUSIONS AND IMPLICATIONS

5.1. GENERAL DISCUSSION

Findings in this exploratory study serve to address dysfunction issues related to self-reporting bias, thought to be the central concern of personally-recorded CoQ data. The study focused on several behavioral factors that were believed to address those dysfunctions: *anxiety*, *cognition*, *apathy*, and *veracity*. Very early in the interview phase, however, it was believed that an additional factor, *quality awareness*, was a significant influence as well. These initially-conceived factors encompass biases that substantially address the mechanics of recording CoQ activities by the ordinary worker.

While these biases are not trivial, they appear to be factors that could be addressed by measures that are reasonably nonintrusive. However, as data collection and analysis continued, this researcher observed additional *management* biases. These biases: *management's reliance on* (1) *appraisal activities*, and (2) *personal accountability*, substantially affect attitudes among both management and staff and have the potential to be more toxic to a CoQ system than issues related to self-reporting bias.

As a result, the study has come to examine issues from a perspective of both employees and management. Implications from those perspectives may provide guidance to the manager or quality practitioner tasked with implementing a CoQ system within a traditional engineering firm.

5.2. STAFF IMPLICATIONS

5.2.1. Anxiety. Findings of this study demonstrate that workers believe that they can record personal CoQ data within an acceptable level of safety. While participants are not willing to concede the system as totally without risk, there is a certain professional attitude that the system has potential value that surpasses its motivational benefit. Supervisory personnel recognize the value of personal data that can effectively become a worker's history of quality-related behavior… good or bad. However, supervisors also believe that there are more efficient ways of rating and ranking workers, and that CoQ data that is aggregated from all workers in a group would be more useful.

Austin (1996) described pure informational measurement as a narrow concept within performance measurement theory whereby bias can be eliminated if all motivation – positive or negative – is removed. That means management has an important role to set the tone for such a system. Launching a CoQ system with appropriate ethical guidelines and a clear statement of purpose that emphasizes the value the system to promote quality improvement, while playing down any motivational component – good or bad – could send a clear signal to workers that a CoQ system is nothing to fear.

5.2.2. Cognition. Findings of the study demonstrate that the complexities of a CoQ system is not beyond an ordinary worker's ability to comprehend. Some participants were somewhat paralyzed by the prospect of recognizing a particular activity from among 47 different CoQ activities. Some participants assimilated the entire color guide and had no difficulty with any of the activities; and some participants found that they could relax and focus only on a select few activities that, for most activities, applied only to them.

Most found the combination of the orientation and the color guide reference to be helpful in day-to-day recognition of CoQ activities. However, the level of complexity was too much for some. Pace, et al. (1985) warned that a respondent's understanding of the system is a key factor in the quality of their reported data. Management may find an acceptable solution by designing a CoQ system that incorporates more training aids and fewer CoQ activities to assimilate. This could be accomplished by (1) reducing the number of activities or (2) managing activities so that workers are exposed to only those activities they are likely to encounter, and at the times they are likely to encounter them.

5.2.3. Apathy. The findings of this study demonstrate that the system devised to collect CoQ data – the recording tool – was an appropriate mechanism for participants to report their CoQ activities. Most workers have at one time or another recorded their time in multiple ways and found that the recording tool was intuitive to operate and superior to the user-friendliness of the Firm's timesheet process. Supervisors recognized other issues related to CoQ on official timesheets, such as unwanted exposure of CoQ data to clients.

Data recorded during the awareness exercise suggest major lapse in recording activity. While some participants reported occasional lapses, most believe that they were quite diligent, especially when recording activities of short duration. Participants believe

that management can encourage compliance by publishing CoQ data as close to real time as possible (as opposed to a single report at project post mortem). Other reminders that would keep workers actively thinking of CoQ activities might include regular CoQ training sessions and professional papers on the subject.

Considering participant responses related to cognition, it is possible that the lack of understanding of all 47 activities played a significant role. Solutions by management to improve cognition of the CoQ system would likely improve compliance as well.

5.2.4. Veracity. Findings of this study suggest that workers would not be inclined to deliberately conceal or exaggerate CoQ data that they report. In one way, this theme is linked to anxiety: participants recognize the temptation to conceal data that reflects poorly on them. However, participants do not agree that a CoQ system would trigger a rise in disciplinary activity.

According to Cronbach (1970), however, deliberate deception is not necessarily the challenge. Cronbach believed that respondents cannot be expected to act impartially when providing self-reported data. As the observation in Section 4.2.8 illustrated, workers can sometimes delude themselves, leading them to mischaracterize their work, resulting in a distorted report of CoQ activity. This type of bias cannot always be readily identified. However, with a reasonable degree of vigilance, management might be able recognize some of the more flagrant examples. Since these situations do not reflect deliberate deception, simple education may neutralize the bias.

5.2.5. Quality Awareness. Examination of quality awareness among the staff calls attention to an interesting irony. Participant staff is familiar with the platitude "do it right the first time" and associate it with a personal effort and attention to detail. However, staff participants have expressed frustration at several ongoing problem areas related to *communications*, *coordination*, and *standards*. (See Section 4.2.9 for discussion of these) The Feigenbaum CoQ approach promotes prevention-based quality activity. Each of these problems is addressable, even solvable with prevention-based activities, yet overwhelmingly, participants associate quality management with appraisal-based activities, such as plan-checking.

Quality awareness is an interesting theme that links staff and management and dovetails into management implications.

5.3. MANAGEMENT IMPLICATIONS

5.3.1. Management Reliance of Appraisal Activities. Management relies heavily on the plan-checking process to fix mistakes and to ensure that plans and specifications conform to a reasonable standard of care. Realistically, the Firm's management understands that the plan-checking process has limitations. Still, there appears to be widespread acceptance to plan-checking by both staff and management.

Management promotes comprehensive appraisal activities, particularly plan-checking. However, in actual practice, projects often encounter budget and schedule obstacles that cause staff to scale back plan-checking activities, particularly on smaller or fast-moving projects.

These two prevailing attitudes do not co-exist well together. Carefully-designed prevention activities as defined by the Feigenbaum model undertake to reduce error-correcting activities and, at the same time, minimize appraisal activities. The Firm management's disproportionate focus on appraisal activities understandably restrains prevention activity. Without adequate prevention activities, design and drafting work accumulates more error that results in lower quality and a heavier burden on the plan-checking process. Since the efficiency of the plan-checking process is finite, lower quality check-plans going into the plan-checking process understandably yields a lower quality set of finished plans delivered to the client. With less comprehensive appraisal activities on low-budget or fast-moving projects, plan-checking efficiency is driven to even lower levels.

The Firm's management currently attributes quality deficiencies to improper application of the plan-checking process. Their solution is to devise more oppressive plan-checking procedures steps, rather than develop quality processes that reduce the need for appraisal activities. The application of the cost-of-quality approach encourages management to track the interplay between good quality and bad quality costs, with the ultimate goal of reducing both error and appraisal costs with properly-designed prevention activities. However, while the Firm's management understands the economics of plan-checking and is willing to pay for it up to a certain point to obtain an acceptable level of quality, it has no such appreciation for the economics of prevention-based activities… a significant impediment to application of a cost-of-quality approach.

5.3.2. Management Reliance of Personal Accountability. At first glance, it is peculiar to examine personal accountability as a concept that might be negatively-related to quality in general and the receptiveness of CoQ principles in particular. The competent manager would most certainly select personal accountability as a key virtue necessary for a smooth-running and high-performing operation.

There is a long tradition of personal accountability in engineering firms. The marks of personal accountability can be found in many aspects of design engineering and architectural culture. Except for certain administrative areas, such as marketing, accounting, and legal, most managers are experienced engineers or architects.

Examined closely, evidence suggests that the concept of personal accountability is perceived differently by the Firm's management and the staff.

Staff perceives the concept of personal accountability as the responsibility to deliver work on time and reasonably free of error. However, that perception presupposes a work system where standards are present and coordination and work-related communications are timely and complete. Staff workers perform with varying degrees of success in an environment where standards, coordination, and communication are deficient. Staff workers appear to measure their ability to perform their work in the context of their work system and their own technical skills.

On the other hand, the Firm's management also perceives personal accountability as the responsibility to deliver work on time and reasonably free of error; with far less regard, however, for the work system. Statements and behavior of the Firm's management suggests that coordination and work-related communications are personal responsibilities and not necessarily a systems element that must be designed and optimized. Instead, management appears to recognize workers within a project's staff as resources in toolbox of sorts, each with a resume of skills. By staffing a project with the correct mix of technical and supervisory skills, management perceives that professionalism of individuals serving on the project team will organically give rise to a system for that project that resolves standards, communications, and coordination issues. Standards-related errors, communication-related errors, and coordination-related errors are not perceived by management as systems failures, but as individual failures.

As a result, Firm management leave themselves with very few quality tools. In an environment of this style of personal accountability, management relies on verification methods as a means of ensuring quality. In the case of an engineering firm, verification methods are plan-checking, design-reviews, quality certifications, and quality system audits.

Systems design and optimization is a prevention activity and, as such, key to the value and success of a Feigenbaum CoQ system. Heavy reliance on appraisal activities and personal accountability is, unfortunately, a formidable barrier to meaningful prevention-based thinking. Unless management is receptive to these concepts, they would be most likely unreceptive to a system that advocates these activities.

5.4. SUMMARY

Since this research problem related to engineering firm employee and management perceptions, a phenomenology study was an appropriate approach. The process was guided by Colaizzi's (1978) proposed a seven-step "explication" process for phenomenology research with significant reliance on Creswell (1998) for specific elements of methodology. Underlying each phase of the process was a consideration for dysfunction that could interfere with the application and use of a CoQ system in an engineering firm involving personally-recorded data.

Phenomenology seeks to obtain the essence of an experience directly from subjects experiencing the phenomenon. Unfortunately, this researcher knew of no known engineering firms that used a cost-of-quality approach to monitor quality. As a substitute, staff of an actual construction/renovation project at a local engineering firm was sensitized to the subject with an "awareness exercise" in order that employees might experience firsthand a CoQ system that required personally-recorded data.

The phenomenology process used to obtain data was an exploratory activity. Concepts derived from reading other works that address self-reporting bias directly or peripherally were used to devise an investigative framework. Those concepts: *anxiety*, *cognition*, *apathy*, and *veracity*, became a starting point for participant interviews. Participant experiences in the interviews quickly gave rise to a fifth concept: *quality awareness* that began to show its possible relevance to CoQ system dysfunctions.

While the interview process is the central data source within phenomenology process, other observations in the engineering firm environment, such as meetings, memos, and company directives, began to show relevance. It is from these observations that two additional concepts: *management reliance on* (1) *appraisal activities*, and (2) *personal accountability* began to reveal significant relevance. It also demonstrated that dysfunction was not confined to the CoQ measurement process.

The goal of the study was to understand biases that could contribute to dysfunctions in a system of recording and applying cost-of-quality data, from the perspective of both engineering staff and management. These biases were revealed and explained during the course of the study and analysis.

6. AREAS FOR FUTURE RESEARCH AND PHILOSOPHICAL COMMENTS

6.1. SUGGESTIONS FOR FUTURE RESEARCH

6.1.1. Case Study on Behavior of CoQ. Unlike a product or process manufacturing environment, daily quality costs for an engineering firm are not expected to be uniformly distributed. Instead, this researcher expects that different phases of the project would be punctuated with specific CoQ expenditures at different points in the life of the project. One key reason would be simply that project labor costs are not uniform throughout the project, so CoQ costs would not be expected to be uniform. It is also expected that certain familiar project activities are likely more heavily-weighted towards one particular type of CoQ. For example, as the project gets underway, more prevention activities are expected. As the project approaches client submittals, more appraisal activities are going to be recorded. In the end, it would not only be useful to see total CoQ, but also its behavior as the project progresses.

In order to normalize the first element of variation related to level of project labor throughout the project, a case study that proposes to compare the weekly and total CoQ expenditures with total project labor and total project revenue could be useful. Hours and revenue seemed ideal bases from which to compare CoQ because they would link CoQ to the project's activity level. Weekly CoQ costs versus total project hours and accrued revenue, week-by-week, could be expected to be a fairly reliable indicator that could be used to infuse some measure of repeatability so one project might be able to be compared to another. The awareness exercise began as a case study of the behavior of quality costs in an engineering firm. Staff was selected and preparations were made to begin recording data that would eventually be examined for its costs in the five Feigenbaum categories described in this research.

6.1.2. Case Study on Streamlining CoQ Activities. Many participants found it difficult to internalize the 47 CoQ activities devised for the awareness exercise. It is clear that in actual practice, firms may find that a more simplified list of activities could dramatically improve participation and reduce confusion.

With all of its variation, engineering design projects have known processes and predictable activities. A study that links CoQ behavior to these processes and activities

would be useful in devising a streamlined process for recognizing and recording CoQ. It may be determined that many activities identified in this study be consolidated or further subdivided to more closely match the realities discovered in the study.

Experts on the subject agree that when devising CoQ activities, it is counterproductive to enshrine questionable activities as CoQ activities where there is significant opposition, or if a CoQ taxonomy could cause confusion. Since CoQ is unknown among engineering firms, there is likely considerable opposition and confusion. Consequently, a study of this type would be no small undertaking. However, if the ultimate goal is a CoQ system that is uniform throughout an engineering firm or, more ambitious, uniform among most firms, it would be a valuable exercise.

6.1.3. Quantitative Attitude Survey. Opposition and confusion within an engineering firm comes part and parcel to establishing a meaningful CoQ system. Establishing such a system in a small firm is likely to be less fraught with difficulties when compared to a large enterprise firm. Still, there should be a way to systematically introduce such a system in a large firm so as to maximize its chance for success.

The Firm in this study had a portfolio of work that was exceptionally diverse, and a corporate structure that extended to all points around the globe. Such a firm could present a rare opportunity to use internal communications networks, such as internal email and corporate internal websites to query employees with a specially-crafted series of questionnaires. With such a large population and wide cultural, geographical, and technical diversity, it appears plausible to collect data that could demonstrate, statistically, the demographic factors that support or undermine acceptance of CoQ.

Preparation for such an investigation would require quite a few hypotheses that might explain employee behavior around an environment where CoQ is collected and used. The hypotheses discovered by this study could be refined and used to study a muli-office engineering firm using a specially-designed questionnaire for a large population of engineering practitioners. By statistical analysis, such a questionnaire could identify demographic factors that might support or undermine introduction of a CoQ system in an engineering firm.

There are variations in the business sector that such an engineering firm serves: government-sponsored infrastructure projects, such as roadways and bridges; institutional

projects, such as hospitals and universities; industrial projects, such as pulp and paper mills and oil refineries, private commercial projects, such as office buildings and parking garages. Engineering firms work differently in each of these sectors.

There are variations in cultures. Business is conducted differently in the United States than it is in the European Union, or in Latin America, or in Pacific Rim countries. These differences relate to business climate, regulatory environment, educational systems, and ethnic cultural diversity and play a large part in determining the working environment of engineering firms.

Engineering practitioners themselves are not monolithic. The diversity of technical expertise is extraordinarily large and getting larger with the passage of time. Educational level of the common practitioner, business demand, and the character of the work all can affect engineer attitudes and motivations.

When considering questionnaires, this researcher discounted the use of the subjective Likert-scale for designing questionnaires. Instead, questionnaire tools such as Guttman or Thurstone scaling (Trochim, 2001) are more likely to reveal deep-seated attitudes and biases. Concepts revealed in this study would be useful in developing the volume of statements required for a Guttman and Thurstone questionnaire.

With a scientific sample, data-mining techniques could be employed to develop a profile. Once the economic, demographic, professional, and cultural factors that are most conducive to collection and use of CoQ are identified, a profile of those factors that characterize virulent opponents and ardent supporters of a CoQ system could be developed. Such profiles could be fundamental to an enterprise-wide adoption plan for CoQ systems.

6.1.4. Qualitative Study on Management Attitudes. Lastly, the final two concepts within this work, "reliance on appraisal activities" and "reliance on personal accountability" were always in plain sight, but not recognized as a concept related to management's receptiveness to CoQ concepts and methods. This dissertation attempted to correctly characterize these management perceptions as they relate to CoQ. However, in the opinion of this researcher, these concepts are generally toxic to the advancement of quality at the firms and should be studied in more detail.

These concepts represent an internal struggle in the Firm that is usually hidden from view. Their particular indignity is that not only do they create a poor quality environment; they interfere with organic growth and progress of useful quality practices. Although well-intentioned, the mindset of these concepts pits management against staff in a destructive way. Hypotheses from a qualitative study that examines attitudes of both management and staff related to these concepts might be incredibly useful not only to the Firm, but to the engineering sector as a whole.

6.2. PHILOSOPHICAL COMMENTS

One of the conclusions identified in this research refers to a deep-seated bias by the Firm's culture in general and management in particular: the issue of quality by applying appraisal, or inspection of work. Activities such as plan-checking, design review, and auditing are mainstays of the Firm's quality system. It is also fair to classify these as verification activities.

Another verification method that appears to have its followers is the certification; that is, the written affirmation that testifies that certain work has been correctly completed. This certification is then signed by a responsible individual: a manager, supervisor, or plan reviewer, and then filed away with other quality records.

The tone of the conclusions may suggest that the author has an aversion to the use of verification and appraisal methods within an engineering firm. Nothing could be further from the truth. If the study appears to disapprove that the engineering firm culture wields tools such as plan-checking, plan reviews, certifications as this study proposes, it is only because the Firm's use of such tools precludes the use other quality activities that can be classified as "prevention."

To the outsider, it may seem that management abrogates their responsibility to train their employees, devise processes, plan activities, and coordinate between different departments. This would be incorrect. The technical and administrative demands of each project frequently leave no room for these types of activities. More likely, though, the concept of process design is an elusive one.

Managers in a design engineering operation are more likely to self-describe as building or bridge designers rather than designers of the process to design buildings or

bridges. As professional, engineers and architects are more likely to rise through the ranks because of their technical proficiency. While this does not seem an irrational scheme for filling management vacancies, it is interesting to note some parallels with a manufacturing operation:

Both engineering firms and product manufacturers desire to deliver quality products to customers (clients). Management in a product manufacturing operation delegates the production of their product to a workforce only after careful product and process design, plus some measure of training. By contrast, management is an engineering firm delegates not only the production, but also most product and process design activities to their professional workforce.

It would not be difficult, of course, to find a manager in an engineering firm that would virulently disagree with assertions equating manufacturing firms and engineering firms in any meaningful way. Still, it is not unimaginable to visualize the services engineering firms deliver to clients as a product whose "manufacturing" process must be designed and fine-tuned.   The challenge is to find the appropriate framework for both functional and project management to provide more planning for the engineering product and process.

APPENDIX A

COLOR GUIDE USED IN THE AWARENESS EXERCISE

Quality Cost Reporting Project

Meeting Handout

30 July 2007

Basic Definition of the Cost of Quality (COQ):

"Costs beyond pure value-added or the necessary cost of delivering value to clients on-time and without error.

COQ is the cost of doing things wrong and it includes PREVENTING, FINDING, and CORRECTING defective work."

COSTS OF GOOD QUALITY

APPRAISAL	PREVENTION	INVESTMENT
Activities that Find Error	"On-Line" Activities that Prevent Error	"Off-Line" Activities that Prevent Error

COSTS OF POOR QUALITY

INTERNAL ERROR	EXTERNAL ERROR	LOST OPPORTUNITY
Activities to Fix Error Not Seen by the Client	Activities to Fix Error Seen by the Client	Cost of Lost Business due to Poor Quality

Name of COQ element along with a classification

Additional factors that add to the basic description

2.2.1	**Back-checking Internal Error**	Internal Error

Verifying that redesign and rework to correct internal error was performed correctly.

Includes: Back-review and back-checking by managers, supervisors, designers, drafters and clerical persons; also includes preparing, printing, and copying check prints for review, and filing them after review.

But not:
- Original review and plan checking.
- Rework or redesign

COQ Category

Additional factors that are specifically excluded from the basic description

Basic description of the COQ element

4.1.4	**Coordination Planning**	Prevention

Activity related to ensuring that Work between technical disciplines or between different offices are coordinated so as to minimize effort and reduce rework due to miscoordination.

Includes: Preparation, meetings, emails, phone calls; also includes preparing, printing, copying, and filing documents.

But not:
- Activities related to verifying that engineering and architectural work conforms to project or company standards.
- Design review activities.
- Non-project specific architectural and engineering standards

How to read COQ data

Enter the number of hours spent on this particular COQ activity in the space provided.

Check "Direct Expense" if the activity involves an expense report or other "direct dollar". If you know the amount, add it in the space provided.

Form1

Project Information

Project Number:
30131

Hours:
5

**Project:
Parkway School District**

Direct Expense Cost

☑ Direct Expense   < Enter Cost >

COQ Information

☑ External Error   ☐ Appraisal   ☐ Investment

☐ Internal Error   ☐ Prevention

1.1.4 Post-Submittal Design Review
1.1.2 Rework External Error
1.1.3 RFIs
1.1.4 Post-Submittal Design Review
1.1.5 Post-Submittal Complaints
1.1.6 Other Direct External Error
1.2.1 Recheck External Error
1.2.2 Other Indirect External Error

Record   Clear   Cancel

Use the pull-down menu to select the proper COQ item; the pull-down will only show the items selected in the COQ category.

After all information is added, hit the "record" button to log your data.

Recording Data

Select the project number from the pull-down menu.

Check the appropriate COQ category. The COQ items in the pull-down menu below will only be from the COQ category checked here.

It will be helpful on some COQ items to explain the hours that were recorded. If extra information is desired, a hint will appear above the data box.

Recording Data

GROUND RULES

1. Log in as yourself in order to properly record time.

2. Record time on the same day it was performed.

3. Do not record time for others.

4. Do not disclose what you have recorded with anyone, even supervisors and managers.

5. Supervisors: do not disclose your reports to anyone.

PRIVACY

1. Your identity will not be disclosed... EVER.

2. Data will be reported ONLY as part of a larger aggregated report.

3. Managers will see reports based upon aggregated data from all participants... not from technical group or individuals.

4. Supervisors will see reports based on aggregated data from their technical groups... never individuals.

1. EXTERNAL ERROR

1.1.1	Redesign External Error	External Error

Activities by an engineer, architect, or manager related to correcting error discovered by the client, contractor, authority having jurisdiction, or any other entity outside the Company, except subcontractors, or correcting error discovered internally after final Work is submitted.

Includes: Calculations, research, redlining, meetings, phone calls, site visits, etc.

But not:
- Drafting and clerical activities, including printing or copying
- Back-review or back-checking activities to verify documents are correct after redesign

1.1.2	Rework External Error	External Error

Activities by drafter or clerical person related to correcting error discovered by the client, contractor, authority having jurisdiction, or any other entity outside the Company, except subcontractors, or correcting error discovered internally after final Work is submitted.

Includes: Drafting, typing, meetings, site visits, phone calls, printing, copying

But not:
- Activities by engineers, architects, or managers
- Back-review or back-checking activities to verify documents are correct after redesign

1.1.3	RFIs	External Error

Activities associated with collecting, reading, and responding to RFIs

Includes: Related copying and filing

But not:
- Related rework and redesign

1.1.4	Post-Submittal Design Review	External Error

Unscheduled design review meetings where final Work has been submitted.

Includes: Copying and printing documents for the meeting and preparation, printing and copying of responses to review comments.

But not:
- Back-review or back-checking activities to verify documents are correct after redesign

1.1.5	Post-Submittal Complaints		External Error

Answering questions from the client, contractor, authority having jurisdiction, or any other entity outside the Company after Work is submitted.

Includes: Calculations, research, meetings, site visits, phone calls, reports, emails, or any activity not included above that is associated with fielding questions about documents or designs after Work is submitted.

But not:
- Related rework or redesign

1.1.6	Other Direct External Error		External Error

Other activities related to responding to error seen by persons outside the Company that are not included above.

Includes:

But not:
- Activities that are described in indirect error category.

1.2.1	Back-checking External Error		External Error

Verifying that redesign and rework to correct external error was performed correctly.

Includes: Back-review and back-checking by managers, supervisors, designers, drafters and clerical persons; also includes preparing, printing, and copying check prints for review, and filing them after review.

But not:
- Original review and plan checking.
- Rework or redesign

1.2.2	Other Indirect External Error		External Error

Other activities to support effort related to responding to error seen by persons outside the Company, other than back-checking activities.

Includes:

But not:
- Activities that are described in direct error category.

2. INTERNAL ERROR

2.1.1	Redesign Internal Error	Internal Error

Activity by engineers or architects related to correcting error discovered by plan check, design review, coordination review, or self-discovered error.

Includes: Calculations, research, redlining, meetings, phone calls, emails, site visits, etc.

But not:
- Drafting or clerical activities, including printing and copying.
- Back-review or back-checking activities to verify documents are correct after redesign

2.1.2	Rework Internal Error	Internal Error

Activity by drafter or clerical person related to correcting error discovered by plan check, design review, coordination review, or self-discovered error.

Includes: Drafting, typing, meetings, phone calls, emails, site visits, etc.

But not:
- Activities by engineer, architect, or managers.
- Back-review or back-checking activities to verify documents are correct after redesign

2.1.3	Waiting due to Mis-Coordination	Internal Error

Non-productive time by drafter or clerical person related to waiting for a necessary activity by an engineer, architect, or functional group.

Includes: Actual time before substituting a productive activity.

But not:
- Ordinary period of inactivity not related to a missed coordination opportunity.

2.1.4	Other Direct Internal Error	Internal Error

Other activities related to responding to error not discovered by persons outside the Company that are not included above.

Includes:

But not:
- Activities that are described in indirect error category.

2.2.1	Back-checking Internal Error	Internal Error

Verifying that redesign and rework to correct internal error was performed correctly.

Includes: Back-review and back-checking by managers, supervisors, designers, drafters and clerical persons; also includes preparing, printing, and copying check prints for review, and filing them after review.

But not:
- Original review and plan checking.
- Rework or redesign

2.2.2	Subcontractor Corrective Action	Internal Error

Activities related to dealing with subcontractor quality/performance issues.

Includes: Meetings, phone calls, site visits, emails, research, etc.

But not:
- Subcontractor prequalification or other pre-contract activity
- Subcontractor scheduling activity.
- Design review or plan checking activity

2.2.3	Computer/Copier Problems	Internal Error

Non-productive time spent by managers, engineers, architects, drafters, and clerical persons due to copier, fax, or computer issues.

Includes: Repair or other maintenance issue, including upgrades.

But not:
- Activity by IT personnel

2.2.4	Correct Time Sheet/Expense Reports	Internal Error

Activity to correct and re-check time sheets and expense reports after discovering error.

Includes: Mistakes and activity to resolve project/charge number issues.

But not:
- Original preparation of timesheet or expense report.
- Non-productive time correcting computer or copier problems.

2.2.5	Other Indirect Internal Error	Internal Error
	Other activities to support effort related to responding to error not seen by persons outside the Company, other than list indirect error activities listed.	
Includes:		
But not:	• Activities that are described in direct error category.	

3. APPRAISAL

3.1.1 Internal Plan Checking	Appraisal

Verifying that drawings and specifications related to drafting and clerical activities were performed correctly.

Includes: Preparing, printing, and copying check prints for review, and filing them after review.

But not:
- Design review activities
- Rework and redesign resulting from plan checking
- Plan back-checking to verify initial plan checking comments have been implemented.

3.1.2 Internal Design Review	Appraisal

Internal validation of design, calculations, and specification related to engineer and architect activities to confirm soundness of design approach and correct methods.

Includes: Preparing, printing, and copying check prints for review, and filing them after review.

But not:
- Plan checking activities
- Rework and redesign resulting from design review
- Subsequent design review to verify initial design review comments have been implemented.

3.1.3 Client Design Review	Appraisal

Scheduled design review meetings before final Work is submitted.

Includes: Preparing, printing, and copying check prints for review, and filing them after review. Also includes travel, preparing, printing, copying, and distributing responses to comments.

But not:
- Plan checking activities to verify that design review comments have been implemented.
- Rework and redesign resulting from design review.
- Unscheduled design reviews.

3.1.4	**Coordination Review**	Appraisal

Activities to verify that Work performed is coordinated with other work performed within or outside the Company.

Includes: Preparing, printing, and copying check prints for review, and filing them after review. Also includes meetings and travel.

But not:
- Activities designed to prevent coordination error.
- Rework and redesign resulting from coordination review.
- Subsequent review to verify that comments from initial coordination have been implemented.

3.1.5	**Shop Drawing Review**	Appraisal

Activities related to reading and responding to shop drawings.

Includes: Research, calculation, preparing, printing, and copying shop drawings for review, and filing them after review.

But not:
- Rework and redesign resulting from shop drawing review.

3.1.6	**Cost Estimates**	Appraisal

Activities related to estimating and reporting construction costs for the purpose of internal validation of design.

Includes: Research, calculation, preparing, printing, and copying cost estimates for review, and filing them after review.

But not:
- Activities that support cost estimates as part of a project deliverable.

3.1.7	**Other Direct Appraisal**	Appraisal

Other activities designed to discover errors in Work to be submitted to the Client other that the direct appraisal activities listed.

Includes:

But not:
- Activities that are described in the indirect appraisal category.

3.2.1	**Evaluate Subcontractors**	Appraisal

Activities related to reviewing, qualifying, and selecting subcontractors.

Includes: Meetings, phone calls, emails, travel, reports, completing forms.

But not:
- Activities after subcontractor is under contract.

3.2.2	**Post Mortem**	Appraisal

Activity related to gathering and evaluating project performance after project or major task is complete.

Includes: Meetings, emails, phone calls; also includes preparing, printing, and copying check prints for review, and filing them after review.

But not:
- Customer service activities or other corrective action recommended by the post mortem.
- Gathering or evaluating project performance data of a previous project.

3.2.3	**Project Quality Audit**	Appraisal

Activity related to gathering and evaluating data to determine if project is following published quality standards.

Includes: Meetings, emails, phone calls; also includes preparing, printing, and copying documents, and filing them after review.

But not:
- Implementing audit recommendations.
- Non-project related quality audits.

3.2.4	**Performance Appraisals**	Appraisal

Activities related to evaluating counseling employees.

Includes: Meetings, phone calls, emails, travel, reports, completing forms.

But not:
- Implementing performance appraisal recommendations.

3.2.5	**Time Card and Expense Report Review**	Appraisal

Activities related to review and approval of employee time sheets and project expense reports.

Includes:

But not:
- Actual preparation time of time sheets and expense forms.

3.2.6	**Other Indirect Appraisal**	Appraisal

Other activities designed to discover errors in Work not submitted to the Client other that the indirect appraisal activities listed.

Includes:

But not:
- Activities that are described in the direct appraisal category.

4. PREVENTION

4.1.1	Drafting Planning	Prevention

Activity related to ensuring that drafting practices and standards are consistently followed on the project.

Includes: Preparation, meetings, emails, phone calls; also includes preparing, printing, copying, and filing documents.

But not:
- Activities related to verifying that drafting work conforms to project or company standards.
- Plan review activities.
- Non-project specific drafting standards

4.1.2	Design Planning	Prevention

Activity related to ensuring that architectural and engineering practices and standards are consistently followed on the project.

Includes: Preparation, meetings, emails, phone calls; also includes preparing, printing, copying, and filing documents.

But not:
- Activities related to verifying that engineering and architectural work conforms to project or company standards.
- Design review activities.
- Non-project specific architectural and engineering standards

4.1.3	Quality Planning	Prevention

Activity related to ensuring that project quality standards are appropriate and are consistently followed on the project.

Includes: Preparation, meetings, emails, phone calls; also includes preparing, printing, copying, and filing documents.

But not:
- Activities related to verifying that project work conforms to project quality standards.
- Non-project specific quality standards

| 4.1.4 | Coordination Planning | Prevention |

Activity related to ensuring that Work between technical disciplines or between different offices are coordinated so as to minimize effort and reduce rework due to miscoordination.

Includes: Preparation, meetings, emails, phone calls; also includes preparing, printing, copying, and filing documents.

But not:
- Activities related to verifying that engineering and architectural work conforms to project or company standards.
- Design review activities.
- Non-project specific architectural and engineering standards

| 4.1.5 | Review Lessons Learned | Prevention |

Activities to review lessons learned from previous related projects.

Includes: Preparation, meetings, printing, and copying.

But not:
- Post Mortem activities or preparing lessons-learned from current project.

| 4.1.6 | Programming | Prevention |

Activities related to refining the scope, fee, and project schedule.

Includes: Research, meetings, site visits, report writing, phone calls, and emails.

But not:
- Pre-contract activities.

| 4.1.7 | Scheduling | Prevention |

Activities related to scheduling personnel and subcontractors for project activities.

Includes: Research, meetings, site visits, report writing, phone calls, and emails.

But not:
- Activities related to resolving schedule conflicts, coordination errors, and project changes.

4.1.8	Contract Review	Prevention

Activities related to review and evaluate client contracts or other documents affecting actual performance requirements.

Includes: Research, meetings, site visits, report writing, phone calls, and emails.

But not:
- Contract activities after acceptance of client terms.

4.1.9	Other Prevention Activities	Prevention

Other "on-line" activities designed to prevent errors in Work other that the prevention activities listed.

Includes:

But not:
- Non-recurring, or "off-line" prevention activities.

5. INVESTMENT

5.1.1	CADD Standards	Investment

Activities to design and disseminate processes and standards to promote quality and consistency in CADD processes and among CADD personnel.

Includes: Preparation, meetings, emails, phone calls; also includes preparing, printing, copying, and filing documents.

But not:
- Activities to produce project-related standards.
- CADD Training

5.1.2	Technical Standards	Investment

Activities to design and disseminate processes and standards to promote quality and consistency among engineering and architects.

Includes: Preparation, meetings, emails, phone calls; also includes preparing, printing, copying, and filing documents.

But not:
- Activities to produce project-related standards.
- Technical Training

5.1.3	Quality System Standards	Investment

Activities to design and disseminate processes and standards to promote quality in technical and support processes.

Includes: Preparation, meetings, emails, phone calls; also includes preparing, printing, copying, and filing documents.

But not:
- Activities to produce project-related standards.
- Quality System Training

5.1.4	Other Standards Activity	Investment

Other standards activities not already defined.

Includes: Preparation, meetings, emails, phone calls; also includes preparing, printing, copying, and filing documents.

But not:
- Activities to produce project-related standards.
- Training activity

5.2.1	CADD Training	Investment

Planned activities designed to increase employee CADD knowledge and skill.

Includes: Preparation, meetings, emails, phone calls; also includes preparing, printing, copying, and filing documents.

But not:
- Activities to produce project-related standards.

5.2.2	Technical Training	Investment

Planned activities designed to increase technical knowledge and skill of engineers and architects.

Includes: Preparation, meetings, emails, phone calls; also includes preparing, printing, copying, and filing documents.

But not:
- Activities to produce project-related standards.

5.2.3	Quality System Training	Investment

Planned activities designed to train employees in auditing, analysis, or other quality activities.

Includes: Preparation, meetings, emails, phone calls; also includes preparing, printing, copying, and filing documents.

But not:
- Activities to produce project-related standards.

5.3.1	Quality Improvement Costs	Investment

Activities designed to improve processes, discover root causes, lower costs, and reduce errors.

Includes: Planning, investigation, preparation, meetings, emails, phone calls, report writing; also includes preparing, printing, copying, and filing documents.

But not:
- Education and training related to quality improvement.
- Planning activities described in "prevention" section

5.3.2	Other Investment Activities	Investment

Other "off-line" activities designed to prevent errors in Work other that the investment activities listed.

Includes:

But not:
- Recurring, or "on-line" prevention activities.

APPENDIX B

DATA COLLECTED DURING THE AWARENESS EXERCISE

COMBINED CHART WITH NO. OF COQ ACTIVITIES, DAYS PARTICIPATION, ENTRIES, AND COQ HOURS RANK BY NO OF COQ ACTIVITIES

participan	no of activities	no of days	no of entries	hrs
Q53	1	1	2	1
L24	1	1	1	8
S8	1	2	2	-
V73	2	3	2	1
D21	2	61	2	3
S24	2	93	10	27
H67	3	7	5	260
R88	4	109	6	46
L38	7	308	15	66
F33	10	139	38	50
R98	11	157	41	136
N72	12	343	36	129
H50	15	203	61	376
Q80	15	286	46	98
G35	16	193	31	81
E98	18	160	44	165
	120	2,066	342	1,447
average	8	129	21	90
max	18	343	61	376
min	1	1	1	-

RANK BY DAYS PARTICIPATION

participan	no of days
Q53	1
L24	1
S8	2
V73	3
H67	7
D21	61
S24	93
R88	109
F33	139
R98	157
E98	160
G35	193
H50	203
Q80	286
L38	308
N72	343

RANK BY NO. OF ENTRIES RECORDED

participan	no of entries
L24	1
Q53	2
S8	2
V73	2
D21	2
H67	5
R88	6
S24	10
L38	15
G35	31
N72	36
F33	38
R98	41
E98	44
Q80	46
H50	61

RANK BY NO. OF HOURS RECORDED

participan	hrs
S8	-
Q53	1
V73	1
D21	3
L24	8
S24	27
R88	46
F33	50
L38	66
G35	81
Q80	98
N72	129
R98	136
E98	165
H67	260
H50	376

RESPONDENT CoQ HOURS BY ACTIVITY

Sum of Hours COQ	Username D21	E98	F33	G35	H50	H67	L24	L38	N72	Q53	Q60	R88	R98	S24	V73	Total
1.1.1 Redesign External Error		2.5	2.0	2.0				1.3	9.0		17.3		2.0			36.1
1.1.2 Rework External Error		2.0	0.8	0.8					4.5		0.8		6.0			14.0
1.1.3 RFIs				1.0									2.0			3.0
1.1.5 Post-Submittal Complaints				3.5												3.5
1.2.1 Recheck External Error									0.5		1.0					1.5
2.1.1 Redesign Internal Error		23.5	0.8	1.0					3.0		25.5		8.0			61.8
2.1.2 Rework Internal Error		30.0									2.2	8.5	55.0	24.0		119.7
2.1.3 Waiting Due to Miscoordination											0.3					0.3
2.1.4 Other Direct Internal Error				1.0												1.0
2.2.1 Recheck Internal Error		10.0	0.8	1.0					9.0		5.4					26.2
3.1.1 Internal Plan Checking (1st)		6.0	0.8	11.5					18.5		1.3		4.0			42.0
3.1.2 Internal Design Review (1st)	2.0	6.0	2.5	2.0					8.5		1.4		2.0			24.4
3.1.3 Client Design Review		3.0	3.0	12.0	50.0	5.0			11.0							81.0
3.1.4 Coordination Review		0.2		-	4.0											4.2
3.1.5 Shop Drawing Review									-		18.0					18.0
3.1.6 Cost Estimates		8.0	5.0		36.0						16.0					65.0
3.1.7 Other Direct Appraisal								6.0								6.0
3.2.5 Timesheet/Expense Report Review					4.0											4.0
3.2.6 Other Indirect Appraisal				0.0												0.0
4.1.1 Drafting Planning	0.8	2.8	0.8	0.8							0.8		5.2	3.3	0.4	14.7
4.1.2 Design Planning		31.5		0.3	4.0		8.0		2.0	0.5			27.0			73.3
4.1.3 Quality Planning		3.0			52.0				1.0			1.0	1.5			58.5
4.1.4 Coordination Planning		9.3			28.0						3.0				0.3	40.6
4.1.5 Review Lessons Learned		1.8									0.5					2.3
4.1.6 Programming			32.9	34.0	16.0	243.0			53.5		5.0					384.4
4.1.7 Scheduling			1.5	4.5	84.0				8.0							98.0
4.1.8 Contract Review					16.0											16.0
4.1.9 Other Prevention		10.0			8.0											18.0
5.1.1 CADD Standards												36.0				36.0
5.1.2 Technical Standards												0.5				0.5
Total	2.7	146.5	49.9	75.3	302.0	248.0	8.0	7.3	128.5	0.5	98.3	46.0	112.7	27.3	0.8	1,253.7

RESPONDENT CoQ HOURS BY DATE

Sum of Hours	Username															
CurDate	D21	E98	F33	G35	H50	H67	L24	L38	N72	Q53	Q60	R88	R98	S24	V73	Total
09-Aug-07		1.5														1.5
10-Aug-07									12.0							12.0
16-Aug-07								40.0								40.0
17-Aug-07		5.5			32.0				1.5							39.0
20-Aug-07			10.0		2.0											12.0
21-Aug-07					32.0											32.0
22-Aug-07									4.0							4.0
24-Aug-07		2.0														2.0
27-Aug-07		2.0							4.0							6.0
28-Aug-07		2.0														2.0
29-Aug-07		8.0														8.0
30-Aug-07					16.0				12.0							28.0
31-Aug-07			0.3	12.0												12.3
04-Sep-07		16.0			16.0				8.0							40.0
06-Sep-07			8.0	16.0	8.0			4.0								36.0
07-Sep-07		8.0														8.0
11-Sep-07			0.2					4.0								4.2
12-Sep-07					8.0			4.0								12.0
13-Sep-07			2.0		8.0	179.0										189.0
14-Sep-07					8.0											8.0
17-Sep-07					8.0											8.0
18-Sep-07		1.3		0.0	16.0				13.5							30.8
19-Sep-07					16.0											16.0
20-Sep-07		2.0			16.0											18.0
21-Sep-07		1.5	1.5	1.5	8.0				4.0							16.5
24-Sep-07					8.0										0.4	8.4
25-Sep-07								1.0			8.5		0.4			9.9
26-Sep-07	0.8	1.0	0.8					4.0			0.8					7.3
27-Sep-07									7.0			1.5	0.8		0.3	9.6
01-Oct-07				0.8					0.5		1.5			1.4		4.1
04-Oct-07												0.5	4.0			4.5
05-Oct-07													0.5			0.5
08-Oct-07				3.0				0.3						0.3		3.5
09-Oct-07		15.5														15.5
11-Oct-07					4.0									0.1		4.1
15-Oct-07					8.0								2.0			10.0
16-Oct-07		1.0														1.0
17-Oct-07		8.0			16.0											24.0
18-Oct-07		2.5														2.5
19-Oct-07		8.0									17.2					25.2
23-Oct-07		5.5			8.0								1.0	0.2		14.7
24-Oct-07			5.5		4.0						6.5					16.0
25-Oct-07					4.0				2.0							6.0
26-Oct-07		9.5	1.0													10.5
29-Oct-07					4.0											4.0
30-Oct-07		0.8			4.0											4.8
31-Oct-07		5.0			4.0											9.0
01-Nov-07			0.8		8.0											8.8
02-Nov-07					4.0				1.0							5.0
06-Nov-07											0.5					0.5
07-Nov-07		3.5			8.0											11.5
08-Nov-07							8.0	1.0								9.0
13-Nov-07					6.0	5.0										11.0
14-Nov-07					4.0			2.0	6.0				2.0			14.0
15-Nov-07		2.0														2.0
16-Nov-07			2.0		12.0				1.5			36.0	1.0			52.5
19-Nov-07		6.0											1.5			7.5
20-Nov-07		0.5				12.0							4.0			16.5
21-Nov-07			0.5													0.5
26-Nov-07					8.0								8.0			16.0
27-Nov-07	2.0		0.5						8.0		1.3		4.0			15.7
28-Nov-07		1.5	3.0										4.0	1.1		9.6
29-Nov-07			1.8	2.0	4.0						3.0		4.0	13.0		27.8
30-Nov-07		4.0			8.0				1.5					4.0		17.5
03-Dec-07		3.0									1.3		4.0			8.3
04-Dec-07			3.0	8.0	-									0.3		11.3
05-Dec-07			0.2													0.2
06-Dec-07				2.0	8.0											10.0
07-Dec-07				2.0	8.0				17.0				4.0			31.0
10-Dec-07		15.0			8.0								4.0			27.0
11-Dec-07			0.8		4.0				6.0				6.0			16.8
12-Dec-07		12.0			8.0				2.0				4.0			26.0

RESPONDENT CoQ HOURS BY DATE

Sum of Hours CurDate	D21	E98	F33	G35	H50	H67	L24	L38	N72	Q53	Q60	R88	R98	S24	V73	Total
13-Dec-07					8.0								2.0			10.0
14-Dec-07		8.0			8.0								3.0			19.0
17-Dec-07					4.0					0.5	21.0		4.0			29.5
18-Dec-07					4.0											4.0
19-Dec-07					4.0				5.0				4.0			13.0
20-Dec-07					4.0								4.0			8.0
21-Dec-07		16.0			8.0								3.0			27.0
27-Dec-07				4.0												4.0
28-Dec-07				2.0												2.0
31-Dec-07											4.5					4.5
02-Jan-08													6.0	7.0		13.0
03-Jan-08			1.8	0.3									8.0			10.0
04-Jan-08				0.5									6.0			6.5
07-Jan-08					8.0											8.0
08-Jan-08													2.0			2.0
09-Jan-08			2.0		8.0								2.0			12.0
10-Jan-08					4.0						4.0					8.0
11-Jan-08													2.0			2.0
14-Jan-08				1.0								8.0				9.0
15-Jan-08									3.0				2.0			5.0
16-Jan-08		6.5			4.0								2.0			12.5
17-Jan-08				1.0									4.0			5.0
18-Jan-08													4.0			4.0
21-Jan-08				1.0												1.0
22-Jan-08					8.0											8.0
23-Jan-08													4.0			4.0
24-Jan-08											0.3		6.0			6.3
25-Jan-08													2.0			2.0
31-Jan-08				3.0	4.0											7.0
11-Feb-08				1.0												1.0
12-Feb-08					4.0											4.0
20-Feb-08				4.0												4.0
26-Feb-08				0.8												0.8
27-Feb-08													4.0			4.0
29-Feb-08				0.5									2.0			2.5
06-Mar-08								6.0								6.0
10-Mar-08					4.0											4.0
25-Apr-08											18.0					18.0
02-Jul-08									2.0							2.0
07-Jul-08											10.0					10.0
09-Jul-08									4.0							4.0
10-Jul-08									2.0							2.0
18-Jul-08									1.0							1.0
Total	2.7	165.0	49.9	81.3	376.0	260.0	8.0	66.3	128.5	0.5	98.3	46.0	135.2	27.3	0.8	1,445.7

APPENDIX C

GROUP 1 INTERVIEW GUIDE

5-15-09 Operational Memo: Interview Guide

INTERVIEW GUIDE

OPENING QUESTIONS

- This is Dave Loduca conducting a recorded interview with [name] at [place and address].
- Today's date is [day, date] and the time is [time].
- We are going to discuss reaction to pilot study that was conducted in the St. Louis Office in conjunction with project number 30131, Parkway School District.
- Do you understand that your remarks are being recorded?
- Do you understand that your participation is strictly voluntary?
- Do you consent to your remarks being recorded today on the condition that they are used only for academic research?
- Could you state your full name and spell your last name?
- Do you work for Parsons Brinckerhoff?
- What is your job title?
- Very briefly, what is the nature of your job?
- What is your technical discipline?
- Do you commonly perform the duties of a project manager?

CONCEPT DISCUSSION QUESTIONS/COMMENTS

- Let me show you the category guide that was provided with the training for quality costing exercise. Do you recognize this color guide?
- What do you remember about the quality costs?
- Did you understand the categories when you were participating in the study and recording time?
- What did you think about the process of recording time against all of those categories?
- How accurate do you think you were recording quality costs?
- Take me through one recording... what were you doing and how did you select what subcategory to record it under and then how did you physically log it in.
- What did you think of the principle behind quality costing?
- How would you feel if, from this Memorial Day, required everyone to record their time in exactly this fashion?
- There are five categories and 48 subcategories... did you think that there were too many?

5-15-09 Operational Memo: Interview Guide

INTERVIEW GUIDE

CLOSING QUESTIONS

- The allotted time is approaching. Is there anything that you would like to add to your remarks?

- Have you understood all of these questions as they were presented to you?

- Do you understand that your remarks have been recorded and that we have your permission?

- Thank you, this concludes the survey; I am turning off the recorder.

APPENDIX D

GROUP 1 INTERVIEW TRANSCRIPTS

18 May 2009 Field Notes: Interview with Respondent N72

Here we go. This is Dave Loduca conducting a recorded interview with [deleted] at [deleted] offices on 1831 Chestnut Street in St Louis. Today's date is 18 May 2009 and the time is 5:19 in the afternoon. We are going to discuss reactions to a awareness exercise that was conducted in the St Louis office in conjunction with the project number 30131 which was Parkway School District. Ok [deleted] you understand that your remarks are being recorded?

Yes I do.

Ok you understand that your participation is strictly voluntary?

Oh, yes I do.

Do you consent to your remarks being recorded today, on the condition that they are used only for academic research?

That's correct.

Could you state your full name and spell your last name.

Ok. [deleted].

Ok. Do you work for [deleted]?

Yes I do.

What is your job title?

Supervising engineer.

Very briefly what is the nature of your job?

I manage projects... the mechanical aspects of the project for [deleted] to produce construction docents.

Ok. What is your technical discipline?

Mechanical Engineering and Fire Protection.

So do you commonly perform the duties of a project manager?

[deleted] refers to it as task manager in most cases.

Ok

But it's a same, similar function.

What is the difference between a task manager and a project manager?

Ok. A task manager would be responsible for the scope and budget of a particular task within a project, as opposed to being responsible for the scope and budget for the entire project.

Ok very good. Now from this point on, I will not be using your name so please do not mention your name at all.

Ok. I won't mention it either.

You participated in an orientation meeting regarding the cost of quality

Yes

And you have actually been refreshed with the slides that were presented then. Are they familiar to you now?

Yet hey are pretty familiar.

Ok. Ok. Alright, now I also seen that you actually did participate you did actually record time.

That is correct

So, in the process of doing your work for Parkway School District you did recognize that some of your work applied to certain categories of cost and quality, and you recorded that time.

That is correct

Ok - first off tell me if you believe that you were diligent in recording your time from the very start of the project, to say the start of construction administration.

Yes I feel I was pretty diligent in doing that.

Ok. Could you give me an idea as to how you came to recognize some of your work, as applying to the categories. By example, Did you look over the guide and commit some of the parts to memory and then and then find that as you perform work that applied to any of the four major categories that you stopped and tried to examine the book and determine whether or not the your work actually- actually applies to a particular category? Or did it come some other way? What I'm trying to get an idea as to why- what made you think that you were diligent.

Ok. I did use the book fairly often for reference to try to determine what category of work that maybe- that was applicable and then did find that were a number of things we did either an appraisal or prevention, or investment that were associated with the project and then we also had a number of the poor cost redoing of work due to internal or external error I would often look at what categories you had made for the different types of errors and then try to assign them to those categories when I recorded my time. Not necessarily catching everything but pretty diligently trying to evaluate whether or not the cost or the time that I was using was related to cost of quality.

Did you find any of the categories confusing?

in particular when I first started I found them a bit to be confusing but I think the orientation you gave helped a lot in trying to evaluate where the cost really are and how you go about allocating the cost of a particular aspect of quality.

Did you find that as you went through it you wished there were fewer categories for instance the major categories appraisal, prevention, investment, internal external error - did you believe if- if that it was explained correctly if you just categorized it in those basic categories that you would have rather have foregone the sub categories which were much more complex?

It might have been easier to assess but it would have been less intuitive as to what really something belonged to.

Ok. So that the definition actually helped differentiate what the hours were. What do you think of the process in general? If -do you think that - as a process if it were implemented universally, you think it could be helpful or do you think it could cause more difficulties than it could help? Now the reason I ask this is because as a project manager and a task manager, I think you'll find that the project manager assigns the work breakdown structure so in general I don't know if you would agree with this, but in general he tries to keep it as simple as possible, based on the size of his project, so that he would he or she would be able to accurately gage the progress of the project with as few categories as possible.

Right.

In other words, he wants to be able to get a physical percent complete by looking at cost, and the way he does that is to try to manage with as few categories as few tasks as possible. Would you agree with that?

Generally they try to manage with as few tasks as possible. There are exceptions where they try to use a lot. But…

Ok. That's fair. So then if in this process we had actually a separate time recording device. Do you think based on what we just talked about the project manager assigning tasks, do you think it would be more helpful if it were to remain as a separate recording device, or do you think if it were integrated in work break structure it would be more helpful?

Well it probably be used a little bit more as a separate recording device, so that its very convenient for a person that was trying to record the cost of quality to find a place to put it. however, it did point out, that you know in preparing cost estimates for a project, you may want to you might want to assess what kinds of cost of quality you have in the normal process of doing work. for instance we usually allocate some time to quality assurance checking and then corrections, but we don't generally assign time to misinterpreting what the owners project requirements were and making corrections to those changes that occur in the course of the project that might not be related to actual changes of scope things that we had to correct due to errors.

 ok. It has been asserted by me and the in the orientation that we do not measure quality as a …. It has been argued that there are some measurements of quality. For instance audit findings is one where the projects already have some measure of quality that is built in. in your estimation, in your personal estimation do you feel that there is enough attention paid in quality projects without not counting this particular system?

I would say we as a company do not pay attention to quality in projects in general, because, we have lots of construction administration issues on a number of projects those would be significantly smaller in my opinion if we had paid a little more attention to the quality in the first place. It doesn't mean that we do sloppy work, it just means that we certainly could be doing a lot better work.

Ok. - As a system then you understand the rationale behind each of the categories?

Yes.

Ok. Alright. So if for instance tomorrow the central region made up a policy of applying this to all new projects would you feel relieved or would you feel a little bit more burdened?

- initially I would think that everyone would feel a little bit more burdened, but, due to my experience with going through this one project, with this system, I can see that there's some value in creating quality by having a system as opposed to creating quality by checking.

Ok. Alright. Well and you're right, the point of the system is that you cannot check quality into a product. So yes, I appreciate that. Did you find the way it was recorded to be ominous? I guess I'm wondering, first off if you thought it was difficult to record time.

I thought the method that was set up to record time was very convenient, fairly intuitive.

Ok. Alright. Do you think there is a possibility of abuse of the information? As you know this is self reported data and I guess I'm getting at when recording error cost, error of time devoted to error, correcting errors, it may appear that the corporation might use that against you .

On the surface it would seem that that is the case. I don't know if anyone including myself considered that.

Ok.

Partly because the ground rules we were given in doing this… So because the ground rules said that the time would never be associated with a person with an actual person that you felt more comfortable recording time.

Right. Ok. In actual practice do you think it's possible that information might get into the wrong hands?

I think it's possible it might get into the wrong hands in actual practice, correct.

Ok. If it was it was determined, if you discovered that it had gotten into the wrong hands, how would that affect you candor in recording time?

Personally I don't think it would affect me a lot because I think the whole purpose is to try and determine what the cost of quality is or to improve quality depending on whether you're talking about the study or the procedure.

Ok. And the folks that work for you because you are a line manager as well as a project manager the folks that work for you on a project… you would encourage them to be candid and diligent in recording the cost of quality?

Yes I would want to do that.

Alright as a line supervisor you would feel that is important that your folks were diligent in recording time that way.

Yes otherwise it's not really valuable if the time isn't recorded relatively accurately.

Ok. Do you think as a line supervisor or project manager you would feel entitled to see the individual result of a person's recorded time?

That would be the tendency is to try to look at that and see where improvements can be made on a person by person basis. I can understand how that might not be conducive to system.

Ok, so if you were denied that information you still might find it valuable?

Yes

Ok. Alright. We are approaching the end of the time. Is there anything that you would like to add to your remarks about things maybe not talked about?

Oh just that for instance I don't really have a good feel for whether anybody else found this interesting or interested in complying, but I did see when I was doing it, it would have some managerial benefit in having the information available whether it was person specific or just project specific.

What would you say would be a reason somebody might not be particularly happy about recording this time?

Well just feeling like if they were in a project where lots of errors were made that they'd be pointed out as the person that made the errors.

So you think that they would feel in perhaps personal jeopardy if their personal errors were made known as their own?

I think some people feel that way.

Do you think that's the principle reason somebody might not want to record time?

Yes would think that would be the two things could see was one, they might not understand the system or its benefit not be really to interested in doing it and the second that they would be concerned how that might point out their own quality issues.

Ok alright ok anything else you like to add?

I do think that there are a lot of people that might feel like there could be repercussions due to the cost of quality. But if they would take the point of view it helps the overall quality of the project and the overall quality of the product, they would have a different point of view as to how those errors were tabulated and pointed out.

But still knowing that you still think that they would not like to have there personal errors to be associated with them? So for instance if…

Well I think that's a point of view issue. While they may feel like they don't- some people don't want errors pointed out; if they take the point of view that it's going to improve the quality of their work as well as other peoples work, and then usually everybody sees the benefit and wants to use the system.

Do you- do you struggle when you do personal assessments at performance review time at salary review time?

Yes I do.

Ok. If error time was made available to you would you be tempted to mention it in a personal interview while you were assessing somebody for a salary increase?

I would probably be tempted to do that but if I was doing it with respect to quality I don't really think neither I nor they or anyone would benefit in bringing that up.

So you see the benefit, but yet you would still be tempted to use that information?

-in the long run probably no, but, when I first saw it I would be tempted to say you know there is an issue here you know with quality but if I recognized that it is biting my nose off despite my face I probably just defer and not bring up the issue.

Ok. Alright well that's good. Then if you were on the other side of the table not just as a individual but as a supervisor, if your performance was examined by virtue of the group that you supervised and there quality costs, would that would that put you on edge?

no

Not really?

I think that I would always have it the back of my mind, similar to the evaluation of the employee, when I was aware of what kind of cost of quality they had compared to other people. On the other hand, I still think that I recognize that system is really separate from the overall performance as an engineer.

While the recorder is still on let me ask you one more thing. As there are some lapses in some individuals recording and I have a feeling that is due a great deal towards apathy the system wasn't exciting enough or sexy enough what would you say would be the most important thing to keep people on track what do you think can be done to help that along to keep people interested and diligent in recording time?

Probably like a progress report… something like that where they could be made aware of that the system is make some progress there is.   I don't know if you can really provide any preliminary data but that once the system was implemented I would think that it could be used incrementally through the course of the project rather than only at the end as a post mortem.

So you see if they were able to see the actual cost of quality data on say week by week or timesheet by timesheet basis that might get them interested in keeping up with that?

It might.   I can't say that it wouldn't backfire because some people may feel like whoops I'm getting to many hours of quality cost here.

And perhaps and perhaps you're right. Now you think it would be more valuable to see an aggregate time-time charge or an individual time only available to that individual? So for instance if you had if you were made aware of your own time would that be more valuable or would be more valuable to see the entire project or the entire groups of time?

Well, as a manager I would think seeing the entire group's time would be more interesting as an individual. If they only saw their time it maybe just kind of a reminder that your getting a lot of time here on the cost of quality. On the other hand, it may be pointing out to them that they're not recording a lot of time and maybe they need to look at their apathy. In other words, I don't know whether the issue really was the fact that they were not recording time due to apathy, or, whether they were just not feeling like they wanted to record time because of blame assignment, or, something like that.

Ok well that is certainly worthwhile. What if the time were not simply recorded just as- as raw data but, were demonstrated in some way for instance as a- as a payback for instance if they had a payback analysis using that data, whereas a certain amount of money would be invested in some kind of prevention activities, how much money could be save in the long run?

I think everybody would be somewhat interested in that. I do find that people actually are more frustrated when do things more than once for any number of reasons. So for doing one thing correctly the first time is much more pleasing to everybody.   So seeing how it is they might able to be more efficient in terms time or cost savings, by a quality system would be interesting to more people.

Alright. Did you understand all the questions and concepts that we discussed?

Yes I did.

Now you understand that your remarks have been recorded and that we have your permission?

Yes I do.

This concludes the survey and I'm now turning off the recorder.

31 May 2009 Field Notes: Interview with Respondent B11

This is Dave Loduca conducting a recorded interview with [deleted] at 1831 Chestnut. Today's date is May 31st and the time is 3:55 in the afternoon. We are going to discuss reaction to the awareness exercise that was conducted in the St Louis office in conjunction with project 30131 Parkway School district. Do you understand that your remarks are being recorded?

Yes.

Do you understand that your participation is strictly voluntary?

Yes

Do you consent to your remarks being recorded today on the condition that they be used only for academic research.

Yes

Will you state your full name and spell your last name.

My legal name is [deleted].

Do you work for [deleted]?

Yes

What is your job title?

Senior Designer.

Very briefly describe the nature of your job.

HVAC design and drafting.

Ok and what is your technical discipline.

HVAC

HVAC. Do you commonly perform the duties of a project manager?

No.

Let me show you the category guide that was provided with quality cost exercising. Do you recognize this color guide?

Yes.

Do you remember about quality costs?

Yes.

Ok. Did you understand the categories when you were participating in the study and recording time?

For the majority

For the Majority? What was it about it that caused you a little bit of trouble?

Deciphering whose fault it was.

Deciphering whose fault it was? Oh you're talking about-

A client issue, an internal issue, or an outside issue that was neither the client nor our fault.

So there categories and sub-categories that in order to correctly classify them you had to understand what was the root of the problem.

Right.

And what was difficult for you to understand, and I think one of the reasons why was if somebody handed you corrections to make, they would have to tell you whether or not it was a client mistake or an internal mistake.

Right.

I understand. What did you think about the process of recording time against all of those categories?

The process itself was easy it was just the confusion of which category went under. The function of it was pretty straight forward.

How accurate do you think you were when you recorded your quality cost and time?

I would like to say I was really accurate but I could say that there were times I forgot to enter time and had to go back and do it later.

So when you forgot was it you simply were not thinking in those terms? What do you think could have happened to jog your memory at the time to make sure you were diligent about recording that time?

Well it would have been just having to write down what I did and just eventually go back and reenter it.

I'm going to skip ahead here. There are five categories and 48 subcategories. Do you think there were too many? You think that's too many for you to put your arms around?

Sub-categories maybe, main categories not really.

These are the main categories. Lost opportunity was not among them so of the remaining five.

Right.

So that was easy enough to understand, but the remaining sub-categories that were more difficult.

Yeah. Only because like I said you don't know who made the change or who affected the change I would say.

If this process were routine over time do you think you would get better at remembering?

Yeah it would just take more time to learn what the categories are and who initiated the change or created the error.

Take a second to peruse through these and pick out one of the sub-categories you can remember recording to and take me through what you were doing and what made you think that "ahh" this is a time for me to record time and take me through the entire process you went through from the time you discovered you had made the internal revelation that you had to record time completing the transaction.

I probably did most of my stuff to the rework internal errors.

Ok.

It was back check things; changes that the architect would make that would cause us to change our plans. Or just plain mistakes that the engineer had to redo which there I had to redo.

Ok. Did you complete the work and then at that moment decided this is how much time I spent on it or did you note the time that you started.

I try to write things down most of the time, just so that if, I do go back I have four people asking you to help them out all of the time, you don't always remember to write things down.

Alright that's fair.

You have to go be memory sometimes and that isn't always the best way.

Well think about this. If for instance this was a requirement, let's say after memorial day this is a requirement for all new jobs, so not only you have to record time for Parkway School District you also have to record time on any other job you were working on, which I know you are going to work on quite a few. Would that cause you confusion or do you think you would be able to manage it?

No I would be able to manage it I would just have to be more alert in writing things down. You know to take 30seconds to write something down is not going to kill anybody.

You remember how you had to log time? What would you say if the project manager would actually create new categories on time sheets, so new tasks numbers, would that make it easy, or do you think that offline the way we did is more preferable?

Offline is probably easier.

Offline is easier.

Yeah

What do you think is the principle behind quality costing is? I know you went through the orientation but in your own words why do you think it could be valuable.

Because you can figure out where you're spending the biggest amount of money on a budget on a job. You can figure out if it is internally a problem or if its people outside the company that are blowing the budgets or there's a hundred different things you can do. But it would give you an idea of how much time is being wasted in the office I guess not wasted but rework time on things that would allow-

I'm glad you said that. We are trying to nail this in 20 minutes so I think I have time to explore this one point. You went back and said not wasted but… And what you meant by that was you believe that all the time that you perform is really not wasted work it is necessary work. You wouldn't want to dock somebody's pay for doing rework, but you would like to find ways to illuminate the work that could be reduced.

To maximizes efficiency.

There you go. Now you remember during the study I indicated that nobody's time would be divulged and of course that hasn't happened. Any reports that were done were done with no names, and this interview will actually have your name removed so it will be published word for word, but without anything that would identify you so at this point forward make sure you don't mention your name. Did you ever fear that any of the time you recorded would be used against you anytime?

 No I didn't.

So when you recorded time, it didn't matter that it might demonstrate that you had made a mistake, and had to go back and rework something?

No, you make mistakes every day. As long as it's not an extremely expensive mistake, it's not that big of a deal, I mean if it's five or ten minutes, that's not going to hurt anybody.

So for instance if there was a monumental mistake, something that you missed, and it was clear that you would have to work 20 hours reworking, solid 20 hours to rework something you had done, because it simply takes that long, and it was personally your mistake, would you feel a little bit hesitant in recording time?

Possibly

Possibly, and you think the reasons is that somebody might have it in front of them at a salary review?

I would be really upset with myself with that kind of mistake to start with but I would owe the company something, to be honest, if I made that kind of mistake I don't know what I would do.

Well people make that kind of mistakes all the time.

But it's not something I'm accustomed to, that I know of.

Think back to the Park Service Job. The entire reason we had the Park Service Job is because someone made a mistake.

Right.

All of the work we did was rework, as far as this office was concerned it wasn't, but as far as another office was, it was. So you see how somebody's mistake could turn out to be a rather lengthy affair, none the less it would give you pause to have to record time.

Not so much pause, it would probably cause me to record it not so-

Record it more conservatively.

Yeah not so one sided

Ok we already went through the actual recording of the time. You found that easy?

Yeah that was fairly simple.

Ok, well, the allotted time is approaching. Now is there anything you would like to add to your remarks that you have made today?

No

Ok have you understood all the questions in which they were presented to you?

Yeah

Do you understand that your remarks have been recorded and we have your permission?

Yes.

Thank you this concludes the survey and I'm turning off the recorder.-

12 June 2009 Field Notes: Interview with Respondent H67

This is Dave Loduca conducting a recorded interview with [deleted] at 1831 Chestnut on the seventh floor. Today's date is June 12ᵗʰ and the time is approximately 2:31 in the afternoon. We are going to discuss reaction to a awareness exercise that was conducted in the St. Louis office in conjunction with project number 30131 Parkway School District. You understand that your remarks are being recorded?

Yeah that's fine.

Do you understand your participation is strictly voluntary?

Yes

Do you consent to your remarks being recorded today on the condition that they are only used for academic research?

That's fine.

Could you state your full name and spell your last name.

[deleted].

Do you work for [deleted]?

Yes

What is your job title?

Senior architect.

And very briefly what is the nature of that job?

Designing buildings and directing staff to aid in the design of buildings related to architecture.

Ok and your technical discipline therefore would be architecture?

That is correct.

Do you commonly perform the duties of a project manager?

Yes.

Let me show the category guide that provided with the quality cost training exercises. Do you recognize the color guides?

Yes.

Do you remember about quality costs?

It's vague at this point.

This is not a quiz.

I remember about programming.

The questions are directed for at the time and not necessarily now. I'm looking for the attitudes and things you did at the time. At the time did you understand the categories when you were participating in the study of recorded time?

Not a hundred percent.

There were five categories and 48 sub categories. So do you think that there were too many?

Probably.

Probably too many? When we talked about the individual sub categories there were small nuances associated with each sub categories. If we were to say that we ultimately record in just the categories-

Yeah it needed to be simplified, and I think what you just said would help simplify the selection issues.

So simplification was real important to you? What did you think of the process of recorded time against those categories?

The process of doing it or just the idea of recording time to create this report, I mean actually doing of it.

I'm speaking of the actual doing of the process, being with the idea that you've performed, you've done something that might warrant the recording of time, actually going through the application of recording your time.

So ask the question again.

The process of recording time against those categories, so it's not just recording the time, because I'm going to ask that again, but, just something that "ah-ha" I've just done something that I think belongs in one of these categories, I'm going to record that time. How was that process?

To tell the truth I don't even think I ever thought about what it was going to take to do the report record the time at the end of the day where-

Let me ask the question once more time. What do you remember about actually conceiving of- let me back up. How do you feel about the actual thought process it took to discriminate in your mind that you've performed some kind of action that required you to try and discriminate among all the categories and then finally record that time but also determining where the time went? How should you record the time? How did you feel about that?

The way I thought I was supposed to fill out the form at the end of the day to me taking way too much time. And so therefore I wanted it simplified. I wasn't looking forward to it at the end of the day, to the point of, there at the end, where I finally gave up on it, it's like let's put some stuff in to get this thing done, get this over with.

Much like the processes we go through to try to learn how to use our telephone, this was kind of like that. Where this like a rather large investment of mental anguish in order to be familiar enough with this system in order to be comfortable with it and you didn't want to do that? Is that what you were saying?

Yeah.

Now let's narrow the question down a bit. Actually recording the time, forget how you would record it how you determined what you would record then actually recording of the time how was that?

It felt like to me there were too many buttons or searches strokes you know movements. You had to make to get one of the single categories was kind of the way I remember it just a single category resolved.

We got the guide here. This is what you were looking at, my guess is what you were talking about, is that you first selected the major categories and from that category the sub category. I think the sub category, can I assume what you're saying, and I don't want to put words in your mouth, that once the sub categories were exposed, that's where it became complicated?

I don't remember enough in detail, Dave, to tell you the truth, I just remember it seemed like there were way too many. There was a checker box here and there, a drop down box here and there, and it was like going through a lot of effort for just trying to record something as simple, as oh yeah I had to work on this single change issue.

The next question would be how accurate do you think you were in recording the time?

At the beginning I would say for the number of entries I did, I'd say the first half of it I tried to be conscience doing it.

How do you remember the process that you made to determine you were accurate? Did you write it down as you did it, or do you figure at the end of the day your memory was good enough to remember, "I spent twenty minutes on this an hour and a half on that"?

I only dealt with it at the end of the day, and it's what I could remember.

And it was what you remember, and you thought it was fairly reliable?

I thought it was fairly reliable, considering that's how I do my time sheets at the end of a two week period, and I'll go over calendars. So doing this at the beginning of it, like I said, at the beginning I was doing it every day so it was much more accurate.

Now I'm going to ask you to take thru one recording. Think back if you can, where you decided you just performed something that day, considering you record your time at the end of the day, what would prompt you to record it and then go through how you recorded it?

Just thinking back, the only thing that would jog my memory was category. Whenever I would hit on a category, it would go right down the list, ok this applied; I remember doing this for that. So that's about how it worked.

Then at the end of the day, you would make one or more entries to accommodate what the actions that you performed that day?

Yes

Do you remember the slide presentation?

Downstairs? Yep I was there.

What did you think about the principle behind quality cost?

It didn't seem realistic to me, at least related to the architecture. I'm just not that sure how realistic it was to do such a thing.

If I told you that say drafters perform inside this system, would require your input in helping them determine what kind of rework they were actually doing for you. Would you feel comfortable explaining to them what kind of rework it was? Let me refresh your memory. In the system a drafter may not be able to tell how he would categorize his time because he may not know if he's performing a rework because of something a customer had changed, or brought to our attention, or something you yourself, your own plan checking, would you feel comfortable cooperating in that sense to tell him where these corrections are, because of something I found or these questions are from a design review that customers gave us back?

Yeah it's pretty normal describing changes.

If I were to tell you that after Labor Day this year the corporation were going to institute this policy across the board how would you feel about that.

Filling this thing out at the end of every day?

Not necessarily everyday but enough to where it would be reasonable to ensure you have the correct time.

I wouldn't feel too good about it.

Ok but if it was done corporation wide it would be something you would try to learn?

I'd get use it.

Ok.

Corporate requiring it.

Ok now I have already asked you a question about how you felt about categories, and we have already talked about that. What I want to touch on one more time is regarding what you think the principle behind it, because that's real important to me. The principle behind quality cost, to refresh your memory, is to identify the time it takes to correct mistakes that would be what they could call the cost of quality, the cost or poor quality, would be the time it takes to fix something in order to make it suitable for delivery. The fact is that you can't fix mistakes, you can't reduce the amount of time that you spend on mistakes simply by saying, and we're going to spend less time on mistakes. You have to front load that by saying, we're going to check more, or we're going to spend more time in planning, which are the other two categories, which are prevention cost and appraisal cost, and across the board to be able to say that we are spending a whole of the time correcting mistakes, that customers don't see, we are not spending enough time on checking, and maybe if you would plan more, we would spend too much time on checking. Its kind of a portfolio thing, kind of a planning tool, even though if you spend a lot of time on mistakes, that time has a cost associated with it, and in your mind I were to take that instead, if I were to spend that on other activities that front load the process so that we don't make those mistakes that might be valuable. But that's the principle behind it and it works in manufacturing, but in this particular case no one has ever tried it in engineering, which based on what you just said, theirs might be good reason for that. But that's what we're trying to discover here. So in that sense do you think maybe if it were done on a limited basis- see at some manufacturing firms they say we're going to do it for a period of time, and we're going to use that to go back and plan for different activities? Other companies who use this say we're going to keep a running count. Always knowing what we spend on those four or five categories, not sub categories, but five categories. Those categories are the ones that are shown here: appraisal, prevention, intervention, internal and external error. We didn't touch on that one at all. So as a point of planning, management planning now let me ask you another question. Now this is something that has come up, and I want your opinion on this. You have already indicated the trouble aspect of it. Now would you fear that at anytime, that your record would be used by management, in a way that would be reflected poorly on you?

No.

So that never entered your mind?

No.

So if it was a system that was imposed, the fact that you would record time, that say that I've spent eight hours on fixing mistakes, that wouldn't bother you either?

No.

If you would have to perform salary reviews for other people, would you find it useful to see that information?

No, I wouldn't look at it, I know the person in general how poorly or how well they perform its all that's needed in some reviews.

It has been asserted by me, that management can't ever see that information. So that's why I was wondering if that was ever a fear in your mind?

No never crossed my mind.

So if it was imposed it would never be a fear for you?

No, if it was imposed it would be a good idea to present a nice bold statement of what it was, or where it was ultimately beneficial to the project.

So you would never, you would always trust the corporation to use the information the way it was intended?

Suppose so.

The allotted time is approaching and I promised you were going to done in twenty minutes. So is there anything else you would like to add, that you haven't said that you think you might like to say?

No.

Did you understand all the questions that I presented?

Yes.

And you understand that your remarks have been recorded, and that we have your permission?

Yes that's fine.

Well thank you very much, this concludes the survey. I am now going to turn off the recorder.

15 June 2009 Field Notes: Interview with Respondent P54

This is Dave Loduca conducting a recorded interview with [deleted] at 1831 Chestnut. Today's date is June 15th Monday and the time is 8:15am. We're going to discuss reaction to the awareness exercise that was recorded in the St. Louis office in conjunction with project number 30131 Parkway School District. Do you understand that your remarks are being recorded?

Yes.

Do you understand that your participation is strictly voluntary?

Yes.

Do you consent to your remarks being recorded today, on the grounds that they are used only academic research?

Yes.

Could you state your full name and spell your last name.

[deleted].

Do you work for [deleted]?

I do indeed.

What is your job title?

I am a senior architect.

Very briefly what is the nature of your job?

Primarily I write specifications and I do project checking.

And your technical discipline is architecture?

Correct.

Do you commonly perform the duties of a project manager?

No.

Do you have special duties when it comes to quality?

Yes.

Could you describe those duties?

I am the local Business Manger System Coordinator, which is the company wide ISO9000 quality program which the company is committed to from corporate on down. I'm project auditor and now a coordinator for our quality process and I also am writing the specifications to inject precision into the architects work.

What are the duties of a project auditor?

A Project Auditor tries to confirm that the quality process has been applied to a project. That the files are kept the way they are supposed to be kept, the checking is done the way its supposed to be done and its part of our renewal of our ISO9000 certification, that we conduct internal audits summary annually, and that there is also a UL 3rd party auditor that comes in and does the same thing. Basically [deleted] has a published quality program. The audits are to determine if we are following our own program.

What triggers your audit?

What triggers it?

Do you determine yourself?

No, the local business executive along with the business management system coordinator make a list of projects that fit the criteria, established by corporate quality, and they tend to be larger projects that have longer durations.

So basically you don't decide?

I don't get to decide.

So you have already seen this category guide that folk's particular in where they are training for the quality cost exercise. You've never seen this guide before have you?

I don't think so.

Actually what it has is there are five categories and in those five categories there are forty eight sub categories that refer to particular- oh I'm sorry you are looking at the slides. This is the color guide. There are five categories this one isn't included in the five categories.

Ok.

These are the descriptions on how you record those and you actually attended the orientation?

That is correct.

So you have actually heard of the categories before?

Correct.

What do you remember about the cost of quality as a concept?

My understanding is that quality work is the best marketing tool that is that it retains clients which are cheaper than getting new clients so it's very important. It's what professionals ought to do is make their product as good as it can be.

If I told you that quality cost was a book-keeping method for keeping track monetarily of quality would that ring a bell to you?

Sure.

What do you think of that process of actually keeping track of quality in addition to audits which actually determine where the quality system has fallen off, actually examining quality from the concept of cost, good quality, that is, cost of how much it cost to make sure your quality is acceptable? Preventions cost and appraisal cost those are the costs you can control. And there the uncontrollable costs are the error cost the internal and external error. Those are cost you cannot simply say we'll not make any errors we can't do that in order to not make errors we have to check to see we haven't made errors and we have to prevent them and correct them in the first place as a system what do you think of that?

Well it's obvious to me that if you don't do your checking you're in trouble. My understanding is that the first check will get rid of 75% of the problems. The recheck will get rid of the next 20%. The next 5% is beyond most processes to eliminate the 5% error.

Let me tell you about 2 folks first is Edward Deming. Deming became popular after a television special in 1980 called "Japan Can Do It Why Can't We?", and basically the spotlight shined on him as fellow that started working with the Japanese in post World War II, and was substantially responsible for there assenting into there incredible reputation for quality, and their economic power.

Right, I remember when made in Japan meant it was junk, and that is no longer the case.

And another fellow by the name of Joe Juran, Edward Deming one of the things he teaches is that, you should cease reliance on appraisal, that you actually can't insert quality in your product that you have to build it correctly to start with. How would you feel about that and applying that to the business section of engineering and architecture?

A checker doesn't know what's missing if it's on the drawings and it's contradictory. You can say well, that's not right, but if somebody else didn't mention it how do you know it's wrong or not or coordinated? A lot of opposition for error in general, if the people that produce the work don't check their own work, because a checker doesn't have access to all the communication and correspondence so he doesn't know if it's been taken care of and record properly. You do what you can, you do but there are limits.

Let me address it from another standpoint. The comment made by Deming, that says, you can't check in quality. The fact is, that Edward Deming does indeed have a place for appraisal, a program for quality control, the differences is that what he attempts to do, is reduce that substantially, so in other words quality control is a surveillance technique not a technique to force quality back into a product that has lost it somewhere along the line.

Well keep in mind what we do is not a kind of manufacturing, which is what a lot of the time quality work studies are done. Everything we do is unique, and we do use the same process over again, but, every project was unique, created on a whole cloth which means it's ripe for error, for people who do not apply the system correctly, or didn't know the system in the first place, or too busy to apply the system, or whatever everyone is unique. It's not like applying the assembly line process, and by the time you work out the kinks, you get a quality product at the end. We start over every time.

Very good point in fact a former area manager used to say "we are not building cars."

Correct.

How would you feel, from this Labor Day, this system were actually required on every project, that everyone would have to record their time in exact fashion as we did in the study?

I didn't record my time so I don't know one way or the other. I suspect that if people record the error correction time required, they would spend more time doing it right the first time. Saying there's never enough time to do it right the first time, but there is always time to go back and fix it, always cost more to fix it, especially once it's out on the street, the client and contractor get to participate and apply their own pricing, and the errors and omissions.

Now I mentioned before, that there are forty-eight sub categories in this guide and the colors, you see, actually refer to the category. So is the changing color, so is the changing category. You did not participate in the orientation that included discussions of these categories and sub categories, but just from your own cursory examination, do you think there were too many, and it may be a daunting task to learn all of these?

I would say the forty eight different ways to look at this is probably too much for the average designer.

Ok what would you say that it might be different, that only a fifth of the categories might apply to the individual, 4/5 of the categories for one particular person might never ever be used?

If there are ten roughly, that's probably more doable.

The question I have asked in the past is that individual sub category might be strapped, and with just a little bit more training to understand the major categories, the broad categories, instead of using the sub categories, just used the top level categories, what would you think about that? Do you think it might be simpler, but not very useful?

Knowing that there are ten different internal errors helps you record one. Just having it recorded as an internal error makes it easier to me. I think that the sub categories might be good at explaining, and might make it easier to identify what you are looking at, but having to record ten different internal errors than if you went down to the basic five categories, that's probably doable.

Let me ask you, as if your job as an auditor, and your unique job of quality in the office, how do you think your job would change if the system was imposed?

If this system really means that the design and the drafters buy into the quality, so there is quality before it gets checked, let alone auditing, and doesn't really measure the quality product it measures the behavior of the system. It's a little bit of a false front frankly, but you have to follow the system because that's what you audit.

Well actually that's a good point. In fact the audits don't determine the quality of a product, just the behavior of the system.

It just says do you have the files? Do you have the records? Do you have copies of the checked sets? Is the project manager planning? Who are the people who are on the project manager's plan? Is there evidence that you are following a process? In the files it doesn't say was this a good project or a bad one it never says that.

It just says the quality system has been applied correctly.

Or not.

What happens, by the way, if there are differences?

We make a report and they have to be corrected.

The allotted time is approaching, so I'm going to ask if there is anything you would like to add to your remarks, keeping in mind that your particular remarks are valuable. So if there is anything you would like to add.

Well for instance, when a mechanical engineer decides to quadruple the weight of a rooftop unit they shouldn't have to wait for the structural engineer to tell them that's going to cost a lot of money to reinforce the roof. They should understand immediately, that this decision will have wide ranging impact on a project. This is a recent example and what it ended up with was mechanical said, we are replacing roof top units they are within 20% of the original weight. Structural said we should be able to handle that. Several weeks later mechanical went to structural and said, oh not those heavier ones. So they spent four weeks under one design assumption. Mechanical had to quick design a solution for the heavier units that cost money. And then the money for those repairs, for the remedial work to the roof was presented back to mechanical so we don't have money for that, so we went back to the lighter units. So we had several weeks of mechanical engineering and several weeks of structural engineering completely wasted, because of bad communication. So the designer on the ground has to internalize the quality from personal motivation and experience, and also from good project management. They need to set the scope very clearly, or else they'll be known, it what we know, as scope creek, or there will be these excursions into things that use money when we don't follow the logical process.

In the orientation, the difficulties that you just described, they weren't named by name, and that particular process wasn't described, but a simple difficulty, in more general terms described in the orientation from a member of the auditor, was that that is the normal design process, and you really can't say that there's an error, because, it's a never ending process and I think what you just described is it certainly could be an interim process, but because mistakes in judgment the cost escalated beyond what it should have.

Well let me just say that when you are designing a solution, engineering solution, architectural solution, frequently you design within limits, because we are not blessed with magical clients with

unlimited budget, and unlimited patience. So there are parameters that are set and usually cost is one of them. And so violating that parameter there's no way that should happen. Let me just say, if the design in its earliest stages and is communicated in its principle disciplines before there is a huge commitment in drafting time and engineering time and designing time, that's the whole idea as you go back and forth, it rattles around and forms itself around an idea, and it solves everyone's problems, pretty much the design development. The next stage you put some numbers to that and you find it doesn't mean you have to change your whole approach to how things are going. It may be interim process. I don't disagree with that, but it's not full of a lot of dead ends, especially long dead ends, with a lot of investment.

Actually I think that what you're describing is poor planning. Activities have to be performed.

The upfront thinking.

Front thinking.

Up front thinking has to be completed. It's an educated question.

Despite the fact that this is not a manufacturer, and we do not have an assembly line that has a very stable product, that we don't make widgets a 100,000 a day, that there is a process that actually could be.

You can know a client can't afford some materials, that it's just too expensive, out of their league.

So the idea, while you can't eliminate the cost of appraisal' the cost of internal errors' because obviously something is going to happen where you have to redesign. If for instance, they find under current law, under current code, the mechanical units cannot be replaced with units of the same size, well obviously that would mean structural would have to come up with a solution.

I'm not saying that there aren't challenges that have to be fixed.

However, I think what you said, that process did not have to extend as long as it did, and it could have been short circuited substantially.

Obviously we were able eventually, in the end, to accomplish whatever code requirements there were with lighter units, so it wasn't a code issue; it was a designer's choice, and ignoring the other discipline requirements.

In other words because the front end planning was not performed those extra cost accrued?

On our part, yes.

So, if the cost of structural to examine an invalid air conditioner selection, or mechanical to go back and revisit an original design, that they now have to go back and redesign, if they had to report that time as an internal error what would you say? Would you say that would be unreasonable?

It's an internal error for sure.

Now what I would like to do is, and we are certainly over time, but let me ask this one question, because you brought it up. There is a kind of dissonance between the normal course of design and the back and forth that we have just been describing, where we might have committed an error in judgment that causes another to have to react and spend time. If time were recorded that suggested that that was a mistake was cost of error an uncontrolled error cost that possibly could have been avoided with whatever planning could have been made. How would you feel about someone recording that time? If you had to record that time would you feel embarrassed? Would you feel any kind of anxiety about having to record that time?

No. I realize when I worked in the building trades, and you realized something was built incorrectly, and on Monday you put in a wall, and on Tuesday the boss says take it out. You realize it's not productive but as we used to say it all pays the same to people on the bottom end. If people doing the thinking on the front end can get it right, then you can avoid paying three times, putting the wall

up in the wrong place. It's going to cost three times what it should. So we should be able to record that and then maybe use the analysis to think of ways we can avoid that in the future.

In your position though, how do you think someone might feel about the exercise of recording that time? I'm suggesting that somebody might have the anxiety that the time they record is error might suggest they are responsible.

Or that their boss is the one that made the screw up, which is just as likely to be told to do the wrong thing, and you say, he's the boss, he knows what he's doing, he's leading the way, leading the show, and then the next week you got to undo. If it's positive, I think it should be recorded if we were perfect we wouldn't be doing this for a living.

Ok, you think it's easy to separate yourself from the anxiety of responsibility, and just say this information we can use to fix it next time.

I think we should be able to learn from our mistakes.

Without fear?

Well, yeah.

So you would not be fearful that your boss might in a salary review, say I see here that last years error numbers for you were 50% over the average, that wouldn't cause you anxiety?

Well I would probably have to say because my job is a specification writer, is usually subsequent to the design effort, although we would like to think that it's simultaneous. If I have to do things over it's because doing the things the way I was directed by the designer, didn't quite work out in the end, and I had to substitute a different solution.

You had indicated that you are not a project manager, but let me ask you a project manager question. This time that was recorded on this study, was done on a separate time recording device, it was not integrated on the time sheet process. My understanding of how a project manager selects tasks for the work break down structure is they want to minimize the number of tasks in order to be able to control the project with the least amount of tasks. Would you say that's a fair statement?

Not for everybody, there's a lot out there with many, many tasks, and you know its common for me to proceed on work before I know what the task is. They just do this, and by all rights I should say what task number it is this before I start. There are just some jobs, they go to fast to have those numbers, so I would advocate for a separate recording.

Ok well a separate re-coding device solves a lot of problems. One, is that when a project runs out of money, project managers might say, well, you're time now is on your own dime, and if that's the case that work was done when the project ran out of money, work might be coded as error cost.

 Very likely its remedial.

Remedial that's correct. So the very time you need to record the time, you might not be able to. Another is that time sheets might be available to clients, and if this recording, this kind of time is recorded, what do you think clients might say about seeing hours against error cost?

Not sure that clients would be pleased, but I think that we're no different than anyone else in the industry. I think a third factor is, the last two or three days of any two week time period are the best estimate of time spent, because time sheet sub schedule, and frankly I don't think many people go back and change. I think it's a 20% error potential.

The other benefit is, that time can be handled differently and kept confidential to certain people, such a way, that anxiety is lowered, because the point was nobodies individual time is available to anybody.

No I can see a reason to shield identities, but on the other hand, I have always been able to admit errors.

But the point is to increase candor, and if you are held accountable, the likelihood is you not being forthcoming, because you can still charge your time and get paid, but you can record as productive time- I'm sorry, value added time rather non value added exercises.

Well like I said, quality project sells itself, and how do you measure that? We'd like to think that change orders, that is changes to the contract amount add after bidding, under 2% but maybe under 5%, is a pretty good job, and I don't know we don't publish numbers. So we don't know if we are doing that but we should all be aware of that.

Those are by the way our category of external errors.

Good. But project managers don't share that info with people on the floor, and since we are horizontally stratified organization, you know, project managers go out and meet the clients, construction administrators go out during construction, designers stay in the office. They don't learn the lessons out in the field. I mean somebody's asking you "now what do I do?" you learn lessons, but if it just something that the project manager thinks is a hassle, and the construction administrator is looking for a solution, and it never gets back to you. I mean you don't know you got a problem.

Have you understood all the questions that I presented to you?

Yes.

Do you understand your remarks have been recorded and we have your permission?

Yes.

Thank you and I am now going to turn off the recorder.

2 July 2009 Field Notes: Interview with Respondent Q60

This is Dave Loduca conducting a recoded interview with [deleted] at [deleted] offices 1831 Chestnut 7th floor. Today's date is the 2nd of July and the time is 140 in the afternoon. We are going to discuss reaction to a awareness exercise that was conducted in the St. Louis office in conjunction with project number 30131 Parkway School District. [deleted] do you understand that your remarks are being recorded today?

Yes.

Do you understand that your participation is strictly voluntary?

Yes.

Do you consent to your remarks being recorded today on the condition that they are used only for academic research?

Yes.

Could you state your full name and spell your last name.

[deleted].

Do you work for [deleted].

Yes.

What is your job title?

I'm a senior mechanical engineer.

Very briefly what is the nature of your job?

I design building systems primarily mechanical heating, ventilating and air conditioning systems for commercial, institutional, some industrial.

What is your technical discipline?

Mechanical engineering.

Do you commonly perform the duties of a project manager or task manager?

Yes.

You see the category guide that was provided with the training for quality cost exercises. Do you recognize this color guide?

Yes.

What do you remember about quality cost?

The better quality we do putting into the design the less of a problem when the job gets finished.

You're basically describing the strategy behind the equation of quality cost, but if I were to suggest to you that quality costs are divided up into four or five categories, in this particular case five categories, which are shown here: appraisal, which is all the activities associated with plan checking, anything that you do to check your work or check somebody else's work; prevention, which is all the activities in a project that you do ahead of time in order to avoid errors. Prevention actually is similar to appraisal, except, prevention prevents the errors from occurring in the first place, appraisal simply uncovers the errors that have already been committed. They are called the cost of good quality, because those are elements that you have control over. You can spend as much money as you want on those two items or as little, they are not a result in cost. You have to agree up front to do those things, as opposed to the cost of poor quality, which is internal error or external error. Those are errors that have been committed. That is the cost of fixing an

error. It's not the cost of doing the original error it's the cost of fixing an error. So an internal error would be something that is found but by us not by the customer. An external error is something that actually leaves our shop, and is found by somebody besides us, like the customer, the contractor, the city plan reviewer, so on. You understand now where this is heading? So the cost of poor quality you have no control over those, cost will arise simply because you failed to do the cost of good quality, because you forgot, you didn't check, or you didn't prevent the error to begin with. There was a fifth category, investment that is somewhat similar to prevention, except it is outside of a project. In other words it's something you do in general to help prevent errors but not something specifically done inside of a project.

Software training just simply calculations training.

Yeah if you did planning for a particular job, a coordination planning, that's before you start the design, and you did coordination planning, that would be considered a prevention job, because it is associated strictly with that project so you are getting the idea of where these are going. At the time your recorded, because I know that you recorded time, in fact you were one of the better ones associated with diligent recording of time, of all of the time that I've seen recorded, did you understand the categories at the time that you participated in the study?

Yes.

What did you think of the process of recorded time against all those categories?

Well having the numbering system, and having the book, and a lot of times, I used this single page that was printed front and back that kind of was a guide to what was in the book.

What you are referring to is a short table that has all of the categories on it, and indication as to who might likely use those categories. So for instance a category that may only be used by the project manager is identified as something that would only be interest to him or her, or a category that might only be of interest to say a drafter.

I had the book and I had made notes in the book but I also had this table and between the two it was vary helpful and it was not a problem and the color coding helped too.

Now when you were recording how accurate do you believe you were at recording time?

I was very accurate.

I take it how you set aside your time was similar to how you do it for your [deleted] timesheet.

That was basically how I did it. I enter my [deleted] timesheet daily, so when I would enter that I would also enter the parkway.

Could you take me through one recoding? I realize that a lot has time that has past. I'm not talking about all the activities, but just in your mind, if you can remember one activity you had performed, and then how it came about that you decided, that first you identified it as an activity, that has an interest with quality cost reporting, and then the actual physical recording of the cost.

Do you want me to refer to an actual recording or a hypothetical?

A hypothetical one that you may have done and the reason we don't have actual is because we don't have those records in front of us and neither do you.

For instance, and I'm looking at some of my notes in the book, when each year maintenance project was over we would try to write down the lessons learned. So then the next year, if we had the contract still, I would always pull out the lessons learned and see what it is and go over it with the people that were working on my projects, and so that would be time that went into prevention. So we talked about issues and talked about what we would want to do differently from previous years before we ever started the project.

Ok very good. That would be one, and tell me how you ultimately recorded that time. Here's what I'm interested in, I'm interested in what are the mental processes that you went through to decide, you've already told me how you decided that is was a particular prevention activity now what I like you to do if you can based on the color guide pick out the prevention activity you think it would have been and then go through what you would have done to record that time.

Ok well on that particular thing, there is actually a line item 4.1.5 of review lessons learned. So I go into co cube icon on the screen and go into the number system and find that and a lot of times I would write a little blurb in the comments box.

And you have, so you have no trouble physically logging those in. In that particular case when you discussed it with the folks who were associated with your work, I guess you talked to other drafters or just other designers?

Well if there were other designers that were going to be helping me on a project. If I was doing say for instance a roofing project then it was only a drafter. If it was a major project that had a lot of design work, there was usually another designer or engineer working with me, and so whoever it was I would talk to them about that, and I would make sure they had a written copy of it too.

What do you think about the principle behind quality costing? I know we just discussed this, but I would like to hear what you think about it, the principle of quality costing program that is being proposed here, once with the color guide, and it would have been discussed in the briefing you attended.

Overall, I think we put too little time into doing this on a regular basis, and I think we need to be doing this all the time, because it is invaluable in getting it done right to begin with. There is the old saying there's never enough time to do it right, but there's always time to do it over, and that's not really humorous. We don't always take the time in the beginning. It's like jump and run. Before you can jump and run you got to have yourself organized, you gotta have yourself a plan. One thing I personally do, on almost every project that I work on is, I sit down upfront and make preliminary lists; I make list of the systems, I make lists of the equipment, I make lists of anything special, then I take that and make a list of spec sections, I make a list of details, I make a list of schedules. And it's all preliminary, its all the first week of the project.

So you plan ahead?

And it may or may not, having that, a lot of things may change but it's a start. I mean if a drafter is assigned to the project, up front they can immediately beginning pulling from our standard schedules our standard details and beginning creating those sheets. You know, try to list out the sheet names and numbers and again they may change. Preliminary I make up those lists, and it saves a tremendous amount of time and effort and mistakes. If we have something to start with and people aren't just randomly- I mean I've actually worked on projects where someone else was leading and nothing like that was done, and at the end of the project we actually end up without some schedules that we needed. It's like wait a minute where's this equipment? Well I guess nobody remembered to put that in there because it was done very sporadic in putting schedules on the drawings. I mean somebody might have handwritten one out but nothing got on the drawing. I think it's a very important thing to emphasize the prevention and the appraisal. Appraisal kind of goes with quality checking, the QC-ing before any submittals in house, but I think that prevention is really, really important.

It was asserted by me, in the original briefing; I gave an example, I purposely did this so when somebody mentioned it. I brought it up of a calculator. Now when calculators first came out, they were clunky, all the bugs haven't been worked out. I told the story of my grandpa, who basically spent over a couple of hundred bucks, which had only add, subtract, multiply, and divide. I think it might have had a floating point decimal and that was its claim to fame. It was prone to errors because the order of operations that you normally associate with a calculator right now; so if you add two numbers, and then you multiply a number, and then

add again, you expect the order of operations to group them for you, but in that calculator that was not done. In addition to that, there were things like key bounce that you don't get on calculators now, so if you hit an eight, you don't fill up the screen with eights every single time you hit a key, only one number pops up on the screen. So in essence, he knew that, so whenever he made a calculation with a calculator, he would check it by hand. Nowadays if you did a hand calculation, you would probably be more prone to check it with a calculator. You would never think of checking a calculation on a calculator by hand, and the reason is because quality improved so much that checking was unnecessary. If you find that quality has improved dramatically you may find that there are certain checks that you don't have to do anymore. In addition to that, keep in mind; checking is only the tip of the iceberg. If you check something there is still the correcting of the errors as a result of the check. The prevention may not eliminate the checking process, but it does smooth things out. Certainly if the checking process is performed on a package that has no errors, then that process is going to go very quickly. If it's got lots and lots of errors, that process is going to drag. Not to mention you have to recheck after it's done. If there are no errors to be made, there is no such thing as a recheck or a bad checking. So that's the idea quality costing is intended to shine a light on the cost that you spend on those activities. Maybe you haven't remembered this, but all of the activities described here are really considered non value added. So in other words, if a client actually saw how much money you spend on prevention or checking errors, correcting errors, they may not be prone to actually pay for those, if they were presented just stark terms. Nobody would ever pay you just simply to check something. Now they may pay to check something in association with, "gee we want our work checked," that sounds simple enough but these are internal measures only. In that sense, that's also something that might cause a project manager to avoid these costs as well, for instance, I am going to ask a question in just a minute about the recording of these costs. Project managers might be sensitive to client seeing the breakdown of these costs, if they were recorded against their project. How would you feel if this Memorial Day, this company said this process is a good process and we are going to implement this, across the board, so every office had to implement this and record it just the way that has been done in the study? How would you feel about that?

It didn't take me that long to record it. I mean if somebody was unfamiliar with the categories, it might take a while to get used to it, but once I got used to the categories it did not take a lot of time.

So exactly how it has been presented in the study, you would have no objections, you wouldn't want to change anything?

Well I might come across a few things from my notes for clarification, other than that-

There are five categories and forty-eight sub categories; did you think there were to many sub categories?

I don't think so. I didn't use the ones for correcting errors because I was usually doing the checking on it but I think if every person who was involved in a project-

Just so you know back checking is considered an error cost.

Right because you have to check-

Because if there were no errors there would be no back checking.

But just like I don't remember, if I had the other, the very last one in each line: other prevention activities, other standards activities. I don't know I had any during the time I was recording things, but I can visualize as soon as there isn't that category, that one would come up, because something would be there that wasn't specifically listed.

This is not necessarily a question for you, but if for instance, we said you understand the principles behind each of the five categories, if we just simply said, record your time under one of those five categories rather than the individual sub categories, do you think that would be better for everybody, or do you think that would make things more confusing?

I think until people got fully integrated into doing it, you would almost need to have all the different distinctions. Would all the entries, for say, external errors, would they all have the same costing to the client? You know if you're trying to work up what's the cost of external errors are all these weighted the same?

Cost is cost. The time it takes you to perform that activity is weighted with your hourly rate.

The only value that I found in having the different categories was being able to add notes or comments, because sometimes, in case there was a question to what I was doing, it put it in there. Whereas if only number one external error, I think there would be more possibility of erroneous entries of somebody not quite getting it in the right category.

We've past the twenty minute mark, so what I would like to close, but I'm going to give you the opportunity to say anything you want. I got one final question, and that has to do with mode of recording. Right now there is a reason why I did this study based with a separate re-coding device, rather than try to integrate these categories in the work breakdown structure, that you would record right on your time sheet. In your mind is it more valuable to record these things separately, or do you think recording them on a time sheet would be easier or more valuable?

No I don't think on a time sheet. Our electronic time sheets are not user friendly as they are, and I think trying to put any additional categories, or designation, would wreak havoc with the time sheets.

I see what you mean.

There are some projects that we work on, that we have to submit weekly time sheets, separate from the [deleted] timesheet, that we are submitting it to the client, or to the project manager, or whatever it is, and I see no issues with having a separate entry.

You had no difficulty, and from what I've seen, that you recorded this, you had no difficulty recording time, and you heard what I said about privacy, where nobody would be able to determine what you had spent, in terms of these non value added activities, because that's exactly what you are doing. If you are recording this time, somebody has evidence that you performed a non value adding activity. Enlightened people would realize that these are necessary functions, however, it's also possible that if there is an error cost, in other words, time that you spent correcting an error that might not reflect well on you. Would you believe somebody that this would never be used, or would you suspect the company might find a way, to uncover these cost, and associate them with you, and then possibly show up on a salary review? Do you understand what I mean?

Yeah, I don't know, I guess I trust if somebody tells me it's not going to be traceable. It would seem to me, if management does not know the quality of a person's work by a supervisor, and what issues come back on projects that someone works on, it would seem like a moot point, if they had to add a little survey or some sort or personal entry to verify someone's ability.

You can see that if these were available, they might be very easy for a manager to use these as a means of determining where you are in terms of your performances. For that reason I think that its most important that they never be used that way, and a system be put in place that take that out. Now that doesn't mean that information, in the aggregate, isn't available. My condition is there should never be an incentive for you not to record time.

If you want to have an accurate entry by an individual it needs to be anonymous.

So nobody should ever be able to get information from their direct reports? So in other words, if you were the group leader in mechanical, and you reported directly to Jack, Jack should never be able to get access to the numbers for an individual person or mechanical in general, because if he was able to hold you accountable for that, then you can turn around and encourage people that work for you to fudge their

numbers. It should only be a system but not an individual group where the info is available in general. General cost decisions are made by the available data, so if these are cost from the entire office you would find out what the cost are for your entire group, but never an individual. Jack would be able to find out the cost of all the groups

And this by project, right?

By project or whatever, and certainly the project manager should be able to make a determination on his entire project. Those costs should be readily available, but you need to be careful to who gets access to what. Those kinds of protections are easy to make, but you can see that somehow they could be perverted, and the questions is would that worry you? Would that stifle your ability to make judgments as to how you record your time? Would it cause you to fudge your time, thinking in the back of your mind that would happen?

No because I'm inherently honest.

I needed to know that. Now let's come to a close. Is there anything you would like to add to your remarks from what we discussed here?

No. I don't think so.

Did you understand all of the questions as they were presented to you?

Yes.

Do you understand that your remarks have been recorded and that we have your permission?

Yes.

Thank you. This concludes the survey. I'm now turning off the recorder.

This is Dave Loduca conducting a recoded interview with [deleted] at 1831 Chestnut, the [deleted] offices. Today's date is the 6th of July and the time is 12:24 in the afternoon. We are going to discuss reaction to a awareness exercise that was conducted in the St. Louis office in conjunction with project number 30131 Parkway School District. Do you understand that your remarks are being recorded today?

Yes.

Do you understand that your participation is strictly voluntary?

Yes.

Do you consent to your remarks being recorded today on the condition that they are used only for academic research?

Yes.

Could you state your full name and spell your last name.

[deleted].

Do you work for [deleted].

Yes.

What is your job title?

plumbing engineer.

Very briefly what is the nature of your job?

The nature of my job is to direct dirty water, sanitary water, or bring domestic water to and from facilities

What is your technical discipline?... I assume that's plumbing…

Plumbing, yes.

Do you commonly perform the duties of a project manager or task manager?

Task manager.

You've already had the opportunity to see the category guide that was provided at the training for the quality costing exercise. Do you recognize the color guide?

Yes.

What do you remember about quality cost?

I remember about quality costs… I remember.

Do you remember ever recording time under quality costs in the exercise?

I do remember recording time

When you participated in the study, did you understand the categories? I'm not asking if you understand them now, but when you were recording, did you believe that you understood the categories?

Yes, I did understand the categories

How accurate do you think you were in recording quality costs?

Accuracy… percentage-wise I would say about 60 percent accurate.

You might say 40 percent either way overestimating or underestimating…

As the project would increase in intensity, there may be an opportunity where it may go unrecorded… that was the reason…

Ok. That's good to mention. Would you open up the guide here and take me through one instance where you were working on your project and recognized something that might be suitable for recording… that you recognized something as… "well gee, that should be classified as some kind of quality cost… take me through that up until the point where you actually do the recording.

One particular project, we were installing a sanitary line or pump system in the bottom of the elevator pit. There are standards in which we have to follow in order to implement that and in doing so, we would get the authority having jurisdiction's approval on a system that we've come up with. We did find a method to do it to their satisfaction only to find out that another inspector came in on the project and did not like the methodology and wanted us to change it and shortly thereafter another inspector took over his place and he wanted to alter the sump pumping system a third time… to the disgruntlement of the client; and we finally got that taken care of. And that's where more of an error on the part of the authority having jurisdiction.

What I'd like to do… and I understand that… what I'm interested in… you're absolutely correct. But is it possible that I can get you to peek through this and possibly select an item that you believe would have been appropriate for a… where would you think that you would be recording your time

I would have been recording my time… before the error, I would have been recording my time…

I didn't mean to put you on the spot… but I am curious as to…

I would have recorded that more in… I guess rework… internal.

If I would have suggested to you that the effort to get preapproval from the authority would have been considered a prevention cost… would you believe me if I told you that?

Yes, I would have.

…maybe design planning or coordination planning…

… Coordination planning.

Now… I do know if you recall ever doing that… we're talking about one particular item as an error cost. I recognize that as you discuss that, there is an additional item that might have been considered a prevention cost. When you actually stop… In order to prevent a future error, you sought approval on an existing design

Right. The coordination with the first inspector was pretty much what the intentions were would be to get approval so we could move forward without any complications. It didn't come to fruition until the second and third person became… wanted to implement their own designs.

I want you to be candid here, because what I'm going to ask you is… let's assume for a moment that you didn't ask for pre-approval, okay? …And the local inspector reviewed your design and found the design lacking for whatever reason and you had to fix it… and you found that he had valid reasons for making the change. How inclined would you be to record that as an error cost? Keeping in mind that in the first instance you actually sought pre-approval and did it exactly by the book what you should have done but found, still, that you had to rework. And in the second case, it may appear from an outside observer that you didn't do your due diligence and as a result, you had to rework. How candid do you think you would be… once again, inside these four walls… it's important now… I'm suggesting in any way shape or form that you would not be honest, is there a likelihood that you might be a little… fudge your data on the low side if it looked like it was your fault, but maybe on the high side if it looked like it was the jurisdiction's problem?

It would have been higher on the side of the jurisdiction, definitely.

Yeah, yeah… that's what I want to know. The point is that I would like to know what you feel about the aspect of fear. Remember that when I was discussing this in the orientation meeting, that I said specifically that privacy would be respected… that nobody would know what you recorded, and that for the system to work… and ever be implemented, that privacy should… that nobody should be able to trace anybody's recording back to an individual. In fact, other safeguards should be put in place so that it can't be traced back to an individual group because your line supervisor might apply pressure for you to go easy on your quality costing recordings. So the idea is that you want to take out that incentive, so to speak… nonetheless, it's really important for me to understand how fearful you can be if somebody could actually… let's assume that these were recorded and all of the categories that you recorded showed up on a data sheet and that data sheet somehow wound up in your supervisors hands when you were in a salary review meeting. Would that have a… knowing that could happen, could that have a chilling effect?

What it has, in effect, for me is a direct attack on my integrity as an engineer. I think that has more of an implication than actual fear that having to do with anything with respect to a salary position. It would be more like… "I did not think it through". And that's the fear of doing that is NOT thinking it through… did I make that mistake?... or could I have done it a different way in order to make it work?

What I want to make a distinction here is… are you suggesting for a minute that it would embarrass you personally or would it embarrass you to the point that you would want to cover up your mistake… at least the financially reporting of that mistake?

Personally.

Personally… Ok…

I would.

Let me ask you to characterize this one way or the other. Would you say that I'm always open to admitting a mistake… that's not a problem. Although it hurts personally, it's ok to own up to a mistake because mistakes are made all the time… is that what you're suggesting?

Yes.

What would you think about other people? How inclined would you think other people would be recording their…

People do things to increase pleasure and decrease pain. So in doing so, I think that others may tend to seek something that would detour blame or detour the mistake and see if there was another method of placing it elsewhere instead of themselves.

So you trust yourself to record faithfully…

I do.

…But you don't trust others.

I do not.

Would you say that would be a widespread distrust or maybe a selective distrust?

I go back to my original phrase people do this to increase pleasure and decrease pain… and given where that might fall is where they would make their decision. If it makes them look good then they would do things… would say things that might make them feel better about their decision.

If there was a credible guarantee that nobody would ever know what you recorded, that it would all be aggregated computer-wise into multiple reports that would be useful for upper management but not traceable back to an individual. Do you think that would increase the credibility in your mind?

Yes, definitely.

So you think that if it could be traceable then you think "o my, nobody's going to be telling the truth", but if it could be made untraceable then "yeah, I think people would tend to be more candid."

Yeah. I think that if there are consequences, people will tend not to be as truthful. I guess you could say, for instance, the war in Iraq… you have guys… Taliban in your area whom you would fear would come back and harm you. You would tend to lie and say "they were never here." Because the consequences of once the soldiers leave and they come back, they're going to come after you. Whereas if you were in an environment where you didn't have to fear that retaliation then, yes, you would tell the truth… "yeah, they were here… they're gone… they're staying in this region."

I hope that if this ever get's implemented that nobody fears life and death… consequences like that.

Yeah.

What do you think about the principle behind quality costs?

I think it's… I really think it's critical. Evidence would that in our current auto market… let's say for example… I hate to pick on a company… let's say Chrysler had a very good product such as the Neon… a car that came in at a price suited almost every family that needed transportation regardless of the size of the family, but they knew they could transport members from "A" to "B" without any problems. Same thing was there… maybe a PT Cruiser… another nice vehicle they came out with. The problem is that they started experiencing difficulty… the company dropped their responsibility of repairing that vehicle. Later on, it was noted by more and more people that, excuse the phrase, piece of junk. And they tended to go away from that. The onset of offshore vehicles coming in setting a quality standard… less breaking down, less money I have to come up, less I have to take it back to the manufacturer to have it repaired, or even his represented, to have it repaired… they tended to gravitate towards those vehicles. As a result, the sales of that Chrysler product went down… went down… went down with the vow of some of those people, some of them who I had spoken with, that say they would never return to that company again for any vehicle as long as they live. That is the price of quality. Now you have something that you could never get back, it takes too much time. Even today, the stigma about the Jaguar having a poor transmission sticks around… another vehicle that has suffered through the years… probably a very good vehicle, but because of its poor history nobody really wants to fool with it very much.

And you're discussing, right now, the cost of lost opportunity

Yes, that's the cost of lost opportunity.

And to quantify that, as you can tell, would be very, very difficult thing to quantify.

Very difficult. I think that at the same time, the consumer is I don't think is a stupid individual. They may be taken advantage of, but I don't think you can discount their ability to assess products. Let's say for example a Wal-Mart product… may not be the best quality, but it does suit the purpose and they understand that it's for a temporary period of time… but they didn't spend $95 for a pair of jeans as opposed to $7 for a pair of jeans if they can wear it… and they KNOW it's temporary… they understand that. Therefore, during these economic times, people who are looking to save money who would normally not be found in that market would turn around and go and buy those $7 jeans, but they have an income that is insurmountable compared to the person that is looking for those bargains but don't quite make the same amount of money.

I understand your feelings on quality in general, but in particular… quality costs as a program is basically a means of measuring the cost of mistakes and the cost of preventing or finding the mistakes… and finding the true point of value… the true point of lowest costs. How much checking can we tolerate in order to satisfy our need in reducing errors… because if errors are insurmountable… if they're huge… we could afford a lot more checking… we could afford a lot more… and that's what it's intended to point out. So

those mistakes… all mistakes, have a cost and it's a matter of finding what that cost is and turning around and weighing it against the investment you would make in checking or preventing.

There is a magic number that tends to come to mind, and I forgot where this number came from: three tends to be the magic number on that cost factor. I our case here, we would do a back-check of a product that is getting ready to go out. And that's given to your lead supervisor or engineer, then they would check it. Whatever is found needs to be corrected and they give it back to you for correcting. You, in turn, make those corrections; turn it back over for a review a second time. And if there anything that needs to be corrected at that time, they return it for the third time. That should be the final in which you would allow that product to go out. After that, you really begin to eat into costs that are a little insurmountable. Also I think at that point you can start going down the tubes if your relationship as far as communicating what goes into that initial check is pretty well done… pretty well defined, then that person can actually do it twice, and the third time needn't exist. And if you can… I think that if you have that relationship where there is a known, you can cut that down to two times, but I think that three is the absolute maximum.

Then would you say that checking should be made part of the design process?

Yes.

Okay. I'm going to clarify what I just said. If the design process should be done going into the checking process or the design process should have loose ends so that the checking process buttons them all up. So my question is that… maybe you have an understanding "gee, if all of those loose ends are all tied up and the checking process is just a verification that you did a great job", rather than "here, you gotta do this, you gotta do that…" becomes part of the supervisory process, part of the design process… so it's a last ditch effort to direct the design in a particular direction, not a confirmation that the design has landed in the right spot.

Correct, I think that that's the intent.

Ok.. we are over time. But I have two additional points to make. Would you mind sitting for the rest of them?

Sure.

If from this Memorial Day, the corporation required everyone to begin recording time… so, in other words, if this system were implemented and everybody had to begin recording time… how would you feel about that?

That's fine… it works for me.

So for you, it was not an exercise that was burdensome, it was not an exercise that appeared to be… aside from the fact that it was a study… it did not appear to be useless

No… not useless at all.

There are in the guide… the color guide… five categories: appraisal, prevention, investment, internal error, and external error, but there were 45… 48 subcategories actually under those five categories. I don't know if you felt that that was a whole lot to absorb.

For a study… no.

In actual practice… obviously all 48 subcategory would not be touched by every individual. Project managers might ever touch rework, drafters may not ever touch a whole host of subcategories… you may not touch many subcategories simply because they would not be something that you would ever deal with. Either because of your pay grade, or your job, or whatever. You might be one to check work, rather than have your work checked, or maybe that would suggest that you would have more categories with those. But, planning purposes, negotiating… there's lots of categories that may not be things you care about. So the actual amount that you'd touch might be half of that… yet, there is still 48, but you regularly touch 24…

in fact, in one particular phase of a project, you may only touch three. So, as projects advance from phase to phase to phase, you might be subject to different categories. If that's the case, do you think that 48 might be manageable?

48 might be manageable. But here is my caveat for saying that: it would depend on the period of time you give people to get used to it… absorbing the 48 before you actually begin your study… an incubation period… then, I think, it would become second nature. But they need to have it where it is (1) you're asking a question… are you doing this often to make sure that they're applying it? And (2) the incubation period. I don't know if you want them to KNOW when the incubation period is, because they may tend to wait until the last minute to start doing it. If you say that there'll be an incubation period without a limit, I think that they would tend to absorb all 48 not knowing when it is going to take effect.

You said at one time that your ability to record faithfully went down as the project intensified. In this particular case, time was recorded on a separate recording device rather than on timesheet. And certainly I posed the question whether project managers should attempt to expand the work breakdown structure to include quality costs. It has been argued by me that there are lots of reasons not to put it on the timesheet and I won't go into those here, but in your opinion, did it make it easier to record them separately or would it have been easier if you would have recorded them on timesheet?

Separately.

Could you share with me… I mean, you answered that rather quickly…

The understanding was that it was a study…

But if it weren't a study, if it were actually on live… Would you still feel that way?

I think that it would be used as a whipping tool… that's just a fear of management.

Ok… so if it was a timesheet, then it would be more inclined that… well, the privacy issue would be taken out… so it would no longer be private

Right, and I say that biasly [sic] because, say for example, I might have a coworker that is working on one or two projects while I'm dangling nine at a time. Theirs might be used as a whipping tool depending on the production of the project that they're working on, whereas mine, there's always a fire… production is always immediate.

Well you had difficulties…

And you measure those, too… like this guy's got eleven-twelve things on his timesheet and you have six… or three. Does that become a "why don't you have as much or why don't you unload that person" does that become something that you use as a whipping post for that individual where you say "I think everyone can do twelve… this guy can do twelve, everybody can do twelve".

That's what I voted when people asked whether we should load up [deleted] more… and I said "hell yeah!… six is just not enough… he needs twelve."

But I see that happening and that's it in a nutshell. It might be that somebody's working on one large project and someone who is external to this place can look at these numbers… say, in New York… would probably say "why is this guy doing one on this project and this person is doing six, and this person is doing eight to twelve, and this person is doing three. What's going on… what's the disparity in these. You know, I just look at externally.

I don't know if someone could say that because you don't know what phase of the project that they're in or what their involvement is… I think that would be very hard to tell. What would be… I'm going to share two items with you in just a second… but I still want to dig just a bit deeper. Now, in those times when you found that recording was a little hard to do… you still found time to fill out your timesheet.

Right. Exactly.

But I'm guessing that the timesheet at that point was just simply I'm recording time, I'm not trying to figure out where to record the time… just recording time… plus, in order to get paid, I have to record time.

That has a bigger Maslow effect.

A much bigger impact. Which brings me to the point, as a separate item, there is less of an incentive to actually record time because whether I record or not… the pay is the same.

Yes, I would imagine you're right.

There would have to be some incentive to record faithfully.

Yes, I would imagine it would be.

And I have no idea what that would be to provide that incentive. The other thing is…

It might be a group function that we did this... we met our objective…

Well, if there is a motivational aspect, there will be an incentive to fudge…

Right. True.

So if it makes a difference, then fudge the numbers, and if it doesn't make a difference, then why bother putting it down, so…

True.

However, there is one thing though that most people don't understand and that's whether or not management sees those numbers and is able to take action. So if management sees: hey, there are lots and lots of mistakes going on and we look over here and see that prevention activities are very small… or prevention activities are very large, why isn't that offsetting errors… maybe we're not being smart about prevention activities. And maybe we just dig deeper into… what are you doing… what kind of prevention activities are you doing? Because well thought out prevention activities could easily be a way of offsetting large amounts of errors

True… true

Now… on the categories, it has been suggested that rather than trying to differentiate between 48 subcategories, simply classify them into one of the five broad categories. Do you think that would be a more workable solution to the complexity issue?

Can I answer that with a question?   I think it would be depended on the desired results that you were looking for from the test… what are you trying to measure? Once you have that down, then you can decide whether or not that would provide you with what you need to…

It has been suggested that the broad categories would be much easier to remember, but then it was suggested that "how would I know what broad category I want to go into if I don't really see the subcategories. For example, if I'm checking, it goes into appraisal. If I'm re-checking, it goes into error costs.

ahhh.

Because recheck means that there are errors found and that I have to do something more. If I'm just checking, I'm trying to uncover mistakes. But rechecking means that I'm uncovering mistakes from mistakes

Right. gotcha.

Or uncovering mistakes from correcting mistakes… so that's a distinction. And so the suggestion is that maybe we can go to the broad categories, but somewhere somebody's got to tell what broad category it goes to by looking at the subcategories

That makes sense.

Ok the allotted time is approaching. Is there anything that you would like to add to your remarks that we didn't cover or maybe something that you said that you really want to change

No. I think we did a pretty good job of covering it.

Did you understand all of the questions as they were presented to you?

Yes.

Do you understand that your remarks have been recorded and that we have your permission?

Yes.

Thank you. This concludes the survey. I'm now turning off the recorder.

8 July 2009 Field Notes: Interview with Respondent F33

This is Dave Loduca conducting a recoded interview with [deleted] at [deleted] offices 1831 Chestnut 7th floor. Today's date is the July 8th and the time is 1212 in the afternoon. We are going to discuss reaction to a awareness exercise that was conducted in the St. Louis office in conjunction with project number 30131 Parkway School District. Do you understand that your remarks are being recorded today?

Yes.

Do you understand that your participation is strictly voluntary?

Yes.

Do you consent to your remarks being recorded today on the condition that they are used only for academic research?

Yes.

Could you state your full name and spell your last name.

[deleted].

Do you work for Parsons Brinckerhoff.

Yes.

What is your job title?

Lead electrical engineer.

Very briefly what is the nature of your job?

Electrical engineering group manager and electrical engineering supervision of some junior engineers

Do you commonly perform the duties of a project manager or task manager?

Yes.

Let me show you a category guide that was provided with the training for quality cost exercises. Do you recognize this color guide?

Yes.

What do you remember about quality cost?... briefly.

There are good costs and bad costs. The bad costs are to correct errors and the good costs are to prevent errors

Did you understand the categories when you were participating in the study and recording time?

Yes

So there... let me point out that there are 5 broad categories and 48 subcategories, so I'm not going to suggest that you understand all of them, but you understood enough of them that you felt competent to record time.

Yep

What did you think about recording time against all of those categories? I'm going to stop the tape for a second.

Ok. We're coming back. The question… what did you think about recording time against all of those categories?

It seemed to be an efficient way to record the data that was asked for and it was probably the least burdensome way that I can imagine to do what Dave had done. It was easy for me to use and I guess at times it caused me to think about what I had… when it prompted me to record time and describe the time that I spent it may have made me think more about the quality costs that we were incurring.

How accurate do you believe you were at recording quality costs?… and here's the reason I'm asking this… these quality costs were done off-line – so to speak – when compared with the timesheet. In a timesheet, you don't record your time… you don't get paid if you don't record your time. But there is really no incentive to record time, except to adhere to the system. Now… that's why I'm asking. So… how accurate, at the time, do you think you were at recording quality costs?

I forgot if we recorded to the nearest half hour or hour…

Actually… that part didn't matter because the process allowed you to go down to minutes… minutes and hours, rather than just hours. In any event, what I'm interested in is… finish what you were going to say.

Since I didn't remember how accurate we were allowed to record time… if were allowed to record to the minute, I recorded time to the minute. I made every effort to record every quality cost. Towards the end of the months that we did it, I probably dropped off in my recording of it. I didn't keep up as well as how I began.

As a task manager and a project manager, how would you feel that at this memorial day, everyone was required to record quality costs in this way?… that, say, this became a requirement for the district?

For a project or all projects in the office?

For all projects

… how would I feel as a manager? I guess if it were a requirement, I would look at and I would probably explain it to my employees as being, in itself, a cost of quality. It would be… it might… I think at first take I think it might be a burden… although a small burden to a…

A burden in what way?

Maybe a nuisance… just in having to bother with it.

Is the bother assimilating the system and learning it from the ground up or the continuous use of the system?

The continuous use… I think the learning of the system was pretty straightforward… short learning curve as to what to do and why we were doing it. I forgot how it popped up.

To refresh you r memory… depending on how you set your machine, you could have it pop up when you first logged-in in the morning and you simply minimized it… it was also a application that you could seek out on your desktop and re… pop it up again… it came up relatively fast, and it was – relative to the regular timesheet – it seemed to be really quick. What you might have encountered as a difficulty when simply tracking down the particular cost that you were looking for… but if you knew where it was, it was probably easy to find it.

Ok… since it's the user who has to initiate the recording, right?… I would imagine that a lot of users might ignore it and wouldn't use it even though it was a PB requirement because PB would not be able to track your non-use of it… does that make sense?

Yes. How would you feel if PB made project managers and task managers responsible for making sure people recorded that kind of time?

It seems difficult to do. I guess I probably wouldn't object to it… how would I feel…

Once again… if a project manager or task manager had to enforce that

Not sure how they would enforce it. I think that they would require it.

Ok… that's a good answer. What did you think about the principle behind quality costs?

I thought it was a good principle… and a good educational tool for the people I think got to take part in it and hear the presentation. It seems meaningful for a company to examine it.

Let me go back to another question that I asked earlier, but ask it in a different way. There were 5 categories: the categories being prevention, appraisal, internal error, external error… and a new category that wasn't part of the original model, and that's investment. But there were actually 45 subcategories. Do you think that there were too many subcategories?

Not necessarily, because I ended up using just a few of them. I became familiar with the ones that I commonly used and used those easily.

So the fact that there were 48 of them didn't overwhelm you?

Right. Because I knew that I might just use six of them 90 percent of the time.

Could you take me through a typical… what I want you to do is describe an event where you encountered an item that you recognized a a quality cost… take me through one time that you did that. I'm taking from the very beginning of the event up until you were finished recording it.

You want a real event?

Obviously you can't remember a real one… a typical event that you….

Just the event of logging the time or the error.

First off… it's not just errors, it's also appraisal, it's also… all of those… pick one…

I'll pick an RFI that comes in from the contractor. I would read the RFI and if I discovered that the request for information was due to some error in some drawings, or in our documents, or some part of our documents that wasn't clear, then I would issue a change of clarification to the contractor so that time then to investigate… not the time reading the RFI… but the time investigating the error and fixing it would have been the time recorded… that would be an internal error, I believe.

So, before you went into… before you seen the RFI, you knew that "oh, that's an RFI… I'll have to record time on this". So it's just a matter of…

No…

You suspected it could be, so, how did you verify that you think you needed to… did you

Only if it turned out to be an error on our part… on PB's part

I guess what I'm asking is that did you return to the guide and say "I'm sure RFI's are in here somewhere… ah, here it is: RFI's"… and that would determine what type of cost it is and then THAT's how you would record the time?

Yeah, I may have looked it up to make sure I knew which subcategory to use

Ok. But eventually it found its way to an RFI category or subcategory.

Right.

But… then you went to your machine and… did you keep track of that with a pencil and paper or did you immediately go to the popup to record the time… how did you...

I'd finish the task and keep track mentally of my time and record the time that way.

Do you record your time daily on your timesheet?

Generally… no

Ok. So I'm guessing that how you record your timesheet would play an important role in how you record time on this particular… so you would be somebody who would wait until the end of the week before he would record his time and rely on notes he left himself throughout the week… somebody would do that the same way, you think?

Yeah, although this… the cost of quality was so specific, and the times were usually so short that I recorded the time the same day that I did the activity.

Once again, five categories and 47 subcategories… what would you say if the system included only the broad categories and none of the subcategories, would that make it more difficult or easier?

I think that it would make it easier.

Okay. I ask that for one reason, that while there are only five categories to remember, there are no subcategories to give you a clue as to what belongs in the category. So, that's why… you still think it would be easier? That's okay if you think it's easier… I'm just asking.

Well, your book that you produced… our instructions had cues for what did or did not belong in a category… I would use those.

So you think that the subcategories should remain, you just don't want to record time against the subcategory… just a broad category

Well, five broad categories are easy for me for me to put in any activity without looking anything up. So that I could easily record the time in five broad categories than I could looking up subcategories. Does that answer your question?

Yes. we still have a little time left. So let me ask another question. Did you ever fear that… remember that in the orientation I said that nobody would ever see the time that you recorded. Nobody would be able to associate your time with you. That the time would only be aggregated and a report would be developed that would show everyone's time and not an individual's time. First off… did that matter to you that nobody would see the time that you spent or nobody would see other people's times?

I guess in principle it mattered to me, I think it's…

Why would it matter to you?

It mattered because it was your project… personally your project so I didn't think it would be appropriate to take data that you've recorded and share it with everybody else.

So if this were implemented corporate-wide, would you trust the corporation to maintain that policy of keeping all of the recordings confidential?

I'm not I understand what the intent of the corporate policy would be.

Well, the point of the policy… anybody who has an incentive to record time or not record time because he may get a pat on the back or he may get a slap on the wrist because of how much or how little time he's recording. Nobody should fear or look forward to the results or consequences of that, but to simply record the time for the purpose of submitting data, so to speak, rather than possibly inviting ridicule or inviting praise.

Ridicule or praise based upon diligence in recording time or the fact that you're the cause of errors?

…That you're the cause of errors or that you're NOT the cause of errors.

Okay.

Anytime somebody perceives that there is a motive for recording time may fudge their time to fit the motive.

So if PB is going to evaluate individuals based upon time recorded or that they're recording their own errors, I think that people would fudge because they're self reporting… I think they would fudge to make themselves look better.

Well, it's not all self-reporting. For instance, if a drafter is correcting an error, it may not be his error he's correcting. He may be correcting an error caused by others. So, but you can see that he may overemphasize errors that he's correcting for others and underreport errors that he's correcting for himself. Nonetheless, in may seem a little bit inhibiting for someone to actually be honest in recording the reports of quality costing is organized so that one can easily see how much time he recording on all of the categories and it may show up in a salary review… or, it may show up in such a way that a functional manager or a project manager can actually see individual performance in that regard and tap somebody on the back and say "take it easy on error costs or take it easy on this cost or really hit this cost hard" because they want to prove a point rather than letting the chips fall where they may. You can see how that happens now on timesheets. One project may be open for business and another project might not be. I'm not saying that anybody lies about their time… it's just that they may give one project the benefit of the doubt that they don't give another project.

Yeah, but the harm there is done to the project budget whereas in this self-reporting, the harm could be done to the individual.

That's correct. The individual… I'm asking if you would fear that knowledge in the hands of management.

Of my reporting of the cost of quality… in the hands of management… Both in the amount of errors and prevention?

Any time you spend at all.

I guess that I wouldn't fear it, I would be suspect of it… I guess the reason the company would gather the information would be to compare employees. And on employee might be more… might have more of an opportunity to be the one to correct errors or be the one to prevent errors, so they have more opportunity to spend quality costs, where another might not be, so reporting for one person might be much greater… more reporting than another person.

That would be a reason not to compare them… not to allow people to compare because there are disparate opportunities to report errors and report prevention, and report appraisal and things like that. Somebody who is… a lower level employee who spends a lot of time in prevention costs may be assigned to projects where project managers require lots of time in prevention costs. One who spends a lot of time correcting errors my simply be that's what his job is… when it comes time to fix problems after plan checking, he's the one… or he or she is the one who is responsible for covering the redlines and those redlines may not necessarily be theirs.

You may also have a dispute between people on a project on what the source of the error was.

That could be… there could be disputes. Any dispute that becomes a distraction could interfere with the free flow of information. So, for me it's important. But for the question that I have is for you… if you thought it was important. Now, do you think it would be important for others? You may think it's important… do you think others would think it's important?

Important to the company to report it or …?

No. Important that confidentiality be maintained. Do you think other people might have that same fear?

Well, you mentioned that it may be used in a salary review. Is the confidentiality…

The purpose of the confidentiality is that nobody can use it that way. So, in other words, if you're performing a review of one of the people who works for you, that… that information is simply not available to you.

So let's back up… PB begins to implement the cost of quality tracking company-wide and the only reason is for PB to gather all of this data and look at the cost of quality without tying anyone's name to it.

For instance, it might be on a project… project-wide that they would be able to report it, or maybe a department able to report it, or an office… but never an individual

Ok. So I wouldn't fear that. Because if the company says they're going to do something, I expect them to do it. I imagine most people would be like that although I imagine some might also fear it and think that the company ahs ulterior motives. I would say the use of that is good… just thinking now… office level or project level, and not so much on individual level.

Well, the individual levels, I think, could be important… trouble is, there is no way to allow access to the really important ones without triggering that fear. If I can access it to find out something that's really unusual, then I should be able to access it for anything that I want. And that shouldn't be the case. Because no matter what, somebody, somewhere along the line is going to figure that that's worthwhile to use as a comparison in a salary review. "you know what… these are really good numbers… we can actually compare and quantify people with dollars and cents…this is how much you cost the company today… or this week or this month"… and it shouldn't be that way. The other thing is I had not envisioned… that's another question that I want to ask you… as a matter of fact, let me ask that now: right now, you see how it's recorded… it's a pop-up independent of the company timesheet. As a project manager or a task manager, what would you think if those categories showed up on the work breakdown structure? Do you think that would pose a problem?

On the timesheet?

Hm-hmm [sic}. How would you feel about that?

It might help, because the employees are thinking about time spent on the project… so they can think about quality time… all the time… together. So, if they're about to record four hours for a project, where they would have ordinarily thought two hours were spent on the quality errors of some kind, they realize that it's 50 percent of my entire time, it might make them think twice about the amount of time they're going to record… other than that, if it's as easy to pop-up as the timesheet is now… well, the timesheet is more cumbersome because you need a password to get into it, so it takes a little less time to… if it's just as easy as the cost of quality pop-up, I don't think it would be an issue.

There is a reason for it: one is that projects sometimes run out of money, and when they run out of money, project numbers close. The likelihood is that when they run out of money, there are quality costs involved. So stopped recording of quality costs… well, it's similar to stopped recording of project time. If you go back and figure how much time you spent, but you've closed the project before you're 90 percent done, then you've shot yourself in the foot on keeping historical data that you can use. The second thing is, timesheets are open to clients… this data would not be.

I had another thought, if I could share it… you mentioned that if a project runs over budget, I think that there would be a tendency for employees to record error costs not add time to error costs, but with the intent of sticking it to the project because they just feel put upon by some errors that other people are causing or if the project manager is known to always change things at the last minute, or if a certain client, in that respect… so at the end of a project you might see more of that, whereas at the beginning, everybody seems to have more time on their hands – maybe not record those kinds of errors.

So you think some employees might be more arbitrary and vindictive?

Yeah, it's possible.

Ok. Do you think the reason for them being vindictive or malicious would be related to an experience on a project or simply by personalities? I say that because if somebody wants to stick it to the project because of something that's gone wrong, maybe that is a well-founded… just because he enjoys it when he records it doesn't mean… it doesn't deserve to be recorded. Likewise, if you have a good feeling about the project… "I don't want to saddle them with the stigma of error costs"

I think it's more like that… in my mind it would be more of an issue of NOT recording error costs when they should have been costs, as opposed to over-recording error costs.

I might agree with you there. By the way… we've already past the allotted time, so let me ask you if I can expand on one last point and we're going to wrap it up. Do you think that underreporting is due to apathy or do you think that there's a conscious effort… do you think that there COULD be a conscious effort to avoid it because of some other motive?

Sure… apathy will play a part. I guess other motives would be… personally, if the person didn't feel burdened by the error that they're correcting, or it was preventative… if it just didn't seem like a big deal to the person, they might not record the time.

Ok… the allotted time is approaching. Is there anything you'd like to add to your remarks today? Something that hasn't been discussed that…

 No.

Did you understand all of the questions as I presented them to you?

Yep.

Do you understand that your remarks have been recorded and that we have your permission?

Yes.

Thank you. This concludes the survey. I'm now turning off the recorder.

APPENDIX E

GROUP 2 INTERVIEW GUIDE

INTERVIEW GUIDE

OPENING QUESTIONS

- This is Dave Loduca conducting a recorded interview with [name] at [place and address].
- Today's date is [day, date] and the time is [time].
- We are going to discuss reaction to pilot study that was conducted in the St. Louis Office in conjunction with project number 30131, Parkway School District.
- Do you understand that your remarks are being recorded?
- Do you understand that your participation is strictly voluntary?
- Do you consent to your remarks being recorded today on the condition that they are used only for academic research?
- Could you state your full name and spell your last name?
- Do you work for Parsons Brinckerhoff?
- What is your job title?
- Very briefly, what is the nature of your job?
- What is your technical discipline?
- Do you commonly perform the duties of a project manager?

CONCEPT DISCUSSION QUESTIONS/COMMENTS

- I have a theory regarding the quality of drafting work with respect to the history of Computer Aided Drafting and Design. Listen carefully to this and tell me if you agree with this explanation.

    a. Before CADD, there was a substantial divide between engineers and drafters. Engineers rarely performed work as drafters and drafting, as a profession, was quite developed. Drafters obtained technical training but, as a rule, no college degree. They focused on drawing format, tidiness, speed, and accuracy. Engineers, on the other hand, focused on design issues, such as code compliance, engineering calculations, notes, and specifications. Engineers took a semester of drafting in their engineering curriculum, but not nearly enough to make them reasonably competent as drafters. Drafters found job security because they were highly skilled and maintained an ethic of high quality.

    b. When CADD was introduced, it was not possible to produce the same high quality work as hand drafting. This was especially true for CADD packages that engineering firms could afford. In addition, the technical barrier for older drafters was quite high. As hand drafters, they were highly skilled, but as CADD drafters, they would be beginners again.

INTERVIEW GUIDE

    c. As CADD packages became cheaper and more widely used, entry level drafters were opting for more computer training so as to accumulate the skills needed for competence in CADD and less training in the art and science behind drafting work. The skill set shifted from drafting quality to CADD competence and computer literacy.

    d. CADD class replaced mechanical drawing in engineering school curriculum. Unlike mechanical drawing, a semester of CADD could provide engineers with a minimum competence. As a result, many engineers found themselves doing at least some of their own drafting, but to a much lower standard of quality.

    e. Even among drafting employees... There may have been a few old-style drafters make the transition, but as a rule, drafters now are substantially less focused on structure and form than hand drafters.

- What do you think of this model?

- What do you think of the quality of drafting work in an environment where both engineers and drafters perform drafting work?

- For what firm did you work before your tenure at Parsons Brinckerhoff?

- What was your job title there?

- Could you describe your management duties there?

- PB's managerial cost accounting system collects timesheet data and compiles multilevel reports. It includes metrics such as performance ratio, financial cost at completion, earned value, and projected cost at completion. What kind of managerial accounting did [Coad-Rascovar][Booker] have along those same lines?

- What kind of flexibility did [Coad-Rascovar][Booker] have in crafting project and company reports?

- Let me show you a project close-out document. It contains an oath, to be signed by the project manager, task manager, and QC reviewers. In your opinion, what affect does this activity... signing of oaths... have on overall quality of deliverables?

CLOSING QUESTIONS

- The allotted time is approaching. Is there anything that you would like to add to your remarks?

- Have you understood all of these questions as they were presented to you?

- Do you understand that your remarks have been recorded and that we have your permission?

- Thank you, this concludes the survey; I am turning off the recorder.

APPENDIX F

GROUP 2 INTERVIEW TRANSCRIPTS

11 August 2009 Field Notes: Interview with Respondent F2

This is Dave Loduca conducting a recorded interview with [deleted] at 1831 Chestnut St., 7th floor, Parsons-Brinckerhoff Offices.

Today's date is the 11th of August and the time is 3:41 in the afternoon.

We are going to discuss reaction to pilot study that was conducted in the St. Louis Office in conjunction with project number 30131, Parkway School District.

Do you understand that your remarks are being recorded?

Yes

Do you understand that your participation is strictly voluntary?

Yes

Do you consent to your remarks being recorded today on the condition that they are used only for academic research?

Yes

Could you state your full name and spell your last name?

[deleted]

Do you work for Parsons Brinckerhoff?

Yes I do.

What is your job title?

I am the [deleted]

Very briefly, what is the nature of your job?

I lead the architects around the company… around the country. Providing professional guidance and staff development.

Your technical discipline is obviously architecture.

Yes

Do you commonly perform the duties of a project manager?

Yes

What is your educational background?

I have bachelors in architecture from Kansas State University

Tell me about the classic architecture curriculum as it was practiced in the course of study when you were there.

Okay… it was a five year program… the initial two years were pre-design professionals that incorporated folks who in the future wanted to be professional architects, interior designers, or landscape architects. At the end of that two year curriculum you declared which major you were going into and then you were placed into advanced program studies that were focused on one of those three disciplines. Majority of the work throughout the five years of architecture study is studio-based design work with an average of five hours a day being spent on studio studies working on design problems. The balance of the curriculum is focused on architectural history, structures,

MEP concepts, and then some specialized design focuses, whether it's focused on history, or on, say, one particular engineering discipline, or project delivery, or some specialized focus. And the balance is a liberal arts program… math, science, literature, social studies. So it's your basic course curriculum.

I have heard from an architect that teaches at old dominion university that the principle design responsibilities of architects include building envelope, building finishes, weatherproofing, and human occupancy. First off… is that an oversimplification or is that fall way short of what you would expect would describe an architect?

Yeah… Actually I think it does. Because our code effectively… our license… says protect the health, safety, and welfare and that description didn't really talk about health, safety, and welfare at all.

Well I guess when I talked about human occupancy; I meant issues associated with human occupancy. Maybe that would be a little more encompassing… but I agree with you.

In your opinion, does an architect's training put him/her in a better position to perform project management duties… than, say, pick an engineering discipline?

Hard to say. An architect's schooling doesn't really provide much background in teamwork and collaboration… it's more individuals working as an individual on projects so you don't have an overall project leadership and management training in academics.

I'm going to turn off the tape for just on second… [TAPE OFF]

[TAPE ON] Okay, we're back now.

Okay, so back to where we were talking about training and background for architects to be project managers. I would say that certainly in the academic programs, architects are exposed to what the other disciplines are doing and how those disciplines impacts the architectural design. So to a certain extent the architects have a pretty wide knowledge of the overall design process as it relates to not only architecture, but the other disciplines. But they don't have any real training in putting together budgets or schedules or actually monitoring progress towards completion because it is pretty much a singular activity while you're in school.

In fact, when you think about it, one of the bad habits that architects have come from school… and that's doing all-nighters until the project is complete at the last week that particular program was due. Let's say that you have four weeks to design this project and the first three weeks you're kinda playing around the edges and not much progress, but by gosh that fourth week it needs to be due and then you're into all-nighter mode. I don't consider that good project management technique… but certainly comes from the atmosphere we grow in while we're in college and university.

Now, related to engineers… I think engineers are exceedingly precise, at least the ones that I've encountered. I think that precision is a better attribute towards project management, but… that precision also is an obstacle because you can't see around things very clearly. There isn't… I would say that engineers have a more linear path than architects do… we tend to bounce from side to side.

Let me stop you for just a moment. Regarding that very thing… would you say that architects have a broader perspective than engineers?

I would say so, yes.

The reason that I'm saying that is that I would expect that engineers… and I'm an electrical engineer myself… I've dabbled into a bit of mechanical engineering… and mechanical engineers have dabbled a bit into electrical engineering… but neither one of us, as I recall, have ever touched anything associated with architecture.

…or structural engineering, probably.

Well… very briefly in something called statics… which is the precursor to solid mechanics… but that's it. I can't imagine anyone going any further than that. So… the expectation is that project management skills aside, because engineers would not necessarily have project management skills either.

Uh-huh [sic]

But just because of perspective, would you say that have, at least in building projects, are more suitable for project management duty then others.

Yes.

Okay, I'm going to zero in on specific skills in just a second. Tell me about testing that was required of you to obtain your professional registration. Compare your testing experience with what you understand to be part of the testing requirements for architects today. Did your testing require that you have drafting skills?

Say that again?... my experience is that I passed my exam in 1983… so we're talking 27years … 26 years ago. The requirements are a little bit different today than they were in 1983.

Let's start with yours then we'll move to compare with what it is today.

Alright… first of all, before you're allowed to sit for the exam you're required to have three years of apprenticeship and then you're eligible. The exam was done over two periods… one in December and the other one in June.   If you wanted to take… if you wanted to pass the exam, you had to do it in those two separate periods. There was no choice to take it all in December or all in June. Half was offered in June and the other half in Deceumber. The June session was, I believe, two days: one day was solving a design problem, given a program at 7 a.m. in the morning, given till something like four or five in the afternoon to come up with a design solution and to document it with plans, elevations, sections and such. The object there was to be able to delineate your understanding of the building codes, have the ability to satisfy spatial relationships, to conceptually design the building systems; structural, mechanical, electrical, and such, and to illustrate a building envelope and architectural character to it all. You didn't have to be a signature designer to pass, you just had to show evidence that you could pull all of the pieces together in a design.

So there was a graphic component…

Yes, in fact it was really pitiful… the paper that you were provided was, I forget the size, probably 11 x 17… reminded me of the thermal fax paper back in the early days…

The greasy paper… the one that left your fingerprints on everything…?

Yeah… Yeah… that stuff. You put a pencil line on it… you couldn't erase it. The paper would tear up… there was no tooth. It was hard to get on it and once you got on it, it was hard to get it off. I ended up taking that exam twice. The first time, I ran out of time… I got tied up… I was designing an airport. It was a two-gate airport, and I came up with a design concept very quickly and I felt pretty good about it… but THEN… let's test it and before started designing too much and before I knew it I was in this designing mode and I couldn't get out of it, until… holy moly… it's two o'clock in the afternoon! I need to get this thing documented!... and I started drawing and I just ran out of gas, but I was partially frustrated by the pen and paper. But the second time I did it I took it I took pens and white-out and learned how to quickly drawing things and get it solved.

The other part of that exam was a professional practice piece where, in the June thing, where it went through a programming, schematic design, design development, construction documents, bid award and construction administration and your knowledge of the activities that took place through the various phases of design. So that was the June exam. The December exam was a lot of book

knowledge… architectural history, structures, materials and methods, systems design… I guess that's probably the majority of it. And those were a series of two hour exams.

Now what has changed to today?

What has changed today is… it's all done on computers, you can take the exam anytime you want, just sign up at Prometric, or one of these testing places. You can fail a piece and come back and retake it again after a certain waiting period… you don't have to wait until next June or next December to take it… it's much more fluid. You can also begin taking the exam before your three year internship. What is required now before you can sit for the exam, you have to demonstrate… you have to complete intern development program, which is an NCARB-guided program to be sure that your getting the prequalifications necessary during your "apprenticeship".

The graphic part of the exam… did that go away because it's a Prometric online?

No… it's now done on a computer with – I haven't personally done it – I understand that you have some rudimentary drawing tools that you use in order to do the design exam.

What was the drafting skills that was part of your curriculum in College?

Interesting… it was one semester of graphic design… well, maybe it was two semesters. I transferred into K-state… I had already been to college three years before I went K-state's architectural school.   I gone to University of Missouri in St. Louis and taken a bunch of liberal arts classes. I did two semesters over summer school and it was graphic design one and graphic design two and it was basic architectural design skills.

In my own curriculum, economics majors had to take calculus, but calculus wasn't something that they had to worry about for the remainder of their coursework, but for engineers, calculus was a major part. But Engineers didn't have much to do with graphic design after it was originally taught. I assume that it was just the opposite with architects.

Oh, well yes. Certainly two semesters of graphic design become the foundation for your drawing work all of the way through… we were always conveying our designs in graphical three dimensional…

I assume instructors would convey their desire to convey good habits throughout the curriculum.

Yes, but we were fairly free to illustrate the way we wanted to, and in whatever medium we wanted… there really weren't any restrictions except perhaps you were required to provide your presentation on a 24 x 36 format or something of that nature for cataloging purposes. We were pretty free to do things the way we wanted to. Now… we were also driven by excellence and driven by our own desire for high quality so as a… the more we drew the better we drew it…the more interesting and better quality those drawings became. So if you look at my earlier drawings versus my later drawings in school, you can see the later drawings are much richer and more refined and certainly have better poise and confidence in them.

How would you compare the drafting skills that you learned in your formal training with what you would expect a professional drafter might encounter in his/her formal training?

Pretty different. My skills are more illustrative… to convey concepts, where a formal drafts person is geared to more precision and drawing things to scale and to be more illustrative than the graphic skills that I was taught in school. Keep in mind that we were doing everything by hand back then and we didn't use computers.

This next question will require your very most objective memory… think about drafting and drafters as a profession (not with respect to a particular individual) at the time you were first registered (back in the Coolidge administration… right?) Now think about drafters and drafting as a profession today.   Certainly

they required totally different skill sets... but how would you compare their collective professionalism of, adherence to standards and values

"Professionalism is a high level of awareness of and meticulous adherence to recognized standards of the profession, plus undeviating courtesy, honesty, and responsibility in one's dealings with customers and associates, plus a level of excellence that goes over and above the commercial considerations and legal requirements." "Professionalism is not about your job title or self-proclaimed worth. In fact, it is not about self-perception at all. Professionalism is about personal ethics, quality work and a quality attitude."

You can use that definition or any definition that you like... but once again, I want you to compare drafters when you were first licensed and drafters of today.

Ok... I think you already know this about me... I've never particularly cared for drafters, per say. And here's the reason... I'm not really answering your question... when... I'm going to dial back for a moment. I learned my drafting skills when I was in high school. I loved drawing. That's really what focused... I loved both drawing and I loved art... and that what kinda drew me to architecture. I loved solving three-dimensional problems. Do you remember the isometric you would draw... maybe you didn't... in high school? Well, those were fun. Drawing isometrics... line weights were fantastic... all those things that make a drawing really sing, I really enjoyed doing.

Alright, when I got out of school, I really didn't have much knowledge about how things went together. But I did know where to get the information and how to get advice on putting things together. And I took a lot of responsibility on trying to do things right and with quality. And we had quality... technical advisor, a technical principle in the office... he'd review the work... he'd sit down with you and make suggestions on how things should go together and make improvements and provide guidance on where to look and... that's how you learned... very much like an apprenticeship. Ok... The folks I've seen coming out of school today that are draftsmen, per say, don't really have an understanding of what their drawing... they just want to draw. We have folks in our own office that are not architects, but we put them in a position of drawing architectural things... and they will replicate lines and linework, but not know what they're drawing, and not have a good understanding what it is... all you're getting is graphic gibberish back to you. There's... There's no problem solving going on. It's more... here, I've sketched a door detail, you know, if I don't put dimensions on it, what I'll get back is crooked lines and things out of place because they think I want them to replicate my detail... not necessarily use it as a point of departure to create the graphic that needs to be put together for the final documents. So... I've never been fond of the profession of the "draftsman" because I think they don't necessarily have the passion that goes into making things right. So you'll know that all the folks that we hired in our architectural group have architectural backgrounds... have degrees in architecture, and are pursuing licenses in architecture except one. [private comment] But... Other-folks that we've hired temporarily, or otherwise, that have been draftsmen, I've just not been happy with their work. It doesn't seem that... it doesn't show... they just don't do much to develop the drawings or develop the concepts... just laying lines on paper.

Consider the advent of word processors. Where a professional secretary used their skills to synthesize business correspondence from notes and dictation, individuals now do their own typing, grammar, and wordsmithing. Compare that to advances such as AutoCAD and Revit where the line between engineer or architect and the drafter is blurred. How do you think that has affected drafters and drafting as a profession?

I think... it will make drafters an albatross. Revit... the power of building information modeling is best in the hands of an experienced designer, because the decisions that you're making in those models are... will have... will impact the design from beginning to end. It's not like drawing a schematic where those parallel lines that you represent a wall with may be any wall... could be block... could be drywall... could be an exterior wall... could be an interior wall. But with Revit,

when you put those lines on paper, you're representing a particular piece of construction. And, while it's not necessary that you understand what that particular piece of construction is from day one, your chances of improved productivity and final quality of the documents will be greatly enhanced if you've sort of thought through the process before you put the wall on paper. So, I think that Revit provides a greater opportunity for an architect to do more work than themselves than previously.

So just like word processing made secretaries kinda into… something else, Revit and AutoCAD makes engineers and architects into somebody that does not necessarily need drafters?

Yes, that's right.

Ok. Alright. We've passed the twenty minute mark for sure, but I have a few more questions if you wouldn't mind.

No, not at all

Ok. Alright. This is going to be going back to the quality costing theme, if you please. The category guide…and that's the one right on top… that was provided for training for the quality costing exercise… what that represents… first off, you don't remember this because I don't think you've ever seen this.

No.

It represents 47 individual subcategories and five categories. You're reading this now… from what you read; do those items look familiar to you?

Yeah.

Okay. So, for you, those subcategories would not be something that you would have trouble with, or understand.

Correct.

Would you think that they're… obviously, a drafter, or engineer, designer, project manager or task manager would have… each of them would not necessarily be addressing all 47 of those… they wouldn't be hitting all 47… they would only be hitting a small group of them.

Right.

But do you think that, in the context of individual jobs, that those are understandable, even by drafters, designers, and engineers? Do you think that they're beyond their comprehension?

I think… this is… nope, I think that pretty much anyone could handle this. They may not necessarily understand the terminology, but could probably pull it off. You know, for example, an RFI, if you don't know what an RFI was, you know, three letters… but once you understand, you can certainly address it.

Okay, let me take you through one recording. If you flip through the beginning of the… what participants had to do was… in this particular example… they would have to discern what exactly they did… recognize it as a quality cost, and… so, this basically tells them what it is… the basic definition of what it is, a detailed definition of what it is, and I even say what it's not.

Hm-hmm [sic]

And then, there would be a pop-up on their machine where they would be able to select the job, select the broad category, and once you select the broad category, all of the subcategories would pop-up that would match all of these.

… match all of these.

They would select one… then hours and minutes… they would enter hours and minutes and hit enter and they would log time that they just spent completing an RFI… or preparing rework… or whatever task/activity that's described there. Is that a… do you think that's a cumbersome activity… to record that time?

No, I wouldn't think so… I think that you've made it pretty simple.

Alright… These are separate logs. In other words, time that's recorded on a timesheet which is accessible by clients… and this is NOT accessible by clients… if somebody would suggest "hey, let's adjust the work breakdown structure to include many of these categories"… how would you feel about that as a project manager?

Uh… I'd be fine with that.

Really?

Yeah.

Wow… okay.

Well… here's a little different scenario for you: the cost of not doing… the cost of quality is significant… I'm kinda curious as to what your research is showing here… the time effort and such. But we are in the architecture and buildings TRC [technical resource center]… we are setting aside budget for doing additional QA/QC to assure that if a project cannot… if a project budget… I'm trying to rewind here… if, for example, the reason a project does not go through enough quality procedures and it's pushed out the door… if the reason for that is that it doesn't have enough budget, and the project manager is, like "I don't have enough budget… just get it outta here!"… that is not appropriate. You don't want to see that happen. The residual cost of that is way too high. So we're developing… we're incorporating a budget… an internal indirect budget to cover those costs so we DO get things checked. Now, this isn't for general dissemination, but it sorta like if someone said "well, if there's no budget left, we're pushing it out"… no, it isn't, it's not going out. I have a budget to get it checked. So, I'm totally fine with identifying costs associated with reworking a project, because I think if we spend enough time up front… if we can record that information and spend enough time up front to do the project right… put quality improvement measure to mitigate the impact of some recurrent theme that causes problems with projects… hey, I'm all for it… let's do it…. Let's spend it. So no… I have no qualms about recording time reworking stuff. In fact, I bet you it has an incentive component to it. If I find myself reworking things and having to record it, I would be incentivized to do it right the first time and do a better job the first time.

Recording time has a three-legged stool of incentives. First off, you want to record time… forget CoQ for a minute… you want to record time because NOT recording time means that you don't get paid.

Right

Okay… So… you want to be billable

Right

And, the second incentive is… you want… you don't want to JUST record time, you want to record time to a project. So, you want to get paid and you want to be billable because billability… despite what people say, billability is important and sometimes it finds its way back to your performance review.

… certainly a performance measure

Third item… third interlocking incentive is to only bill what work that you do because the project manager is going to be stingy with his dollars and say "okay, fine… you can bill to my project but you have to give work in exchange and you have to do it efficiently.

Okay

Ok… so there is three incentives that keep the process relatively honest.

Mm-hmm [sic]

ok…in separate logs for quality costing… none of those three items exist… so it's just your internal incentive to report time that… if this was done on a continuous basis… to report time that you feel will help the quality… the general quality of the company.

Right

It's a… maybe a mark of professionalism… "I'm going to disclose all of my quality costs because those are important." However, the reverse of that… to INCLUDE costs of quality in the work breakdown structure… like I said before, there are 47 subcategories… it's been my experience that project managers try to minimize work breakdown structure tasks to just enough so that he can control the project adequately. He can make judgments as to perhaps percent complete by looking at the dollars spent on a task. He's not going to be… he's not going to be incredibly lavish in how many tasks he provides unless it's a super project manager with very large projects, then they're going to be very, very complete… very lavish… you're going to get tons of tasks. But with medium to small projects, they're going to try to keep tasks to a minimum. Either by discipline… by office…

…By phase of service…

By phase of service…

Sure… but you didn't ask me that, though…

But that's exactly what I wanted… I wanted your opinion on that and I'm grateful that you told me what you thought up front, because, to be honest, I would have thought you would have told me the opposite. And now you've told me what you thought…

You're unfolding more… the work breakdown stru… how the costs get charged to the project is not of huge concern to me. We can set up the work breakdown structure so that, from a project manager perspective… I'm just looking at it from a level 2 rolled-up tasks. I don't need to know the 47 layers of detail. I mean, one can drill down to level 3, level 4, and level 5 in a work breakdown structure to get all of this information in there if one wants to. But from looking at it from an overall project management perspective, let's say a budget of $20,000 for quality, I can compare at a high level… at a level two or level 3 in a work breakdown structure… how we're performing against that $20,000.

This is exactly what is being used in some construction projects… and what they do is that they have codes that they apply to their timesheets that identifies it as a cost of quality item. So, in addition to the function that you just charged to, you can also classify it as another cost of quality item. So, it is being done, but I don't know if construction is a really good model to go by. I think that it's closer than any other industry, but not necessarily an exact fit. The other thing is that timesheets are… timesheets are record documents that are accessible to clients. So a client may be less than inclined to pay for a service that he identifies as an error. Whereas in our business, we know that our business has a repetitive nature to it that you make an error… you fix it… you make another error… you fix it…and it's… you seek to reduce those, but we're not building cars, as [deleted] used to say… we only do them once. Son the notion of starting… going from start to finish without making an error doesn't seem very feasible.

No it doesn't.

Ok… and the other thing is… just what you said… by the way, in answer to that question, when project managers run out of money, they usually close off charges… and that's the exact time when you're probably expending quality costs.

Absolutely. One of the things that drives me crazy is, well, it's PB's method for cost accounting on projects. And I think that it impacts at little bit… to a certain extent… how we go about doing our work and how we record our time. You know, when I… I think all the firms that I worked for prior to PB recorded your labor as number of hours worked… salary paid per week divided by number of hours worked in that time period. So, let's say that I got paid 100 dollars for 40 hours of work… that would be $2.50 an hour for a 40 hour work week… for a 50 hour work week, it was $2.00 an hour… for a 60 hour work week, it was $1.66 an hour… and my projects only got charged that $2.00 per hour or that $1.66 an hour… they didn't get charged that $2.50 an hour. So, our system de-incentivizes us to record the true amount of time that we spend on projects, because it inflates the cost of the project without any real additional cost made to it because we don't pay our professionals overtime.

So when you go back to see what the project has done… what similar projects have done in the past, you don't get a true picture.

You really don't. It really depends on the person… you know… did the person spend a Saturday on the project… did he work 80 hours a week… 60 hours a week… 70 hours a week? So… the second thing that drives me a little crazy is we will fix things, we won't charge it to the project, we'll charge it to overhead. So, we don't know what that project cost really is there either, because all that money is going into overhead. And, wouldn't it make more sense if you're going to charge for every, just take an example, if you're going to charge for every dollar of labor and we're going to charge $1.60 of labor of overhead to that dollar of labor, you know… wouldn't it make more sense to take the cost of fixing something as a direct project expense without overhead on it, so you can at least record… that same dollar that was going to go to overhead… just to put it on the project? We haven't moved that dollar around, we just taken it out of overhead and stuck it in the project without burdening it with additional overhead.

Because the overhead is paying rent and you're not paying rent just because you're staying here later

Exactly.

You're not paying your phone bill… more phone bill… yeah I get it.

Yeah. So, we do things… the accountants do things that make us record things in weird ways

Ok… the allotted time has certainly past. Is there anything else you would like to add to your remarks?

You going to be here tomorrow?

I'll be here, yes.

It's interesting because [deleted] and [deleted] and I we're working on an overall quality program for the architecture TRC [technical resource center]. It would be good to share some of your information with [deleted]. [deleted personal comment]. But it would be very good to share this stuff.

Once again, I have to edit out all of the names.

So… anyway… any last words on the costs of quality?

No… have you understood all of these questions as they were presented to you?

Yes

Do you understand that your remarks have been recorded and that we have your permission?

Yes

Ok… I'm turning off the recorder.

2 April 2010 Field Notes: Interview with Respondent S12

This is Dave Loduca conducting a recorded interview with [deleted] at 1831 Chestnut St., 7th floor, Parsons-Brinckerhoff Offices.

Today's date is the April 2nd 2010 and the time is 5 minutes after two in the afternoon.

We are going to discuss general quality and operational issues here in the St. Louis Office related to the administration of an engineering operation.

Do you understand that your remarks are being recorded?

Yes

Do you understand that your participation is strictly voluntary?

Yes

Do you consent to your remarks being recorded today on the condition that they are used only for academic research?

Yes

Could you state your full name and spell your last name?

[deleted]

Do you work for Parsons Brinckerhoff?

Yes.

What is your job title?

I am a senior supervising engineer

Do you have any corporate titles?

Yes, but it's lengthy and confusing…

Could you…?

I am the manager of mechanical and electrical services for the central geography

Very briefly, what is the nature of your job?

I oversee the mechanical and electrical activities performed by the company in the central region and I am responsible for the work assignments and the cost effectiveness and the quality of the product that we produce

You're a degreed engineer, is that correct?

Yes, that's correct

What is your technical discipline?

Mechanical engineering

Do you commonly perform the duties of a project manager?

From time to time, yes I do.

I have a theory about the quality of drafting work with respect to computer aided drafting and design… no listen carefully at this explanation and tell me if you agree.

Before CADD, there was a substantial divide between engineers and drafters. Engineers rarely performed work as drafters and drafting, as a profession, was quite developed. Drafters obtained technical training but, as a rule, no college degree. They focused on drawing format, tidiness, speed, and accuracy. Engineers, on the other hand, focused on design issues, such as code compliance, engineering calculations, notes, and specifications. Engineers took a semester of drafting in their engineering curriculum, but not nearly enough to make them reasonably competent as drafters. Drafters found job security because they were highly skilled and maintained an ethic of high quality.

When CADD was introduced, it was not possible to produce the same high quality work as hand drafting. This was especially true for CADD packages that engineers could afford. In addition, the technical barrier for older drafters was quite high. As hand drafters, they were highly skilled, but as CADD drafters, they would be beginners again.

As CADD packages became cheaper and more widely used, entry level drafters were opting for more computer training so as to accumulate the skills needed for competence in CADD and less training in the art and science behind drafting work. The skill set shifted from drafting quality to CADD competence and computer literacy.

CADD class replaced mechanical drawing in engineering school curriculum. Unlike mechanical drawing, a semester of CADD could provide engineers with a minimum level of competence, and as a result, many engineers found themselves doing at least some of their own drafting, but to a much lower standard of quality.

Even among drafting employees… There may have been a few old-style drafters make the transition, but as a rule, drafters now are substantially less focused on structure and form than hand drafters.

What do you think of this model?

In general, I agree with that model. A few comments… I would say that when CADD… when hand drafting was performed, it was commonplace for engineers to perform some of the drafting, but they relied heavily on mark-ups and hand-drafters to do most of the work. Hand drafters developed their expertise by practice, not by training; and the drafters had greater practiced abilities than the engineers. The engineers did less drafting so they were less proficient at the manual tasks of executing line work. With the advent of CADD, the emphasis is now… I think in terms of drafting,,, on training and with practice on the computer. But the piece that's lost is the language… the language of a drawing; that drafters are not trained in the differential meaning of different symbols on a drawing and the differential meaning of the different line types on a drawing; and while they may be practiced at executing CADD work and setting up files and creating drawings with the computer they don't know and are not taught the language that is used in drafting. Consequently, the resultant drawings are technologically advanced, but they're produced using a computer to do so; but they are not as descriptive, because they have lost some of the nuances of the language of drawings.

What do you think of the quality of drafting work in an environment where both engineers and drafters perform drafting?

I think it is… as I said, it's… in this case, engineers are not as… engineers do more of their own drafting, but they are not as dedicated to the task of learning drafting; and neither new engineers nor experienced CADD drafters now the language of a drawing. Therefore, I think the quality of the drawing product using CADD computer aided drafting techniques is not as good as it was using manual drafting techniques

Just to clarify, when you were in college… your engineering training… did you take mechanical drafting?

Yes,

For how many semesters?

I took mechanical drafting in high school and mechanical drafting in college… but I don't recall if it was one or two semesters.

How did you feel about you skill when you were done?

I took CADD as an elective. When I got out of school, I…

I mean your original training.

I felt I was reasonably proficient at drawing. But I also feel that I had a little bit of a bent towards doing that. I was reasonably proficient drafter… I was not as good as someone who did drafting on a regular basis, but I was reasonably proficient… and when I got out of school I went to work and did some manual drafting.

For what firm did you work before your tenure at Parsons Brinckerhoff?

I worked for a consulting engineering firm by the name of [firm name deleted]

What was your job title there?

I started out as a mechanical engineer in training and progressed through as project engineer, mechanical department head, up to a position of vice president with responsibility for the mechanical engineering department, among other things.

PB's managerial cost accounting system collects timesheet data and compiles multilevel reports. It includes metrics such as performance ratio, financial cost at completion, earned value, and projected cost at completion. What kind of managerial accounting did [firm name deleted] have along those same lines?

Similar… using a different platform… some different terminologies. We didn't use the earned value metric, but it was a similar tracking of hours and comparing those hours to budgeted cost

Ok… there were several metrics that you used after all of the time sheet data was compiled.

Correct.

What kind of flexibility did [firm name deleted] have in crafting project and company reports?

Very little. The reports that we used… I don't even recall what platform they were based on, but they were very rigid and you had very little opportunity to modify those reports. There were… each individual would create separate reports… often times being manual recordings of where they were on their budgets just to keep a record that was more user friendly than the rigid reports that were available from the accounting system.

So project managers and functional managers created their own reports when they wanted to deviate from the structure opf the automatic system.

Yes

Let me show you a project close-out document. You've seen these before. It contains an oath, to be signed by the project manager, task manager, and QC reviewers. In your opinion, what affect does this activity…the signing of oaths… have on overall quality of deliverables? Keep in mind that this is an anonymous interview.

I think that this sheet title "quality assurance review certification" and its effectiveness is depended on how it's employed. As this particular form is presented, this is just a certification by several individuals that quality assurance has been performed. There is no verification that goes along with this.

I guess the question is, if it didn't exist, what would actually suffer?

Well, I'll answer that. As this form exists, there is no verification of any of these certifications… it's just a statement that "yes, I did this… or we did this." As such, I think this form as you presented it does nothing to improve quality. It's just a statement that says "we did something".

The next document… you remember this one as well… it's a procedure for plan checking. It contains the language on how plans are to be reviewed and corrected. It also has a procedure… a progression of people and titles of who gets to see drawings and the corrections and what they do at each phase of the review. As it stands right now, in this particular operation, how compliant is the operations… projects… in using that particular system as it's written?

In our operation, on sizeable projects, I would say that this procedure of checking of design deliverables for Americas' project delivery management system is followed closely in its intent. It is not followed in all details, but it's followed in its intent; and it is also not followed for all documents. It's not followed, for example, for some calculations and it's not followed for small projects. But on major deliverables, this is generally followed.

Okay, then the next question with respect to that procedure… If that procedure evaporated and the ordinary checking that departments may or may not use… do you think quality would suffer?

You did not ask me… not to change your questionnaire

No… go ahead…

You did not ask me if I thought that this benefited the quality of the product.

Answer that question, then…

Ok. This document on the checking of design deliverables, includes a procedure whereby the originator, the person who produced the document signs it, a separate person checks it, either the originator or a third party decides to agree or disagree with the checker's comments… it is corrected, and the corrections are verified. In this instance, there is verification and it imp… I think it has the ability to improve the product quality at the end level. It does not verify that everything shown on the drawing is correct, but it does coordinate… show what's on the drawing tends to show that the drawing is coordinated and notes and references are written appropriately and make appropriate references.

How much do you think the checking process at the end of… at the end has to inject quality into the deliverable?

It only injects quality into the format of the end product. It does not look at the quality of the input to the end product and it does not evaluate whether all of the decisions that lead up to what's reflected in that end product were appropriate decisions. It only reflects an evaluation of the document itself and it does not evaluate the design decisions.

So it's fair to say that it verifies the design was done correctly, but it does NOT verify that you used the correct design

No. it does not verify that the design was done correctly. It verifies that the design that was done was documented correctly.

Fair statement.

If the design was done incorrectly, or the decisions that lead to that design were invalid, then the design is still invalid, but you have verified that whatever decisions had been made previously have been documented effectively.

Ok… we're at twenty minutes right now. The allotted time is approaching. Is there anything that you would like to add… that we talked about and you thought that I should have asked… but didn't?

You had asked if I thought that removing that removing that would have an impact and I said "yes, that would have an impact"

And you chose to answer in a different way… that's okay.

It would reduce the quality of the document. The other thing that I would say is that the prior document… we have seen documents that are similar to the prior document that you presented that's a certification, but the certifications similar to the second document… there is a final check that goes back to see if… it makes a spot check to see if certain things are done. With that spot check and verification, there is a greater tendency to be truthful in your response to say that it has been checked because there is the potential that you may be found to be misrepresenting because it's going to be checked by a third party. The third party check is important to get an accurate response.

So basically, what you're saying is that the form, in the way that… the first form that I showed you…the oath… that it was not particularly effective because that it was not verifiable.

There was no verification.

Ok… it's just a closeout document that somebody signs to get things moving.

Correct

Have you understood all of these questions as they were presented to you?

I believe that I did.

Do you understand that your remarks have been recorded and that we have your permission?

Yes.

That's it. This concludes the survey; I am turning off the recorder.

2 April 2010 Field Notes: Interview with Respondent M53

This is Dave Loduca conducting a recorded interview with [blank] at 1831 Chestnut St. 7th Floor. Today's date is April 2nd, 2010 at 1:30 in the afternoon. We are going to discuss quality issues and issues related to running an engineering firm.

Do you understand that your remarks are being recorded?

Yeah.

Do you understand that your participation is strictly voluntary?

Yes.

Do you consent to your remarks being recorded today on the condition that they are used only for academic research?

They can be used for anything because my life is an open book.

Could you state your full name and spell your last name?

[blank]

Do you work for Parsons Brinckerhoff?

Yes.

What is your job title?

I'm called Senior Engineering Manager.

Is that you're only job title?

Yeah… well, I'm also a certified project manager and I am manager of the mechanical and electrical engineering groups in the St. Louis office.

Do you have an corporate titles?

I am a vice president of Parsons Brinckerhoff Corporation.

Very good. Very briefly, what is the nature of your job?

My job consists of marketing our services and consists of supervising the mechanical engineers here at the St. Louis office which right now is about 24 people. It involves maintaining… we do a number of projects at a time and I'm responsible for seeing that these projects… our services are performed within the budget that we marketed the job for. I also review the performance of the engineers and other technical people in our department.

Okay. You are a degreed engineer.

Yes…

What is your technical discipline?

I am licensed in both electrical and mechanical engineering. I graduated in mechanical engineering but on my first job I worked for five years doing nothing but electrical engineering. So I am licensed in both fields.

Do you commonly perform the duties of a project manager?

I do from time to time because I am a project manager of two projects right now. At the current time I am spending about 20 percent of my time on those projects. In addition to project management, as I indicated before, I am a managing department head.

I have a theory regarding the quality of drafting work with respect to the history of Computer Aided Drafting and Design. Listen carefully to this description and tell me if you agree with this explanation.

Before CADD, there was a substantial divide between engineers and drafters. Engineers rarely performed work as drafters and drafting, as a profession, was quite developed. Drafters obtained technical training but, as a rule, no college degree. They focused on drawing format, tidiness, speed, and accuracy. Engineers, on the other hand, focused on design issues, such as code compliance, engineering calculations, notes, and specifications. Engineers took a semester of drafting in their engineering curriculum, but not nearly enough to make them reasonably competent as drafters. Drafters found job security because they were highly skilled and maintained an ethic of high quality.

When CADD was introduced, it was not possible to produce the same high quality work as hand drafting. CADD packages were very underdeveloped and could not possibly get the same quality as with someone doing by hand. This was especially true for CADD packages that engineering firms could afford. It was easy to find a package for a quarter-million dollars, but that was generally out of reach of an engineering firm. In addition, the technical barrier for older drafters was quite high. As hand drafters, they were highly skilled, but as CADD drafters, they would be beginners again.

As CADD packages became cheaper and more widely used, entry level drafters were opting for more computer training so as to accumulate the skills needed for competence in CADD and less training in the art and science behind drafting work. The skill set shifted from drafting quality to CADD competence and computer literacy.

CADD class replaced mechanical drawing in engineering school curriculum. Unlike mechanical drawing, a semester of CADD could provide engineers with a minimum level of competence. As a result, many engineers found themselves doing at least some of their own drafting, but to a much lower standard of quality.

Even among drafting employees… There may have been a few old-style drafters make the transition, but as a rule, drafters now are substantially less focused on structure and form than hand drafters. What do you think of this model?

I think that's… I agree with you.

When you were in school, did you take any mechanical drawing?

Yeah, we took two semesters of it.

When you got out, how did you feel about your skill as a drafter?

Frankly, I never used it.

Never used it?

Hmm-mm [sic] my first job was as a project manager and I never used it.

How common do you think that was among engineers that graduated at that time?

At that time… very common.

What do you think of the quality of drafting work in an environment where both engineers and drafters perform drafting work?

I would have to say that I agree with your statement… the engineer is not nearly as well qualified in producing CADD drawings as the person who does nothing but producing CADD drawings. So I feel

that the quality of drawings done by a CADD person to be with equal experience with an engineer or better.

[telephone interruption… tape off]

What firm did you work for before your tenure at Parsons Brinckerhoff?

A firm called [firm name deleted].

And what was your job title there?

I was the director of engineering.

Ok. And could you describe your management duties there?

They were pretty much like they are here.

Alright. PB managerial cost accounting system collects timesheet data and complies multilevel reports… and you're well aware of those…and includes metrics such as performance ratio, financial cost at completion, earned value, projected cost at completion. What kind of managerial accounting did [firm name deleted] have along those same lines?

It was pretty much the same except we might have had different buzz words. But it was basically the same.

So it would collect the same costs and be able to report the same…

I think that every… every engineering firm… it doesn't take them long to gravitate to that way of accounting. I mean… by engineering… I mean a firm that does consulting engineering… that's always working for a different client … and on many projects at a time.

Let me show you a project close-out form. This is a PB closeout form. Could you read the title of that form?

"Quality Assurance Review Certification"

It contains an oath, to be signed by the project manager, task manager, and QC reviewers.

An oath?

Yes… signatures attesting to the truth of the statement on the form….

 Hmm-mm [sic]

In your opinion, what affect does this activity… signing of oaths by these persons… have on overall effect does it have on the quality of deliverables?

Nothing.

Nothing?

I have one more… and that is… one second… this is also very familiar to you… this is a procedure on plan review. And it's a procedure on how to prepare check prints and how to review check prints.

Yes… I've seen this.

Basically, it gives you the… it's proofreading of drawings, and it gives you the language of the proofreading plus the general administrative tasks as to who signs what and where… and how you collect those documents later on for audit. Do you recognize those?

Yeah… hm-mm [sic]

And how long has this been in effect here at PB?

It's been… in one version or another, it's been in effect since I've been here. They've changed it… periodically revise it. But it's basically the same.

So it basically says that we're supposed to be checking plans in a particular way and there is a very structured way of selecting people for review for checking and rechecking and so on…

Yeah.

Could you tell me about how you feel about that [procedure's] contribution to the overall quality of the deliverable?

Well, I would that on the average on the projects that the St. Louis office has done… those are the ones that I am aware of… and the projects that I've been the PM for, and some of those weren't in St. Louis… they were all relatively small compared to some of the projects that Parsons Brinckerhoff does… like the widening of the Panama Canal and the new Honolulu Rapid Transit System… like these… some of these multi-multi-million dollar projects. For the average project that I've seen and been involved in since I was here… this doesn't mean much… this procedure. First of all, it's very hard to implement on a fast moving project… and on a project where you don't have a lot of money to spend on getting it done. This was probably followed to the letter on the Honolulu project because it's like a WPA project. They want to get people working on the project so this gives them something to do…following these procedures to the letter. But on an average project that we do in St. Louis, it doesn't mean much at all.

What would you say would be the compliance rate of that particular procedure on all of our projects?

On the ones that I've been exposed to?

Yes.

Probably zero.

Zero. okay

In one form or another, what would you say the compliance rate would be? Not necessarily 100 percent compliance to the letter of that particular procedure?

Well, I think that certain tasks shown in here are done almost automatically by any ethical conscientious project manager.

Okay, actually, we're approaching the allotted time. Is there anything that you would like to add to your remarks that I didn't quite explain to you?

No… not really.

Did you understand the questions that I posed to you?

Yeah.

Do you understand that your remarks have been recorded and that we have your permission?

Yeah. Hm-mmm [sic]

Thank you, this concludes the survey; I am turning off the recorder.

APPENDIX G

INTERCODER AGREEMENT RELIABILITY ANALYSIS

INTERCODER AGREEMENT

In this analysis, the inercoder agreement is calculated in two ways: (1) percent agreement (p) and (2) Cohen's Kappa (K). Percent agreement is calculated per code and is defined as the ratio of the total quantity of agreements to total opportunities for agreement.

(1) $p = [\, \#(Y_L Y_A) + \#(N_L N_A) \,] \div N$ percent agreement

where

$\#(Y_L Y_A) =$ quantity of responses where both coders mark for the code

$\#(N_L N_A) =$ quantity of responses where neither coders mark for the code

$N =$ number of responses (opportunities for agreement

Cohen's Kappa is the percent agreement corrected for chance agreement.

(2) $K = (\, P_A - P_C \,) \div (\, 1 - P_C \,)$ Cohen's Kappa

(3) $P_C = P(Y_L)P(Y_A) + P(N_L)P(N_A)$ probability of chance agreement

(4) $P_A = P(YY) + P(NN)$ probability of actual agreement

where		and	
$P(Y_L) =$	$P(YY) + P(YN)$	$P(YY) =$	$\#(Y_L Y_A) \div N$
$P(Y_A) =$	$P(YY) + P(NY)$	$P(YN) =$	$\#(Y_L N_A) \div N$
$P(N_L) =$	$P(NY) + P(NN)$	$P(NY) =$	$\#(N_L Y_A) \div N$
$P(N_A) =$	$P(YN) + P(NN)$	$P(NN) =$	$\#(N_L N_A) \div N$

Traditional cutoff of Cohen's Kappa is 0.7. LeBreton, et al. (2008) suggests that the 0.7 cutoff may be too high; that a value as low as 0.5 might be more suitable as a lower limit to signal weak agreement

CONFUSION MATRICES

CODE

| INTERVIEW: F33 | INTERVIEW: N72 | INTERVIEW: H67 | CODE |

COGNITION

INTERVIEW: F33 — Loduca / Alternate

	YES	NO	
YES	12	3	15
NO	3	31	34
	15	34	49

INTERVIEW: N72 — Loduca / Alternate

	YES	NO	
YES	9	0	9
NO	0	28	28
	9	28	37

INTERVIEW: H67 — Loduca / Alternate

	YES	NO	
YES	7	4	11
NO	0	19	19
	7	23	30

ANXIETY

INTERVIEW: F33 — Loduca / Alternate

	YES	NO	
YES	6	1	7
NO	0	42	42
	6	43	49

INTERVIEW: N72 — Loduca / Alternate

	YES	NO	
YES	12	4	16
NO	2	19	21
	14	23	37

INTERVIEW: H67 — Loduca / Alternate

	YES	NO	
YES	7	1	8
NO	2	20	22
	9	21	30

APATHY

INTERVIEW: F33 — Loduca / Alternate

	YES	NO	
YES	6	5	11
NO	2	36	38
	8	41	49

INTERVIEW: N72 — Loduca / Alternate

	YES	NO	
YES	7	1	8
NO	1	28	29
	8	29	37

INTERVIEW: H67 — Loduca / Alternate

	YES	NO	
YES	8	5	13
NO	1	16	17
	9	21	30

VERACITY

INTERVIEW: F33 — Loduca / Alternate

	YES	NO	
YES	3	4	7
NO	2	40	42
	5	44	49

INTERVIEW: N72 — Loduca / Alternate

	YES	NO	
YES	2	0	2
NO	0	35	35
	2	35	37

INTERVIEW: H67 — Loduca / Alternate

	YES	NO	
YES	0	0	0
NO	0	30	30
	0	30	30

QUALITY AWARENESS

INTERVIEW: F33 — Loduca / Alternate

	YES	NO	
YES	2	1	3
NO	4	42	46
	6	43	49

INTERVIEW: N72 — Loduca / Alternate

	YES	NO	
YES	4	5	9
NO	2	26	28
	6	31	37

INTERVIEW: H67 — Loduca / Alternate

	YES	NO	
YES	1	0	1
NO	0	29	29
	1	29	30

CODE

INTERVIEWEE F33

Code	COGNITION						ANXIETY						APATHY						VERACITY						QUALITY AWARENESS					
Coder	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A
resp 1	1	1		1								1														1				
resp 2	1	1	1									1						1						1						1
resp 3	1	1	1									1						1						1						1
resp 4	1	1	1									1						1							1	1	1			
resp 5				1		1						1	1			1								1						
resp 6	1	1		1		1						1		1	1									1						1
resp 7						1						1		1										1						1
resp 8						1						1	1	1	1									1						1
resp 9						1						1		1	1					1										1
resp 10	1	1	1			1						1	1		1			1						1						1
resp 11						1						1	1		1			1						1						1
resp 12						1						1	1	1	1			1		1										1
resp 13						1						1	1				1							1						1
resp 14			1			1						1						1						1	1			1		
resp 15	1	1	1			1						1		1				1						1						1
resp 16	1	1	1			1						1						1						1						1
resp 17			1			1						1						1						1						1
resp 18	1	1	1			1						1		1		1								1						1
resp 19	1	1				1						1						1						1						1
resp 20						1						1						1						1						1
resp 21	1	1	1			1						1		1				1						1						1
resp 22	1	1	1			1						1						1						1						1
resp 23						1						1						1						1						1
resp 24						1						1	1	1	1			1						1						
resp 25						1						1	1			1			1	1	1			1						1
resp 26						1						1	1	1	1					1	1			1						1
resp 27	1	1	1			1						1						1						1		1				1
resp 28	1	1	1			1						1						1		1	1			1		1				1
resp 29	1	1				1						1					1	1						1	1					1
resp 30						1	1	1	1									1						1						1
resp 31				1		1	1	1	1									1						1				1		1
resp 32			1			1	1			1								1						1						1
resp 33					1		1	1	1									1	1					1						1
resp 34						1						1						1		1				1						1
resp 35						1						1						1	1	1	1									
resp 36						1						1						1	1					1						1
resp 37						1						1				1		1				1					1			1
resp 38						1						1						1	1	1	1				1					1
resp 39	1	1				1						1						1						1		1				
resp 40						1						1						1						1				1		1
resp 41						1	1	1	1									1				1		1						1
resp 42						1	1	1	1									1	1			1		1		1				1
resp 43							1	1	1													1		1						1
resp 44						1					1							1						1						1
resp 45						1						1				1		1						1	1	1	1			1
resp 46						1						1						1						1		1		1		
resp 47						1						1						1					1					1	1	1
resp 48						1						1						1					1			1				
resp 49						1						1						1												1
Total	15	15	12	3	3	31	7	6	6	-	1	42	11	8	6	2	5	36	7	5	3	2	4	40	3	6	2	4	1	42

INTERVIEWEE N72

Code	COGNITION						ANXIETY						APATHY						VERACITY						QUALITY AWARENESS					
Coder	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A
resp 1	1	1	1									1						1						1						1
resp 2			1			1						1	1	1	1									1						1
resp 3	1	1	1									1						1						1						1
resp 4						1						1	1	1	1									1						1
resp 5	1	1	1									1						1						1						1
resp 6	1	1	1									1						1						1						1
resp 7	1	1	1									1						1						1						1
resp 8	1	1	1									1						1						1						1
resp 9	1	1	1									1						1						1						1
resp 10	1	1	1									1	1	1	1									1						
resp 11						1						1	1	1				1						1	1	1				
resp 12	1		1									1	1	1				1						1	1	1				
resp 13						1	1	1									1							1	1	1				1
resp 14						1						1	1	1	1									1						1
resp 15						1	1	1	1									1						1						1
resp 16						1	1	1	1									1						1						1
resp 17						1	1	1	1									1	1	1	1									1
resp 18						1						1						1	1	1	1									1
resp 19						1						1						1						1						1
resp 20						1	1	1					1	1				1						1	1	1			1	
resp 21						1	1	1		1			1	1				1						1	1	1			1	
resp 22						1	1	1		1								1						1	1					
resp 23						1					1							1						1	1	1				
resp 24						1	1	1	1									1						1		1				1
resp 25						1	1	1	1									1						1		1				1
resp 26						1	1	1	1									1						1			1			1
resp 27						1	1	1	1									1						1	1					1
resp 28						1	1	1	1		1							1						1					1	
resp 29						1	1	1	1									1						1						1
resp 30						1	1	1	1		1							1						1		1				1
resp 31						1	1	1	1									1						1			1			1
resp 32	1		1				1	1	1				1	1	1									1		1				1
resp 33						1	1	1	1									1						1						1
resp 34						1	1	1				1	1	1				1						1						1
resp 35						1	1	1	1				1	1	1	1								1						1
resp 36						1				1		1						1						1	1	1			1	
resp 37						1						1						1						1	1	1				
Total	9	9	9	-	-	28	16	14	12	2	4	19	8	8	7	1	1	28	2	2	2	-	-	35	9	6	4	2	5	26

INTERVIEWEE H67

Code		COGNITION						ANXIETY						APATHY						VERACITY						QUALITY AWARENESS					
Coder		Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A	Loduca	Alt	Y_LY_A	N_LY_A	Y_LN_A	N_LN_A
Total		9	9	9	-	-	28	16	14	12	2	4	19	8	8	7	1	1	28	2	2	2	-	-	35	9	6	4	2	5	26

APPENDIX H

GROUP 1 INTERVIEW CODING NOTES

Credentials

Respondent N72 was the first interview of the study. He was specially selected to be first out of the gate because he is a peer of the researcher and works very closely on many projects; it is for this reason that the researcher has a higher confidence that this respondent would be especially candid.

The respondent identifies himself as a mechanical engineer by discipline and supervising engineer. He regularly performs the duties of a task manager; this suggests that he has a more extensive knowledge of the activities mentioned in the color guide. He is the first to differentiate project and task managers:

"A task manager would be responsible for the scope and budget of a particular task within a project, as opposed to being responsible for the scope and budget for the entire project."

In the opinion of the researcher, this respondent, generally, has a higher quality awareness than a drafter, designer, or other engineer.

This respondent participated in the awareness exercise. He attended the orientation sessions and recorded time against CoQ activities.

Fear

The respondent admitted that it was possible that the company might abuse the data reported by staff, but that he, himself, did not consider it when recording data.

"On the surface it would seem that that is the case. I don't know if anyone, including myself, considered that."

But admitted that it was possible:

"I think it's possible it might get into the wrong hands in actual practice."

The respondent appeared to have faith in the ground rules, which basically mandated that no one would be able to trace recorded data to a particular individual. He went further to say that the CoQ system had a higher purpose:

"Personally I don't think it would affect me a lot because I think the whole purpose is to try and determine what the cost of quality is or to improve quality depending on whether you're talking about the study or the procedure."

Even so, the respondent felt that knowledge of individual data recording would be valuable as a tool for personal improvement.

"The tendency is to try to look at that and see where improvements can be made on a person by person basis."

But had to admit that supervisor knowledge of individual recordings might have a stifling affect:

"I can understand how that might not be conducive to system."

Further describing one fear that staff might generally feel about a CoQ reporting system, the respondent stated:

"…if they were in a project where lots of errors were made that they'd be pointed out as the person that made the errors."

The respondent also felt that some might even feel in personal jeopardy.

"…there are a lot of people that might feel like there could be repercussions due to the cost of quality. "

The respondent suggested that a systems perspective might serve to ease those fears:

"…if they would take the point of view it helps the overall quality of the project and the overall quality of the product, they would have a different point of view as to how those errors were tabulated and pointed out."

When asked about his desire to use personal CoQ data during a salary review, the respondent admitted that:

"I would probably be tempted… but if I was doing it with respect to quality I don't really think neither I nor they or anyone would benefit in bringing that up."

"…if I recognized that it is biting my nose off despite my face I probably just defer and not bring up the issue."

When asked about his personal anxiety related negative repercussions due to CoQ of his group being reported, the respondent said:

"…I would always have it the back of my mind, similar to the evaluation of the employee, when I was aware of what kind of cost of quality they had compared to other people. On the other hand, I still think that I recognize that system is really separate from the overall performance as an engineer."

Accuracy

The respondent admitted that he used the color guide extensively in order to ensure that he was applying the CoQ subcategories correctly. He reported to be initially confused by the color guide, but that orientation provided "helped a lot".

"…when I first started I found them a bit to be confusing but I think the orientation you gave helped a lot in trying to evaluate where the cost really are and how you go about allocating the cost of a particular aspect of quality."

The respondent here suggests that written guidelines supplemented by formal verbal instructions substantially improved cognition.

"It might have been easier to access but it would have been less intuitive as to what really something belonged to."

He is saying that the explanations described on the subcategories are actually instructive and serve to improve understanding, but he admits that it would be simpler as a system with fewer categories to remember.

When referring to the data collection method itself, the respondent described the tool favorably:

"…it probably be used a little bit more as a separate recording device, so that its very convenient for a person that was trying to record the cost of quality to find a place to put it."

He commented that the system might enjoy greater acceptance as a separate recording device.

Diligence

This respondent claimed that he was "pretty diligent" in recording time up until the start of construction administration. Still, he admitted:

"…Not necessarily catching everything but pretty diligently trying to evaluate whether or not the cost or the time that I was using was related to cost of quality."

This self-awareness, albeit after the fact, pointed to an inability to catch all activities related to CoQ. This is a first indication that suggests that even with a rather heavy commitment; some CoQ will not be recognized.

This respondent admitted that staff would not be accepting of such a system of recording at first:

"… initially I would think that everyone would feel a little bit more burdened."

Still, the respondent thought that the CoQ recording system introduced in the awareness exercise was not difficult to understand:

"…the method that was set up to record time was very convenient, fairly intuitive."

The respondent did not get a feel for whether or not CoQ reporting would interest the staff:

"I don't really have a good feel for whether anybody else found this interesting or interested in complying…"

Also stating that lack of understanding could promote apathy among staff:

"…they might not understand the system or its benefit and not be really too interested in doing it…"

Further, the respondent suggested that interest could be maintained if:

"Probably like a progress report… something like that where they could be made aware… I don't know if you can really provide any preliminary data but that once the system was implemented I would think that it could be used incrementally through the course of the project rather than only at the end as a post mortem."

Quality Awareness

This respondent recognizes the value of historical CoQ data:

"…in preparing cost estimates for a project, you may want to assess what kinds of cost of quality you have in the normal process of doing work. For instance, we usually allocate some time to quality assurance checking and then corrections, but we don't generally assign time to misinterpreting what the owners project requirements were and making corrections to those changes that occur in the course of the project that might not be related to actual changes of scope things that we had to correct due to errors."

He further says:

"…we as a company do not pay attention to quality in projects, in general, because we have lots of construction administration issues on a number of projects; those would be significantly smaller, in my opinion, if we had paid a little more attention to the quality in the first place. It doesn't mean that we do sloppy work, it just means that we certainly could be doing a lot better work."

In fact, this respondent suggested "system" thinking as superior to a "goal-tending" philosophy where quality is injected into the product at the last minute:

"..due to my experience with going through this one project, with this system, I can see that there's some value in creating quality by having a system as opposed to creating quality by checking."

Individually, the respondent felt that the quality purpose of the CoQ system would tend to surpass any fear of honest reporting:

"Personally I don't think it would affect me a lot because I think the whole purpose is to try and determine what the cost of quality is or to improve quality depending on whether you're talking about the study or the procedure."

He also expressed support for the system, despite possible apathy among the staff:

"I did see when I was doing it, it would have some managerial benefit in having the information available whether it was person-specific or just project-specific."

"Just" suggests that "project-specific" is less valuable than "person-specific".

The respondent also shows a systems perspective when confronted with the possibility of negative repercussions of reports of CoQ from the group that he supervises.

"I recognize that system is really separate from the overall performance as an engineer."

In fact, the respondent stated that:

"…as a manager I would think seeing the entire group's [CoQ] time would be more interesting as an individual."

His final thoughts were quality-related:

"I do find that people actually are more frustrated when do things more than once for any number of reasons. So for doing one thing correctly the first time is much more pleasing to everybody. So seeing how it is they might able to be more efficient in terms time or cost savings, by a quality system would be interesting to more people."

Veracity

No veracity codes

New Concepts

He is the first to differentiate project and task managers:

"A task manager would be responsible for the scope and budget of a particular task within a project, as opposed to being responsible for the scope and budget for the entire project."

This respondent also asserted that project managers try to minimize project tasks:

When asked about how project managers might react to an extensive list of subcategories with which to add to a work breakdown structure, the respondent said:

"Generally they try to manage with as few tasks as possible. There are exceptions where they try to use a lot."

Remember that this respondent is a veteran engineer and is more likely to recognize the subcategories. However, when speaking as a task manager and a supervising engineer, he recognized that project managers tended to prefer simplicity when creating work breakdown structures.

The respondent brought up another concept of reluctance to record time:

"I don't know whether the issue really was the fact that they were not recording time due to apathy, or, whether they were just not feeling like they wanted to record time because of blame assignment, or, something like that."

Not wanting to implicate a coworker [blame] might play a role in the avoiding of recording of time against CoQ.

Summary

Respondent N72 was a guinea pig of sorts because he was the first interview out of the gate. As a supervisor, this respondent has particular perspective that is different than drafters, designers, and even engineers.

This respondent had a considerable amount to say with respect to fear. It was his personal impression of the system that use of a CoQ system would not be something to fear, but acknowledged that it had the

potential. He thought that the value of monitoring the system outweighed any value of personal accountability… that CoQ for a group would be of much more interest than an individual's.

The respondent thought that the CoQ system was a bit complicated at first, but believed that an extended list of subcategories is instructive and serves to educate the worker regarding the component parts of CoQ. He thought the personal log rather than the official timesheet is more convenient for recording CoQ.

The respondent thought the system was fairly intuitive once he got used to it, but he thought that if it were implemented, he could see others feeling a bit burdened by the extra recordkeeping. He thought that it came down to interest… whether the staff's attention could be maintained in order to keep the system working. He suggested making CoQ data available as near to real time as possible (not waiting for post mortem to report).

This respondent thought that this system would highlight quality within existing processes rather than have a quality process (checking) at the end of the design process, that everyone is tired of rework and redesign and any system that shines a light on activities that lead to that would be interesting to a lot of people.

This respondent said, as a task manager, that project managers prefer a smaller compliment of tasks for their work breakdown structure, with few exceptions.

Credentials

Respondent B11 participated in the awareness exercise and identified himself as a senior designer that does HVAC design/drafting. He said that he did not perform project or task manager duties. By way of disclosure, this respondent had performed work for the researcher in the course of his normal duties. He suggested that most of his CoQ coding was on rework subcategories.

Fear

The respondent seemed to be very adamant that fear would not play a role in his behavior with respect to honest recording of CoQ.

"…you make mistakes every day. As long as it's not an extremely expensive mistake, it's not that big of a deal, I mean if it's five or ten minutes, that's not going to hurt anybody."

But when pressed about the possibility of a large personal mistake, he left room for the possibility of hesitation. Still, the respondent did not associate this fear with poor ratings from the outside, but with his own self-image:

"I would be really upset with myself with that kind of mistake to start with but I would owe the company something. To be honest, if I made that kind of mistake, I don't know what I would do."

Accuracy

The respondent said that he understood the "majority" of the categories, but when pressed to explain the trouble spots, his response was:

"Deciphering whose fault it was."

He went on to explain that the root of the trouble was

"A client issue, an internal issue, or an outside issue that was neither the client nor our fault."

I think that this was a red herring. While there were distinctions that needed to be made between internal or external error, at this respondent's level of experience, I believe that (1) he would have most likely known, and (2) if he didn't know, he knew exactly how to find out with a very easy inquiry. I am left to wonder whether this respondent is embellishing his response because he wants to impress me, or wished to conceal his lack of real effort in the awareness exercise. Although he clarified his remarks to say that:

"The process itself was easy it was just the confusion of which category went under. The function of it was pretty straight forward."

In this context, "function" is the mechanism for recording time. This respondent felt that there may have been too many subcategories:

"Sub-categories maybe, main categories not really."

He stayed on this theme by suggesting that he would eventually get the subcategories:

"…it would just take more time to learn what the categories are and who initiated the change or created the error."

In order to ensure that remembers the pertinent information needed to make a reasonably accurate CoQ data entry, he stated that:

"I try to write things down most of the time, just so that if, I do go back I have four people asking you to help them out all of the time, you don't always remember to write things down… You have to go by memory sometimes and that isn't always the best way."

When confronted with the notion that the activities of the awareness exercise might become a permanent system at the company and might cause general confusion, he stated:

"No, I would be able to manage it. I would just have to be more alert in writing things down. You know to take thirty seconds to write something down is not going to kill anybody."

When the respondent was asked to express a preference between an offline system of CoQ recording or an integrated timesheet approach, he stated:

"Offline is probably easier."

Diligence

This respondent admitted lapses in his recording of CoQ, but that he managed to make good on his CoQ recording at some later, and unspecified time:

"I would like to say I was really accurate but I could say that there were times I forgot to enter time and had to go back and do it later."

This respondent went on to describe the method of reconciliation:

"…it would have been just having to write down what I did and just eventually go back and reenter it."

Quality Awareness

This respondent own words regarding the value of a system of recording CoQ data :

"Because you can figure out where you're spending the biggest amount of money on a budget on a job. You can figure out if it is internally a problem or if its people outside the company that are blowing the budgets or there's a hundred different things you can do. But it would give you an idea of how much time is being wasted in the office I guess not wasted but rework time on things that would allow…"

He correctly remembers that this is a system to assist in budgeting, but is sadly incorrect (or at least inarticulate) that run-away costs are caused by either people inside or outside the company. This suggests that, in the orientation, I did not explain the system as well as I could have. Still, he was correct in one of the main themes:

"…To maximizes efficiency."

Veracity

This respondent makes an interesting description of his CoQ-related activities:

"It was back check things; changes that the architect would make that would cause us to change our plans. Or just plain mistakes that the engineer had to redo which there I had to redo."

He describes two major activities, actions by another group that would cause changes in his group, or changes by an engineer, to whom he provides drafting services. Conspicuously absent is the notion that HE might be responsible for a mistake. When confronted with the possibility of making major mistakes, the respondent said:

"…it's not something I'm accustomed to, that I know of."

When reminded of a current project transferred from another office that was being completely re-worked because another office did not complete the job competently… and that it was being totally re-done in the

respondent's office to avert a lawsuit… and that all of the work to re-constitute the design from scratch would be considered re-work. The respondent was a bit more hesitant:

"..it would probably cause me to record it not so- so one sided."

Suggesting that there could be a level of error that might cause "fudging".

New Concepts

No new concepts.

Summary

This reviewer was indirectly in a position of authority over the respondent, so it is not clear whether the respondent was honest about his assertion that he did not fear the system. Based on his remarks on the inner workings of the system of recording… the categories and the recording mechanism itself… this reviewer believes that the respondent was trying to impress.

This respondent's remarks suggested that he is quality-minded. However, as the respondent speaks of error correction, he suggests that, as a drafter, he does not make mistakes, but merely delivers mistakes made by designers and engineers in his group or changes/ mistakes made by other groups. He even said that he was not accustomed to making major mistakes.

This respondent said that he was fairly diligent in recording time, but may have missed some opportunities because of being busy. His means of reminding himself of CoQ to eventually record was small notes to himself.

He thought that he would be fairly honest in recording time, but might feel a bit of pressure in fudging the recording of errors that he made. Still, he thought that offline recording would be easier. It's possible that he believed that he could avoid timesheet problems if the CoQ recording were offline.

Credentials

Respondent H67 described himself as a senior architect that commonly performed the duties of a project manager.

This respondent participated in the awareness exercise. He attended the orientation sessions and recorded time against CoQ activities.

For the record, he was not serving as the project manager when participating in the awareness exercise.

This respondent's interview was considered to be particularly valuable because he quit the study prematurely. When a pattern of not recording data was discovered and he was confronted, he stated at the time that he found the entire affair confusing and did not have the time to fool with it.

Fear

The respondent listened to a lengthy explanation as to the darker possibilities of management's handling of CoQ data, particularly with respect to individual records, but flatly denied that it would be useful for individually rating employees.

"No, I wouldn't look at it, I know the person in general how poorly or how well they perform its all that's needed in some reviews."

Also flatly denied the internal prospect of fear of such a system:

"No, never crossed my mind."

The respondent made a practical suggestion to reduce possible anxiety…

"…if it was imposed it would be a good idea to present a nice bold statement of what it was, or where it was ultimately beneficial to the project."

Accuracy

The respondent stated that his recollection of CoQ concepts were vague… remembering only one subcategory:

"I remember about programming."

This is probably the case because, while participating in the study, "programming" would have been the first CoQ concept that he would have encountered. It also suggests that it was his last recording.

The respondent thought that the complement of subcategories was too overwhelming:

"It felt like to me there were too many buttons or searches strokes you know movements. You had to make to get one of the single categories was kind of the way I remember it just a single category resolved."

I intentionally left the confusing quote as it was transcribed because it suggests the level frustration and confusion. This particular quote describes the interplay between the complexity of the subcategories and the recording device.

"I don't remember enough in detail, Dave, to tell you the truth, I just remember it seemed like there were way too many. There was a checker box here and there, a drop down box here and there, and it was like going through a lot of effort for just trying to record something as simple, as: 'oh yeah I had to work on this single change issue'."

Still, this respondent suggested that broad categories were somewhat comprehensible:

"Just thinking back, the only thing that would jog my memory was category. Whenever I would hit on a category, it would go right down the list, ok this applied; I remember doing this for that. So that's about how it worked."

And, at least at first, he had a measure of confidence in his CoQ recordings:

"I thought it was fairly reliable, considering that's how I do my time sheets at the end of a two week period… and I'll go over calendars. So doing this at the beginning of it… like I said… at the beginning I was doing it every day so it was much more accurate."

Diligence

This respondent claimed that he was not diligent in recording time:

"To tell the truth I don't even think I ever thought about what it was going to take to do the report record the time at the end of the day…"

He went on to explain why:

"The way I thought I was supposed to fill out the form at the end of the day to me taking way to much time. And so therefore I wanted it simplified. I wasn't looking forward to it at the end of the day, to the point of, there at the end, where I finally gave up on it, its like lets put some stuff in to get this thing done, get this over with."

It is the opinion of this researcher that he was not an incompetent individual, but merely frustrated. In fact, the interview seethed with frustration. No doubt that had it not been a awareness exercise, this respondent would have taken the time to educate himself on the particulars of the system.

He went on to describe more frustrating aspects of the recording device:

"It felt like to me there were too many buttons or searches strokes you know movements. You had to make to get one of the single categories was kind of the way I remember it just a single category resolved."

His tone became more conciliatory after a while and admitted trying at first:

"At the beginning… for the number of entries I did, I'd say the first half of it I tried to be conscience doing it."

Still, admitted that he did not record time as often as he should have:

"I only dealt with it at the end of the day, and it's what I could remember."

He suggested that it was broad categories that jogged his memory to record an activity:

"Just thinking back, the only thing that would jog my memory was category. Whenever I would hit on a category, it would go right down the list, ok this applied; I remember doing this for that. So that's about how it worked."

When confronted with the possibility of the system used in the awareness exercise becoming a company policy, the respondent was not pleased:

"Filling this thing out at the end of every day?... I wouldn't feel too good about it… [but] I'd get use it."

Quality Awareness

This respondent expressed a lack of confidence in the theory behind CoQ:

"It didn't seem realistic to me, at least related to the architecture. I'm just not that sure how realistic it was to do such a thing."

Veracity

No veracity codes

New Concepts

No new concepts.

Credentials

Respondent P54 is a senior architect whose job is self described as writing specifications and doing project checking. The respondent's duties are not special. Specification writing and project checking are performed by many engineers and architects. However, this respondent has a proclivity for this work and his contribution to projects is recognized by management as extremely valuable. The respondent's does not practice classical architecture, but his architectural training significantly enhances his approach to his duties.

In addition, the respondent has special duties which he describes:

"I am the local Business Manger System Coordinator, which is the company wide ISO9000 quality program which the company is committed to from corporate on down. I'm project auditor and now a coordinator for our quality process and I also am writing the specifications to inject precision into the architects work."

The respondent has an intense interest in quality issues and the company's written processes. He describes his duties as a project auditor thus:

"A Project Auditor tries to confirm that the quality process has been applied to a project. That the files are kept the way they are supposed to be kept, the checking is done the way it's supposed to be done and its part of our renewal of our ISO9000 certification, that we conduct internal audits summary annually, and that there is also a UL 3rd party auditor that comes in and does the same thing. Basically [deleted] has a published quality program. The audits are to determine if we are following our own program."

The respondent did not participate in the awareness exercise but attended the study orientation.

Fear

When asked if recording errors against CoQ redesign due to a coordination difficulty… in this case, a rooftop unit that has to be re-designed because of weight issues on the roof. When asked directly about possible anxiety, the respondent said:

"No. I realize when I worked in the building trades, and you realized something was built incorrectly, and on Monday you put in a wall, and on Tuesday the boss says take it out. You realize it's not productive but as we used to say it all pays the same to people on the bottom end. If people doing the thinking on the front end can get it right, then you can avoid paying three times, putting the wall up in the wrong place. It's going to cost three times what it should. So we should be able to record that and then maybe use the analysis to think of ways we can avoid that in the future… or that their boss is the one that made the screw up, which is just as likely to be told to do the wrong thing, and you say, he's the boss, he knows what he's doing, he's leading the way, leading the show, and then the next week you got to undo.

The respondent exhibited a fearless attitude:

"If it's positive, I think it should be recorded if we were perfect we wouldn't be doing this for a living… I think we should be able to learn from our mistakes."

What he commented next betrays a prevalent attitude:

"If I have to do things over it's because doing the things the way I was directed by the designer, didn't quite work out in the end, and I had to substitute a different solution."

Responding to the anonymity issue, the respondent goes on to suggest that others may be squeamish about reporting mistakes:

"No I can see a reason to shield identities, but on the other hand, I have always been able to admit errors."

Perhaps this respondent doesn't believe that he makes mistakes, but merely delivers the mistakes made by others.

Accuracy

When asked about the complexity of the CoQ system as proposed in the awareness exercise, the respondent replied:

"I would say the forty eight different ways to look at this is probably too much for the average designer. If there are ten roughly, that's probably more doable."

The respondent went on to endorse some level of complexity, suggesting that a diversity of elements might have an instructive effect.

"Knowing that there are ten different internal errors helps you record one. Just having it recorded as an internal error makes it easier to me. I think that the sub categories might be good at explaining, and might make it easier to identify what you are looking at, but having to record ten different internal errors than if you went down to the basic five categories, that's probably doable."

Still, the response still appears to look at the system as a confined to reporting errors.

When asked about project manager's tendencies to minimize task numbers... in the context of the question of whether to have a separate recording mechanism separate and apart from the official timesheet:

"Not for everybody, there's a lot out there with many, many tasks, and you know its common for me to proceed on work before I know what the task is. They just do this, and by all rights I should say what task number it is this before I start. There are just some jobs, they go to fast to have those numbers, so I would advocate for a separate recording."

This respondent acknowledged the problem of a project whose budget was expended and chargeable tasks closed for recording:

"Very likely it's remedial."

Also commenting on the separate timekeeping device:

"Not sure that clients would be pleased [seeing error costs], but I think that we're no different than anyone else in the industry. I think a third factor is, the last two or three days of any two week time period are the best estimate of time spent, because time sheet sub schedule, and frankly I don't think many people go back and change. I think it's a 20% error potential."

This was an unsolicited estimate of error costs, very likely a low-ball.

Diligence

When asked his opinion of the prospect of living under a system of CoQ recoding, the respondent pointed out a peripheral benefit:

"I didn't record my time so I don't know one way or the other. I suspect that if people record the error correction time required they would spend more time doing it right the first time. Saying there's never enough time to do it right the first time, but there is always time to go back and fix it, always cost more to fix it, especially once its out on the street, the client and contractor get to participate and apply their own pricing, and the errors and omissions."

The respondent does not leave room for any problems with acceptance of such a system.

Quality Awareness

When asked about his recollection of the orientation he stated:

"My understanding is that quality work is the best marketing tool that is that it retains clients which are cheaper than getting new clients so it's very important. It's what professionals ought to do is make their product as good as it can be."

The respondent's response suggests that he does not remember the COQ principles, but instead expresses his own belief about what quality is all about. "Retaining clients is cheaper that getting new clients" plus he believes that is it a professional's duty to aspire to "as good as it can be". In this context, professionals could mean engineers and architects. It could also mean drafters and designers.

This researcher then tried to reiterate the CoQ principles which suggest that in addition to eliminating errors through appraisal (checking) that prevention activities can reduce errors plus appraisal as well. The respondent repeated what I think was his core belief:

"Well it's obvious to me that if you don't do your checking you're in trouble. My understanding is that the first check will get rid of 75% of the problems. The recheck will get rid of the next 20%. The next 5% is beyond most processes to eliminate the 5% error."

This researcher discussed the teachings of two quality giants: Deming and Juran… that their collective belief was to cease reliance on appraisal, and that quality could not be injected into the product during the checking process. He did not deviate from his checking paradigm:

"A checker doesn't know what's missing if it's on the drawings and it's contradictory. You can say well, that's not right, but if somebody else didn't mention it how do you know it's wrong or not or coordinated? A lot of opposition for error in general, if the people that produce the work don't check their own work, because a checker doesn't have access to all the communication and correspondence so he doesn't know if it's been taken care of and record properly. You do what you can, you do but there are limits."

The respondent acknowledged the Japanese quality miracle, but does not accurately reflect it. He continues to look at quality through the prism of the checking process. When pressed on this point he defended his opinion:

"Well, keep in mind what we do is not a kind of manufacturing, which is what a lot of the time quality work studies are done. Everything we do is unique, and we do use the same process over again, but, every project was unique, created on a whole cloth which means it's ripe for error, for people who do not apply the system correctly, or didn't know the system in the first place, or to busy to apply the system, or whatever everyone is unique. It's not like applying the assembly line process, and by the time you work out the kinks, you get a quality."

This respondent's view of quality is firmly entrenched in a checking philosophy. In this last explanation, his reasoning is rooted in the uniqueness of the engineering product… that it defies application of "work studies". In this particular reference, this respondent connects CoQ with time and motion studies. The respondent properly points out the difference in business models between the manufacturing sector and the engineering sector… that engineering projects are "one-offs". However, he does not appear to blame the nature of that difference, but the lack of adherence to the "system"… he warns that errors occur when the "system" is not applied properly. In this case, the "system" is a checking process.

Still, the respondent thought that reporting CoQ data was a good thing… in pursuit of a quality product:

"Well like I said, quality project sells itself, and how do you measure that? We'd like to think that change orders, that is changes to the contract amount add after bidding, under 2% but maybe under

5%, is a pretty good job, and I don't know we don't publish numbers. So we don't know if we are doing that but we should all be aware of that."

But lamented the fact that such information is not available, and if available not reported:

"…project managers don't share that info with people on the floor, and since we are horizontally stratified organization, you know, project managers go out and meet the clients, construction administrators go out during construction, designers stay in the office. They don't learn the lessons out in the field. I mean somebody's asking you "now what do I do?" you learn lessons, but if it just something that the project manager thinks is a hassle, and the construction administrator is looking for a solution, and it never gets back to you. I mean you don't know you got a problem."

Veracity

This respondent raises no veracity issues.

New Concepts

This respondent describes an overarching quality mechanism and his role in its execution.

"A Project Auditor tries to confirm that the quality process has been applied to a project. That the files are kept the way they are supposed to be kept, the checking is done the way it's supposed to be done and its part of our renewal of our ISO9000 certification, that we conduct internal audits summary annually, and that there is also a UL 3rd party auditor that comes in and does the same thing. Basically [deleted] has a published quality program. The audits are to determine if we are following our own program."

The respondent used the word "tries" to describe his involvement in the process, suggesting that the auditing activity may not actually guarantee that quality policies are followed. When asked what triggered his audit, he stated:

"No, the local business executive along with the business management system coordinator make a list of projects that fit the criteria, established by corporate quality, and they tend to be larger projects that have longer durations."

This acknowledgment from the respondent suggests that the system is not universally applied. In fact "larger projects that have longer durations" suggests that the selection process does not favor projects normally done in this office.

When asked his opinion of the prospect of living under a system of CoQ recoding, the respondent pointed out a peripheral benefit:

"I didn't record my time so I don't know one way or the other. I suspect that if people record the error correction time required they would spend more time doing it right the first time. Saying there's never enough time to do it right the first time, but there is always time to go back and fix it, always cost more to fix it, especially once it's out on the street, the client and contractor get to participate and apply their own pricing, and the errors and omissions."

The respondent does not leave room for any problems with acceptance of such a system. But it also suggests another aspect of the respondent belief system. Despite the heavy reliance on the checking paradigm, he still acknowledges several quality concepts: (1) the difference between internal and external error and the dramatic difference in cost, and (2) the value of prevention activity. However, the value of prevention activity is limited to personal responsibility… people would do it right the first time if they had to record their errors. The respondent went on to speculate about the usefulness of a CoQ system:

"If this system really means that the design and the drafters buy into the quality, so there is quality before it gets checked, let alone auditing, and doesn't really measure the quality product it

measures the behavior of the system. It's a little bit of a false front frankly, but you have to follow the system because that's what you audit."

The natural follow-up was to get the respondent to acknowledge that auditing does not test quality, but tests only the system.

"It just says do you have the files? Do you have the records? Do you have copies of the checked sets? Is the project manager planning? Who are the people who are on the project manager's plan? Is there evidence that you are following a process? In the files it doesn't say was this a good project or a bad one it never says that."

Still, the respondent holds on to the role of the individual in the design process in a case study:

"...when a mechanical engineer decides to quadruple the weight of a rooftop unit they shouldn't have to wait for the structural engineer to tell them that's going to cost a lot of money to reinforce the roof. They should understand immediately, that this decision will have wide ranging impact on a project. This is a recent example and what it ended up with was mechanical said, we are replacing roof top units they are within 20% of the original weight. Structural said we should be able to handle that. Several weeks later mechanical went to structural and said, oh not those heavier ones. So they spent four weeks under one design assumption. Mechanical had to quick design a solution for the heavier units that cost money. And then the money for those repairs, for the remedial work to the roof was presented back to mechanical so we don't have money for that, so we went back to the lighter units. So we had several weeks of mechanical engineering and several weeks of structural engineering completely wasted, because of bad communication. So the designer on the ground has to internalize the quality from personal motivation and experience, and also from good project management. They need to set the scope very clearly, or else they'll be known as scope creek, or there will be these excursions into things that use money when we don't follow the logical process."

When I asked the respondent if the problem really is more associated with interim design cycles… trial and error… that it may not be clearly an error. The respondent disagreed:

"Well let me just say that when you are designing a solution, engineering solution, architectural solution, frequently you design within limits, because we are not blessed with magical clients with unlimited budget, and unlimited patience. So there are parameters that are set and usually cost is one of them. And so violating that parameter there's no way that should happen. Let me just say, if the design in its earliest stages and is communicated in its principle disciplines before there is a huge commitment in drafting time and engineering time and designing time, that's the whole idea as you go back and forth, it rattles around and forms itself around an idea, and it solves everyone's problems, pretty much the design development. The next stage you put some numbers to that and you find it doesn't mean you have to change your whole approach to how things are going. It may be interim process. I don't disagree with that, but it's not full of a lot of dead ends, especially long dead ends, with a lot of investment."

The respondent, here, acknowledges that there are possible avenues of improvement in the process, but still does not make the connection that it could be a system, rather than an individual enhancement.

Summary

This respondent is important because he is the office quality auditor and is probably more tuned in than most regarding company (but not necessarily technical) processes. He self-described his job as ensuring that quality processes are followed, not whether we produce a quality process. I would say, however, that he is also fairly astute in pointing out many different types of errors and incongruities.

This respondent did not record time but commented favorably on the intent behind the CoQ system… recounting an old saying "there is never time to do it right, but always time to do it over."

This respondent superficially appears to subscribe to a prevailing attitude among management that the company produces quality products when each individual manages their own quality… placing a high value on self-checking to eliminate errors.

On the other hand, he admits that checking processes cannot catch all errors. This respondent appears astute in pointing out many ways a firm can avoid errors by investing up front with up-front effort, such as resolving coordination issues before design.

Further interview with this respondent would be valuable, if only to examine attitudes with respect to a systems approach. It appears that unless there is a systems perspective, CoQ systems will never be accepted.

Credentials

Respondent Q60 is a senior mechanical engineer whose job is to:

"…design building systems primarily mechanical heating, ventilating and air conditioning systems for commercial, institutional, some industrial."

She also asserts to perform the duties of a task manager. This respondent participated in the awareness exercise and appeared to have been very meticulous about recording time against CoQ categories. She recognized the color guide that described all of the CoQ categories and descriptions.

Fear

This respondent does not find a particular problem with confidentiality… particularly if the specter of personal data is used by management.

"Yeah, I don't know… I guess I trust if somebody tells me it's not going to be traceable. It would seem to me, if management does not know the quality of a person's work by a supervisor, and what issues come back on projects that someone works on, it would seem like a moot point, if they had to add a little survey or some sort or personal entry to verify someone's ability."

Still, this respondent concedes that others may not be as trusting:

"If you want to have an accurate entry by an individual it needs to be anonymous."

Accuracy

When asked about her opinion of her accuracy on recording time, she took no time to reply:

"I was very accurate."

When asked about a particular recording event, she was able to describe the procedure in detail:

"…there is actually a line item 4.1.5 of review lessons learned. So I go into the cube icon on the screen and go into the number system and find that and a lot of times I would write a little blurb in the comments box."

She knew what the activity was all about…

"…if there were other designers that were going to be helping me on a project. If I was doing, say for instance, a roofing project then it was only a drafter. If it was a major project that had a lot of design work, there was usually another designer or engineer working with me, and so whoever it was I would talk to them about that, and I would make sure they had a written copy of it to."

As with other respondents, this person had an opinion of committing errors that is worth noting. When asked about whether there were too many subcategories, she replied:

"I don't think so. I didn't use the ones for correcting errors because I was usually doing the checking on it but I think if every person who was involved in a project."

This respondent thought that the distinctions between subcategories were important to retain:

"I think until people got fully integrated into doing it, you would almost need to have all the different distinctions. Would all the entries, for say, external errors, would they all have the same costing to the client? You know if you're trying to work up what's the cost of external errors is all these weighted the same?"

The opinion is a bit different when speaking about her own recording experience:

"The only value that I found in having the different categories was being able to add notes or comments… because sometimes, in case there was a question to what I was doing, it put it in there. Whereas if only number one external error, I think there would be more possibility of erroneous entries of somebody not quite getting it in the right category."

Diligence

The respondent did not express any kind of adverse feelings towards recording CoQ time during the study. She seemed genuinely interested in letting me know how she managed to master the practice of recording time and recognizing CoQ activities:

"Well having the numbering system, and having the book, and a lot of times, I used this single page that was printed front and back that kind of was a guide to what was in the book."

She referred to a short table that I distributed that was a matrix of sorts that categorized the different CoQ subcategories into groups that would be of interest to a particular practitioner… like those items most likely to be used by a drafter, or a project manager, or an engineer.

"I had the book and I had made notes in the book but I also had this table and between the two it was vary helpful and it was not a problem and the color coding helped too."

She was very clear that she recorded CoQ time in the same manner as she recorded time on official timesheets:

"That was basically how I did it. I enter my PB timesheet daily, so when I would enter that I would also enter the Parkway."

She was very descriptive so as to eliminate the possibility that she was fabricating a story for my benefit. When asked if the practice of recording CoQ became permanent, would she have a problem…

"It didn't take me that long to record it. I mean if somebody was unfamiliar with the categories, it might take a while to get used to it, but once I got used to the categories it did not take a lot of time."

She had a definite opinion of the use of official timesheets to record CoQ data:

"No I don't think on a time sheet. Our electronic time sheets are not user friendly as they are, and I think trying to put any additional categories, or designation, would wreak havoc with the time sheets… There are some projects that we work on, that we have to submit weekly time sheets, separate from the PB timesheet, that we are submitting it to the client, or to the project manager, or whatever it is, and I see no issues with having a separate entry."

Quality Awareness

This respondent, probably more than any other was tuned into quality concepts that went beyond the company's standard reliance on appraisal.

"…I'm looking at some of my notes in the book… when each year's maintenance project was over we would try to write down the lessons learned. So then the next year, if we had the contract still, I would always pull out the lessons learned and see what it is and go over it with the people that were working on my projects, and so that would be time that went into prevention. So we talked about issues and talked about what we would want to do differently from previous years before we ever started the project."

I don't think it was by accident that she zeroed in on one of the key points of the orientation: prevention activities. Her opinion on the subject was quite extensive:

"Overall, I think we put too little time into doing this on a regular basis, and I think we need to be doing this all the time, because it is invaluable in getting it done right to begin with. There is the old saying there's never enough time to do it right, but there's always time to do it over, and that's not really humorous. We don't always take the time in the beginning. It's like jump and run. Before you can jump and run you got to have yourself organized, you gotta have yourself a plan. One thing I personally do, on almost every project that I work on is, I sit down upfront and make preliminary lists; I make list of the systems, I make lists of the equipment, I make lists of anything special, then I take that and make a list of spec sections, I make a list of details, I make a list of schedules. And it's all preliminary; it's all the first week of the project."

"… it may or may not, having that, a lot of things may change but it's a start. I mean if a drafter is assigned to the project, up front they can immediately beginning pulling from our standard schedules our standard details and beginning creating those sheets. You know, try to list out the sheet names and numbers and again they may change. Preliminary I make up those lists, and it saves a tremendous amount of time and effort and mistakes. If we have something to start with and people aren't just randomly- I mean I've actually worked on projects where someone else was leading and nothing like that was done, and at the end of the project we actually end up without some schedules that we needed. It's like wait a minute "where's this equipment?" Well I guess nobody remembered to put that in there because it was done very sporadic in putting schedules on the drawings. I mean somebody might have handwritten one out but nothing got on the drawing. I think it's a very important thing to emphasize the prevention and the appraisal. Appraisal kind of goes with quality checking, the QC-ing before any submittals in house, but I think that prevention is really, really important."

Veracity

When asked about the possibility that she may be tempted to fudge time in order to avoid self-reporting errors, this respondent replied:

"No because I'm inherently honest."

New Concepts

This respondent suggested that she does not have error costs because her duties include checking only. Although she conceded that re-checking activities are error costs

Summary

This respondent was self-described as being very accurate with recording CoQ with the computerized personal log. She approached the system very professionally and mastered all of the subcategories. She found that the color guide and a matrix that categorized items by which staff position would be most likely to use what CoQ subcategory item was very user friendly. She logged her time daily… as she did with her official timesheet.

She was diligent in making sure everyone associated with her work had all of the necessary information needed to accurately report their time as well.

This respondent thought that CoQ recording would wreak havoc on official timesheets and thought personal logs were ideal.

This respondent described habits that can only be described as heavy into prevention activities, so she is very quality minded with respect to the whole process, rather than quality check only. One activity she discussed was "reviewing lessons learned"… a bonafide CoQ activity that probably no one else used.

This respondent also reported that she doesn't need to report errors, only drafters (she only CHECKS drafter's work). This lends itself to an ongoing trend that many individuals have a skewed self-image that suggests that only others make errors.

This respondent flatly denied that she would be inclined to fudge recordings because she was inherently honest.

This respondent used to work for a design-build firm with a more Taylor-like approach to management. It would be worth an additional interview to query her about her experience there.

Credentials

Respondent Q53 is a plumbing engineer whose describes the nature of his job as:

"…direct dirty water, sanitary water, or bring domestic water to and from facilities".

He also asserts to perform the duties of a task manager. This respondent participated in the awareness exercise and reports that he remembers recorded time against CoQ categories.

Fear

When asked about the possible misuse of CoQ data by management when such data is traceable to an individual:

"What it has, in effect, for me is a direct attack on my integrity as an engineer. I think that has more of an implication than actual fear that having to do with anything with respect to a salary position. It would be more like… 'I did not think it through'. And that's the fear of doing that is NOT thinking it through… did I make that mistake?... or could I have done it a different way in order to make it work?"

I suspect that this response is more likely to be a statement that is tilted for the researcher's consumption …in order to make the researcher think higher of the respondent. Still, this respondent was emphatic that he would find personally-traceable errors to be embarrassing, but not so as to make him fearful.

Later in the interview, the respondent expressed a fear of management… that the awareness exercise was fine… as a study, but if it were implemented permanently, it could be use adversely:

"I think that it would be used as a whipping tool… that's just a fear of management."

He went on to explain his reasoning:

"Right, and I say that biasly [sic] because, say for example, I might have a coworker that is working on one or two projects while I'm dangling nine at a time. Theirs might be used as a whipping tool depending on the production of the project that they're working on, whereas mine, there's always a fire… production is always immediate… and you measure those, too… like this guy's got eleven-twelve things on his timesheet and you have six… or three. Does that become a "why don't you have as much or why don't you unload that person" does that become something that you use as a whipping post for that individual where you say "I think everyone can do twelve… this guy can do twelve, everybody can do twelve. But I see that happening and that's it in a nutshell. It might be that somebody's working on one large project and someone who is external to this place can look at these numbers… say, in New York… would probably say "why is this guy doing one on this project and this person is doing six, and this person is doing eight to twelve, and this person is doing three. What's going on… what's the disparity in these? You know, I just look at externally."

Accuracy

When asked about her opinion of his accuracy on recording time, he replied:

"Accuracy… percentage-wise I would say about 60 percent accurate… as the project would increase in intensity, there may be an opportunity where it may go unrecorded… that was the reason…"

When asked about a particular experience recognizing and recording CoQ activities, this respondent took a great deal of time to explain the event:

"One particular project, we were installing a sanitary line or pump system in the bottom of the elevator pit. There are standards in which we have to follow in order to implement that and in doing so, we would get the authority having jurisdiction's approval on a system that we've come up with. We did find a method to do it to their satisfaction only to find out that another inspector came in on the project and did not like the methodology and wanted us to change it and shortly thereafter another inspector took over his place and he wanted to alter the sump pumping system a third time… to the disgruntlement of the client; and we finally got that taken care of. And that's where more of an error on the part of the authority having jurisdiction."

This respondent thought that the activities were rework - internal. I reminded the respondent that a portion could easily be regarded as "coordination planning"… and he agreed. Still, this was a sore subject because the coordination planning did not have the desired effect:

"The coordination with the first inspector was pretty much what the intentions were would be to get approval so we could move forward without any complications. It didn't come to fruition until the second and third person became… wanted to implement their own designs."

When asked if he thought the CoQ recording process was a useless exercise, the respondent disagreed, but suggested that 48 subcategories might be a bit too much… at first:

"48 might be manageable. But here is my caveat for saying that: it would depend on the period of time you give people to get used to it… absorbing the 48 before you actually begin your study… an incubation period… then, I think, it would become second nature. But they need to have it where it is (1) you're asking a question… are you doing this often to make sure that they're applying it? And (2) the incubation period… I don't know if you want them to KNOW when the incubation period is, because they may tend to wait until the last minute to start doing it. If you say that there'll be an incubation period without a limit, I think that they would tend to absorb all 48 not knowing when it is going to take effect."

This respondent makes reference to a human weakness to procrastinate… in this case, to delay internalizing the process of recognizing and recording CoQ activities.

Diligence

It was interesting that the respondent reported that during those times when it was difficult to record CoQ time because of available time, that he still found time to enter time on his timesheet. Humorously and honestly he said why:

"That has a bigger Maslow effect."

Suggesting that an individual gets paid the same whether or not he records time against CoQ activities… whereas not recording time on official timesheets will result in not getting paid.

Quality Awareness

This respondent, when asked about his opinion behind the principle of CoQ, responded with another non-company example:

"I think it's… I really think it's critical. Evidence would that in our current auto market… let's say for example… I hate to pick on a company… let's say Chrysler had a very good product such as the Neon… a car that came in at a price suited almost every family that needed transportation regardless of the size of the family, but they knew they could transport members from "A" to "B" without any problems. Same thing was there… maybe a PT Cruiser… another nice vehicle they came out with. The problem is that they started experiencing difficulty… the company dropped their responsibility of repairing that vehicle. Later on, it was noted by more and more people that, excuse the phrase, piece of junk. And they tended to go away from that. The onset of offshore vehicles coming in setting a quality standard… less breaking down, less money I have to come up, less I

have to take it back to the manufacturer to have it repaired, or even his represented, to have it repaired… they tended to gravitate towards those vehicles. As a result, the sales of that Chrysler product went down… went down… went down with the vow of some of those people, some of them who I had spoken with, that say they would never return to that company again for any vehicle as long as they live. That is the price of quality. Now you have something that you could never get back, it takes too much time. Even today, the stigma about the Jaguar having a poor transmission sticks around… another vehicle that has suffered through the years… probably a very good vehicle, but because of its poor history nobody really wants to fool with it very much."

When asked about quantifying quality, this respondent interestingly brought up a quality issue that relates to value… perceived value… that perhaps quality could be relative:

"Very difficult. I think that at the same time, the consumer is I don't think is a stupid individual. They may be taken advantage of, but I don't think you can discount their ability to assess products. Let's say for example a Wal-Mart product… may not be the best quality, but it does suit the purpose and they understand that it's for a temporary period of time… but they didn't spend $95 for a pair of jeans as opposed to $7 for a pair of jeans if they can wear it… and they KNOW it's temporary… they understand that. Therefore, during these economic times, people who are looking to save money who would normally not be found in that market would turn around and go and buy those $7 jeans, but they have an income that is insurmountable compared to the person that is looking for those bargains but don't quite make the same amount of money."

This respondent share his thoughts with respect to the "quality equation" related to the costs of quality:

"There is a magic number that tends to come to mind, and I forgot where this number came from: three tends to be the magic number on that cost factor. I our case here, we would do a back-check of a product that is getting ready to go out. And that's given to your lead supervisor or engineer, then they would check it. Whatever is found needs to be corrected and they give it back to you for correcting. You, in turn, make those corrections; turn it back over for a review a second time. And if there anything that needs to be corrected at that time, they return it for the third time. That should be the final in which you would allow that product to go out. After that, you really begin to eat into costs that are a little insurmountable. Also I think at that point you can start going down the tubes if your relationship as far as communicating what goes into that initial check is pretty well done… pretty well defined, then that person can actually do it twice, and the third time needn't exist. And if you can… I think that if you have that relationship where there is a known, you can cut that down to two times, but I think that three is the absolute maximum."

Veracity

When responding to a question regarding other person's honesty regarding recording of time, the respondent said:

"People do things to increase pleasure and decrease pain. So in doing so, I think that others may tend to seek something that would detour blame or detour the mistake and see if there was another method of placing it elsewhere instead of themselves."

He went on to say that he could be trusted to record faithfully but he could not place the same trust in others. He amplified his response by saying that it would depend on the circumstances:

"I go back to my original phrase people do this to increase pleasure and decrease pain… and given where that might fall is where they would make their decision. If it makes them look good then they would do things… would say things that might make them feel better about their decision."

He suggested that a veil of anonymity would improve the credibility of reporting. He gave a non-company example to demonstrate his point:

"…I think that if there are consequences, people will tend not to be as truthful. I guess you could say, for instance, the war in Iraq… you have guys… Taliban in your area whom you would fear would come back and harm you. You would tend to lie and say "they were never here." Because the consequences of once the soldiers leave and they come back, they're going to come after you. Whereas if you were in an environment where you didn't have to fear that retaliation then, yes, you would tell the truth… "yeah, they were here… they're gone… they're staying in this region.

New Concepts

No new concepts

Summary

This respondent was not fearful of adverse treatment by management if traceable CoQ data was revealed; instead that he thought it would be a professional slap in the face. The statement sounds like he is not open to criticism. Many statements in the interview suggest that he has ongoing issues that may have been revealed related to his workload.

He addressed the fear/veracity issue in great detail. Individuals want to maximize pleasure and avoid pain, and that individuals might likely fudge CoQ records in order to alleviate those issues. He thought that it would be much less of an issue if CoQ data remained untraceable, at least to individuals. He appeared to be tuned in on previous management training when he mentioned the Maslow Hierarchy.

He said that he recorded about 60% of the CoQ activities and missed the 40% due to lack of time. Although he conceded that he was able to find the time for official timesheet recording. He humorously referred to Maslow, a veiled reference to his need to be paid.

This respondent is highly aware of quality issues in corporate America related to foreign competition, but not particularly well-versed in modern quality theory. Still, he was able to point out that quality and features are not necessarily the same…. That it was possible for a product with few features but with a low price tag be of higher quality than a product with many features and a large price tag.

As with other respondents to date, this respondent has a rather myopic view of his own fallibility, thinking that errors are made by others, or made by him only after being caused by others. I'm wondering at this point if the expressed view that one doesn't make mistakes nearly as often as the general populations is a proxy for fear. It certainly suggests that errors made by such individuals might not get reported with the same enthusiasm as the errors reported to be caused by others.

Credentials

Respondent P54 is a Lead Engineer whose job is self described as supervision of junior engineers. The respondent's duties included task management.

This respondent participated in the awareness exercise and recorded costs against CoQ categories.

By way of disclosure, this respondent reported to the researcher at one time.

Fear

When asked if CoQ data in the hands of management would be cause for concern this respondent, he made a case for the possibility for wrong conclusions:

"I guess that I wouldn't fear it. I would be suspect of it. I guess the reason the company would gather the information would be to compare employees. And on employee might be more... might have more of an opportunity to be the one to correct errors or be the one to prevent errors, so they have more opportunity to spend quality costs, where another might not be, so reporting for one person might be much greater... more reporting than another person... You may also have a dispute between people on a project on what the source of the error was."

If the company had a policy that ensured that CoQ data would not be personally tracked, this respondent expressed greater trust in the company motives:

"...I wouldn't fear that. Because if the company says they're going to do something, I expect them to do it. I imagine most people would be like that although I imagine some might also fear it and think that the company ahs ulterior motives. I would say the use of that is good... just thinking now... office level or project level, and not so much on individual level."

Accuracy

When asked about the complexity of the CoQ system as proposed in the awareness exercise, the respondent replied:

"It seemed to be an efficient way to record the data that was asked for and it was probably the least burdensome way that I can imagine... It was easy for me to use and I guess at times it caused me to think about what I had... when it prompted me to record time and describe the time that I spent it may have made me think more about the quality costs that we were incurring."

This respondent reported to be very accurate in reporting time during the perceived duration of the study:

"...I recorded time to the minute. I made every effort to record every quality cost. Towards the end of the months that we did it, I probably dropped off in my recording of it. I didn't keep up as well as how I began."

The respondent remarked that the complement of subcategories (47) were not too many because he used only a few.

"...I ended up using just a few of them. I became familiar with the ones that I commonly used and used those easily... I knew that I might just use six of them 90 percent of the time."

He described a typical event that involved CoQ activity:

"...I would read the RFI and if I discovered that the request for information was due to some error in some drawings, or in our documents, or some part of our documents that wasn't clear, then I would

issue a change of clarification to the contractor so that time then to investigate... not the time reading the RFI... but the time investigating the error and fixing it would have been the time recorded... that would be an internal error, I believe."

This respondent was only partially correct, in that answering an RFI is a CoQ cost, but an external error cost regardless of whose fault it was. However, by using the CoQ pop-up on his desktop, he would have been informed of that. I leave room for the possibility that time had passed and memory had faded slightly.

This respondent believed that the five categories, rather than 47 subcategories would make it easier to record time; however, his reasoning tilted towards the 47 subcategories:

"...your [color guide] book that you produced... our instructions had cues for what did or did not belong in a category... I would use those."

Still, he thought the 5 categories would be workable.

"... five broad categories are easy for me for me to put in any activity without looking anything up... So that I could easily record the time in five broad categories than I could looking up subcategories."

Diligence

This responded reported to have been very diligent in recording CoQ time during the perceived time period of the study.

When asked his opinion of the prospect of living under a system of CoQ recoding, the respondent pointed out a peripheral benefit:

"... how would I feel as a manager.... I guess if it were a requirement, I would look at and I would probably explain it to my employees as being, in itself, a cost of quality. It would be... it might... I think at first take I think it might be a burden... although a small burden... maybe a nuisance... just in having to bother with it."

The respondent differentiated between learning the system and continuous day-to-day use of the system:

"The continuous use... I think the learning of the system was pretty straightforward... short learning curve as to what to do and why we were doing it. I forgot how it popped up."

He believed that some users might not bother to record, given no other incentives:

"... since it's the user who has to initiate the recording, right?... I would imagine that a lot of users might ignore it and wouldn't use it even though it was a [deleted] requirement because [deleted] would not be able to track your non-use of it..."

Still, this respondent felt at ease promoting the use of the recording tool, but suggested that it would be difficult to enforce:

"Not sure how they would enforce it. I think that they would require it."

This respondent said that he kept track of his CoQ activities mentally.

"I'd finish the task and keep track mentally of my time and record the time that way."

He reported that he did not generally record on his official timesheet daily. While others reported that they recorded CoQ time at nearly the same frequency as their timesheet entries...

"...although this... the cost of quality was so specific, and the times were usually so short that I recorded the time the same day that I did the activity.

The respondent suggested that use of a timesheet, rather than a personal log might be helpful:

"It might help, because the employees are thinking about time spent on the project… so they can think about quality time… all the time… together. So, if they're about to record four hours for a project, where they would have ordinarily thought two hours were spent on the quality errors of some kind, they realize that it's 50 percent of my entire time, it might make them think twice about the amount of time they're going to record… other than that, if it's as easy to pop-up as the timesheet is now… well, the timesheet is more cumbersome because you need a password to get into it, so it takes a little less time to… if it's just as easy as the cost of quality pop-up, I don't think it would be an issue."

Quality Awareness

When asked about his recollection of the orientation he stated:

" There are good costs and bad costs. The bad costs are to correct errors and the good costs are to prevent errors"

His impression of the CoQ system, in general, was favorable:

"I thought it was a good principle… and a good educational tool for the people I think got to take part in it and hear the presentation. It seems meaningful for a company to examine it."

Veracity

When asked about the possibility of the Company evaluating individuals based upon their recorded time, this responded concluded:

"…if [deleted] is going to evaluate individuals based upon time recorded or that they're recording their own errors, I think that people would fudge because they're self reporting… I think they would fudge to make themselves look better."

The respondent made his reasoning more clear in this comparison of fudging time on personal logs vs. official timesheets:

"…but the harm there is done to the project budget whereas in this self-reporting, the harm could be done to the individual."

This respondent also opened the door to arbitrary behavior based upon workload:

"I had another thought, if I could share it… you mentioned that if a project runs over budget, I think that there would be a tendency for employees to record error costs not add time to error costs, but with the intent of sticking it to the project because they just feel put upon by some errors that other people are causing or if the project manager is known to always change things at the last minute, or if a certain client, in that respect… so at the end of a project you might see more of that, whereas at the beginning, everybody seems to have more time on their hands – maybe not record those kinds of errors."

The respondent believed that CoQ would not likely be recorded early in the project because the prevailing feeling among staff is more "amenable" as opposed to the end when anxiety levels are higher as coordination errors are exposed. He described the form that this would manifest itself would be in the form of apathy:

"Sure… apathy will play a part. I guess other motives would be… personally, if the person didn't feel burdened by the error that they're correcting, or it was preventative… if it just didn't seem like a big deal to the person, they might not record the time."

New Concepts

This respondent discussed no new concepts.

Summary

This respondent suggests that a CoQ system that openly tracks individual CoQ data would be cause for concern… personally and with the integrity of the system because of tendency of others to fudge data rather than face adverse consequences. On the other hand, a firm company policy that prohibits traceable CoQ data could and should be trusted.

The respondent believed that the mechanism was an efficient tool and was easy to use. He thought that the complement of 47 subcategories was not overwhelming because he recognized that he would personally use relatively few. Still, he thought it would be simpler to rely only on the broad categories when recording time.

The respondent thought that there was a "nuisance element" such that others might not feel motivated to record time. He also suggested that recording CoQ on official timesheets would improve compliance and also make staff more quality aware. He personally recorded CoQ time more frequently than he recorded time on official timesheets.

APPENDIX J

GROUP 1 INTERVIEW CODING REDUCTION NOTES

7-15-2009 Code Reduction Notes: Preliminary Properties for Group 1

The coding memo from the Group 1 interviews collates respondents' remarks in the following categories: anxiety, cognition, diligence, veracity, and quality awareness. These remarks can be reduced to the following concepts:

<u>Anxiety</u>

- Personal suspicion that data would be abused

- Personal suspicion that, despite institutionalized protection against disclosure, management would obtain data

- Personal indifference to the issue due to contempt for the CoQ system

- Personal indifference to the issue due to belief that data could not be misused

- Personal belief that data has a purpose, and that purpose is worth protecting with non-disclosure protections

- Supervisor belief that personal data would be useful to supervisors for rating personnel

- Supervisor concession that disclosure of personal data would do more harm than good

- Personal belief that as mistakes are made every day, disclosure of personal data would not be disruptive

- Personal fear that major mistakes could be disclosed

- Personal belief that more effective means exist to rate employees than personal CoQ data

- Personal belief that anxiety would be reduced if systems purpose of collecting CoQ data were disclosed with some fanfare

- Personal belief that many errors are out of the control of the individual employee and disclosure of data would not be stigmatizing

- Personal concession that disclosure of personal data would have instructive value… learning from one's mistakes

- Personal belief that one should be able to face up to errors, but personal concession that many have trouble admitting errors

- Personal belief that accuracy depends on anonymity

- Personal belief that disclosure of data would be viewed as a direct attack on professional competence

- Personal belief that, if available, personal data would be used as a "whipping tool"

- Personal belief that many errors are out of the control of the individual and personal data could be misunderstood if disclosed

- Personal belief that management would use personal data to rank employees

- Supervisor belief that disclosed personal data would spark disputes over responsibility of errors

- Personal belief that management would not attempt to circumvent protections against disclosure of personal data

- Supervisor belief that disclosure of data aggregated to project or office level would be less controversial and, thus, more useful.

<u>Cognition</u>

- Subcategories were confusing at first but orientation was helpful

- Explanations under each CoQ item made categorization more intuitive

- Separate recording device is much more useful for selecting CoQ items

- Recording errors was stymied because internal or external character of rework was not normally identified

- Categories were fine, but there were too many subcategories

- Forgot sometimes, but writing down time to record later was helpful

- I remember very little about the system

- Recording device was too complicated… too many buttons and too many steps

- Too much to remember

- Easy to be accurate when CoQ time was recorded on the separate recording device at the same time as the official timesheet

- Accuracy degraded with the passage of time

- Too many subcategories for the average designer

- Categories alone may be easier to remember

- Separate recording device removes congestion and confusion of CoQ recording on official timesheets

- CoQ time would be missed if official timesheets would be used because of possible closed tasks

- Policy of completing timesheets early would degrade accuracy of CoQ recording

- Personal belief that time and category were recorded very accurately

- Personal practice of reminding others on the staff to record time, and how much, on a particular subcategory

- Large quantity of subcategories okay because not all are used by an individual

- Descriptions attached to subcategories were instructive and helped select the correct classification, which would not be possible if only broad categories were used

- Multiple subcategories were risky because sometimes only small nuances separated one subcategory from another and judgment would vary among individuals

- Personal belief that more than half of CoQ activities were correctly identified and recorded

- 48 subcategories are manageable if a grace period for learning is identified and that period is enforced

- Recording tool is a very efficient way of collecting CoQ data

- Recording tool was easy to use, convenient, and fairly intuitive

- Recorded time down to the minute

- Ended up using and becoming familiar with just a few CoQ items

- Tried to, but didn't catch everything

Diligence

- System is manageable. 30 seconds to record an item won't kill anybody

- Initially, everyone will feel more burdened

- No sense as to compliance level of others

- Lack of understanding of the system and its benefits would lead to apathy

- Regular progress reports, not just at post mortem, would raise awareness and promote compliance

- Forgot to enter time sometimes and had to go back and do it later

- Writing it down would permit entering data later

- Forgot about CoQ activities by the end of the day

- Only looked at CoQ recording at the end of the day

- Took way too much time to record time at the end of the day

- Frustrated because of too many buttons and keystrokes

- Process because burdensome over time

- Category jogged my memory more than subcategory

- I wouldn't like it if forced to do it, but I would get used to it

- The cheat sheet that identified likely persons and project phases for different CoQ items was very helpful to identify opportunities to record CoQ

- Entered time on CoQ recording device and official timesheet at the same time

- Recording didn't take a lot of time

- Searching for correct CoQ item for the first time might be a bit time consuming

- Official timesheets are not user friendly so recording time separately would be easier

- CoQ items would wreak havoc on official timesheets

- Recording CoQ time would have the paycheck incentive where a separate device would not

- May not have time to record CoQ data on separate data entry device but will never lack time to record time on an official timesheet

- Supervisor belief that recording CoQ would initially be seen as a nuisance or burden

- Learning how to use the system was a short learning curve

- Without the ability to track non-use, user-initiated recording would mean that many legitimate CoQ activities would be ignored

- Compliance would be difficult to enforce

- I mentally track of CoQ activities and record at the end of the day

- I recorded shorter activities right away

- Recording on timesheets would force more compliance

Veracity

- I would not slant data because I'm inherently honest

- An embarrassing round of errors would cause me to slant my recording of CoQ activities

- People seek to increase pleasure and decrease pain and, thus, would slant data to avoid blame or other adverse consequences

- People would fudge to make themselves look better

- People would be more inclined to report time honestly if it were to remain anonymous

- Personal feelings about a project could play a large role in an employee's decisions to record CoQ

- To the extent an employee feels burdened by an error will affect how closely or even if an error made by another is recorded

Quality Awareness

- Recording time would call attention to quality activities and promote good quality awareness

- System well-suited to the adage "never enough time to do it right, but always enough time to do it over"

- Historical CoQ data would be useful in fee estimating

- Many CoQ items are not generally part of fee estimates

- The company does not pay enough attention to quality in projects because of the construction administration issues we address

- Room for improvement does not mean that work is sloppy

- There is value is a system approach to quality rather that the sole reliance of checking

- Performance of the system is really separate and apart from the overall performance of any individual employee

- Supervisor belief that CoQ data aggregated over an entire group is much more interesting that individual data

- It is frustrating to do a technical task more than once... for whatever the reason

- CoQ could be valuable in identifying expensive areas or activities

- CoQ can be used to maximize efficiency

- The concept of CoQ is not realistic, at least as it relates to architecture

- Quality work is the best marketing tool

- Retaining clients is cheaper than acquiring new ones

- It is obvious that if you don't perform checking, you're in trouble

- The first check identifies 70% of the problems, the second check identifies another 20%, and the third pass yields another 5%

- The last 5% of errors is beyond most processes

- A checker doesn't normally have the specific knowledge of project conditions to do a thorough review

- It is incumbent on the employee to check his own work in order for the checking process to work

- Engineering cannot be evaluated with time and motion studies as can manufacturing

- While there are repetitive processes, engineering and architecture projects are all unique and, thus, ripe for error

- Project managers don't share information with the staff regarding lessons learned from construction administrators

- Quality audits confirm that the quality process has been applied to a project, not whether there is a quality project

- Shorter projects are not normally selected for audit

- If employees recorded time against errors, they might spend more time doing it right the first time

- A system where the employees buy into quality is a bit of a false front

- Quality audits never distinguish high or low quality projects, only whether staff conformed to the quality process

- Principle disciplines should communicate when the design is in its earliest stages before there is a huge commitment in drafting time

- I review lessons learned from last year's projects and go over it with people working on my projects

- I sit down and make preliminary lists… I make lists of the equipment, I make lists of anything special, I make lists of details, I make lists of schedules… it's all preliminary and it's all the first week of the project

- The costs borne by the client is a rather large part of the CoQ

- There are bad quality costs are to correct errors and the good quality costs are to prevent errors

APPENDIX K

GROUP 1 INTERVIEW THEME CLUSTERING NOTES

The 7-15 code memo describing recognized concepts in the five code categories were examined and sorted. Those concepts tended to coalesce around broader categories. The grouped concepts that relate to anxiety are discussed below:

1. Fear of what management might do with personal CoQ data if permitted

A portion of the expressed anxiety relates to fear of what management might do with personal CoQ data if permitted.

- Personal suspicion that data would be abused

- Personal belief that management would use personal data to rank employees

- Personal belief that, if available, personal data would be used as a "whipping tool"

One concept gleaned from the interviews is that management might use the data to rank employees. If CoQ data were made available, a list of employees from largest to smallest of reported CoQ costs would not be inconceivable. When comparing two employees for raises or promotions, their position on such a list could tip the balance. A concept related to this concern is that employees who are responsible for CoQ are not necessarily the ones who are required to record it. Basically, a fear that such a system does not treat everyone fairly.

Another concept is a fear that, absent other metrics, management might be tempted to use personal CoQ data as a way of building a case against an employee for demotion, suspension, or even dismissal. And as with the previous concept, CoQ data recorded by one individual cannot necessarily be associated with the performance of that individual.

2. Fear that management might find backdoor means of obtaining personal CoQ data

Some of the comments expressed suggested that even if there were corporate protections that limited access of personal CoQ data, management might find clever ways of obtaining the data, with the same result as if top management permitted the use of personal CoQ.

- Personal suspicion that, despite institutionalized protection against disclosure, management would obtain data

- Personal fear that major mistakes could be disclosed

- Personal belief that management would not attempt to circumvent protections against disclosure of personal data

The concepts gleaned from the interviews suggested two extremes: that management would, and management would not attempt to circumvent policy. The author speculates that this particular issue is a matter of trust that may be more related to an employee's rank or position, where higher placed individuals are more likely to maintain.

3. Indifference to management use of personal CoQ data

Perhaps the opposite of anxiety/fear is indifference. There were several concepts related to an indifference to management threats.

- Personal indifference to the issue due to contempt for the CoQ system

- Personal indifference to the issue due to belief that data could not be misused

First was the indifference to the threat of management because of a low opinion of the CoQ system. The indifference is based on the notion that what management does with such data doesn't matter because the concept of a CoQ system has no practical value, and therefore no practical threat exists from disclosure of data produced.

The basis for the other concept of indifference was based upon a basic faith that it was not possible to pervert the CoQ process into something toxic.

4.   Should personal CoQ data be protected?

Previous concepts are related to fear of what management would do if it had personal CoQ data. The following concepts examine whether CoQ data should be protected at all.

- Personal belief that data has a purpose, and that purpose is worth protecting with non-disclosure protections

- Supervisor concession that disclosure of personal data would do more harm than good

- Personal belief that mistakes are made daily, so personal disclosures should not be disruptive

- Personal concession that disclosure of personal data would have instructive value… learning from one's mistakes

- Personal belief that one should be able to face up to errors, but personal concession that many have trouble admitting errors

- Personal belief that accuracy depends on anonymity

- An embarrassing round of errors would cause me to slant my recording of CoQ activities

- Supervisor belief that disclosed personal data would spark disputes over ownership of errors

These concepts resulted from a very limited exposure to a CoQ recording system. It is clear that all problems have not been addressed.

Most comments agree that protecting personal data is important to the process and disclosing personal data would be counterproductive. Remarks at the opposite end of that concept is that concept suggest that, as professionals, we should be able to look our mistakes head on and learn from them… still, at least one remark is qualified by saying that others may not feel that way. Another remark goes still further to describe disputes over blame as another possible consequence of disclosure of personal data.

5.   Would personal CoQ data be of value to a supervisor?

Some remarks addressed the possible value of personal CoQ data if disclosed.

- Personal belief that more effective means exist to rate employees than personal CoQ data

- Supervisor belief that personal data would be useful to supervisors for rating personnel

- Supervisor belief that disclosure of data aggregated to project or office level would be less controversial and, thus, more useful.

One remark suggested that supervisors would find personal CoQ data useful for rating personnel. The context of this remark was that all other things equal. Respondents conceded that things are not all equal.

The other extreme included a remark that suggested personal CoQ data would not be as useful as other means that already exists. The researcher can only speculate that the reasoning is related to other remarks, such as damage done to the recording integrity, or perhaps a reason unrelated to the current discussion, such as direct observation and review of the employee's work product.

Seemingly between the two extremes is the suggestion that personal CoQ data would not be as interesting as aggregated data.   There are other concepts related to this particular one

6.   Why would disclosure of personal CoQ data be undesirable?

Slightly different from "how management might use personal CoQ data", this concept focuses on fear of simple disclosure of CoQ data.

> - Personal fear that major mistakes could be disclosed
> - Personal belief that disclosure of data would be viewed as a direct attack on professional competence

This concept appears to suggest that respondents would be embarrassed at the thought of mistakes… QUANTIFIED mistakes being disclosed for everyone to see. An engineer suggested that such a disclosure might serve to undermine the perception of technical competence. This reinforces the possibility of fear of CoQ data being taken personal. The next remark/concept probably addresses that well.

> - Personal belief that anxiety would be reduced if systems purpose of collecting CoQ data were disclosed with some fanfare

The respondent from whom this remark originated was a harsh critic of the CoQ system as it was presented in the awareness exercise. Still, this was a helpful comment to suggest that by hailing the benefits of such data in a very public way, it might be easier to avoid anxiety and minimize the problem of individual employees perceiving it as personal.

7.   Would individual data be a fair measure of personal performance?

Related to other concepts, these remarks suggest that employees realize an inherent unfairness of personal CoQ data. Both refer to "out-of-control situations.

> - Personal belief that many errors are out of the control of the individual employee and disclosure of data would not be stigmatizing
> - Personal belief that many errors are out of the control of the individual and personal data could be misunderstood if disclosed

The first remark suggests that it should be common knowledge that personal CoQ data would not necessarily reflect a personal weakness, but the failing of other parts of the system. After all, it is common that some mistakes are corrected by others. Would this attitude encourage individuals to exaggerate reports of CoQ activity in order to affect change?

The second remark suggests that it would not be common knowledge that CoQ data, regardless of who records it, usually suggests a failing of the system. Disclosing personal CoQ data would unfairly subject individuals to criticism. This fear might encourage withholding reports on CoQ activities.

Either attitude could be problematic for the CoQ recording process.

8.   Other remarks related to anxiety

Any aspect of a respondent's remarks that point's to anxiety/discomfort to the respondent or perceived to be uncomfortable to others should not be discounted.

- Too much to remember

- Initially, everyone will feel more burdened

- People seek to increase pleasure and decrease pain and, thus, would slant data to avoid blame or other adverse consequences

- People would fudge to make themselves look better

Unrelated to direct personal consequences, but addressing the fear that the CoQ system itself would be difficult to comprehend, the respondent makes a blanket comment that the system is too much to remember.

Also anxiety-related is the notion of extra burden. The comment that a CoQ system would, at least initially, an extra burden. This could be a troublesome indicator because the anxiety related to the extra burden might not diminish, but propagate unless some sort of payoff were evident; a payoff that would tend to clarify the value of the CoQ system and offset the extra burden.

The next two remarks are related in that they demonstrate a basic human response that people tend to seek gratification and avoid adversity. This is a related concept with another theme "veracity". An individual facing exposure of mistakes or other behavior to which ha/she expects scorn of management or fellow employees might tend to diminish the resulting adversity by "fudging" CoQ data. Maintaining personal CoQ data without disclosure is an obvious response to that fear. Although it hasn't been established that it is the correct one.

Definition

Fudge: to tamper with the purpose of deception, exaggerate, distort, present with a bias, slant.

The 7-15 code memo describing recognized concepts in the five code categories were examined and sorted. Those concepts tended to coalesce around broader categories. The grouped concepts that relate to *cognition* are discussed below:

1. Were the number of categories and subcategories manageable?

Categories were the basic Feigenbaum CoQ categories and the subcategories were fashioned from the manufacturing model, and modified for the engineering firm project delivery process. Still, comprehending all 48 subcategories during the awareness exercise may have been overreaching.

- Subcategories were confusing at first but orientation was helpful

- Categories were fine, but there were too many subcategories

- Too many subcategories for the average designer

- Categories alone may be easier to remember

- Large quantity of subcategories okay because not all are used by an individual

- Multiple subcategories were risky because sometimes only small nuances separated one subcategory from another and judgment would vary among individuals

- 48 subcategories are manageable if a grace period for learning is identified and that period is enforced

- Ended up using and becoming familiar with just a few CoQ items

Comments were across the board. Most felt that there were too many subcategories. Some suggested that the only way to internalize the system was to keep only the broad categories. Others recognized that any single employee might only use a few of the subcategories during the performance of their job.

There were some that suggested that 48 subcategories were not overwhelming at all, especially if granted a learning period.

More than one respondent suggested that the 48 subcategories were instructive… that they served to clarify the broad categories. This suggests that the broad categories were seen as more abstract while the subcategories lent a certain degree of practicality or reality.

Still, one respondent made an interesting observation that the descriptions of some subcategories were separated by only small nuances that may have caused unnecessary confusion. Note: This researcher concedes that part of that is true… a rather large part. Sadly, the questionable subcategories separated only by nuances did not occupy the same category but, instead, resided in different broad categories.

2. Did the color guide provide any clarity?

The color guide provided to all awareness exercise participants had very complete descriptions that allowed users to recognize CoQ activities. It listed the title of the subcategory, it's parent category, a basic definition, an extended definition, examples of activities that might be covered by the subcategory. And because it was possible to confuse subcategories, examples of activities that were not covered by the subcategory were also provided. Lastly, the subcategory item was color coded so that it could be easily recognized as belonging to a particular broad category.

- Explanations under each CoQ item made categorization more intuitive

- The cheat sheet that identified likely persons and project phases for different CoQ items was very helpful to identify opportunities to record CoQ

- Descriptions attached to subcategories were instructive and helped select the correct classification, which would not be possible if only broad categories were used

While there were criticisms of two many categories, there were no criticism from study participants that the color guide was anything but helpful. Some respondents expressed positive feedback that the descriptions within the color guide were instructive and lent clarity to the broad categories.

3. Did the recording device make a difference in the process?

A Microsoft access database was used to collect on collate data reported by individual study participants. The tangible connection that study participatants had to the database was a pop-up installed on each participant's workstation that was constructed from visual basic. It permitted participants to select the study project, broad category and the precise CoQ activity (subcategory), and to enter time spent on the activity…. As opposed to the company's official timesheet.

- Separate recording device is much more useful for selecting CoQ items

- Recording device was too complicated… too many buttons and too many steps

- Frustrated because of too many buttons and keystrokes

- Easy to be accurate when CoQ time was recorded on the separate recording device at the same time as the official timesheet

- Separate recording device removes congestion and confusion of CoQ recording on official timesheets

- CoQ time would be missed if official timesheets would be used because of possible closed tasks

- Recording tool is a very efficient way of collecting CoQ data

- Recording tool was easy to use, convenient, and fairly intuitive

- Policy of completing timesheets early would degrade accuracy of CoQ recording

Overwhelmingly, the separate recording device was preferred over the official timesheet. There were several reasons offered by respondents: the device's user friendly design was superior to the official timesheet. Use of the official timesheet would have required that study participants select one of 48 CoQ activities from a virtual task list, whereas the CoQ recording device permitted the user to drill down to the correct activity with fewer keystrokes and delays.

4. Red Herrings?

The interview process was very methodical on the part of the researcher; however, the respondents were not always at ease during the proceedings. It is possible that the respondent felt truly confused, or did not want to feel well versed on the subject, but one person blamed the department for his inability to establish the correct CoQ activity. He claimed that the fact that the source of an error was unknown made the activity difficult to categorize.

- Recording errors was stymied because internal or external character of rework was not normally identified

First, the source of the error was never an issue with recording CoQ; instead, it was whether the error was discovered by individuals outside the company. Second, if the discoverer of the error was truly an issue, it

was easily obtainable information. The statement called into question the respondent's grasp of the CoQ system.

5.   How did you remember to record data?

It was clear from individuals that their personal style in the frequency and delay at which they recorded CoQ data after the CoQ activity was based on their personal style in recording on official timesheets.

- Forgot sometimes, but writing down time to record later was helpful

- Accuracy degraded with the passage of time

- Personal belief that time and category were recorded very accurately

- Personal belief that more than half of CoQ activities were correctly identified and recorded

- Recorded time down to the minute

- Tried to, but didn't catch everything

Some respondents had self-proclaimed to be very accurate. Those individuals also indicated that the update their timesheets very frequently. Others who had more difficultly remembering were also the individuals that neglected their official timesheets until the last minute. In this case, the last minute can be defined as the biweekly close of the timesheet period.

In the case of neglected official timesheets, the individual devoted a great deal of effort near the close of the timesheet period to reconstitute the task/time recordings by any means possible… Email, memos, and time stamps on document files to name a few. There was a strong incentive to populate an official timesheet with billable work. Not so with reporting CoQ activities. Some individuals so much as admitted that their records were less than perfect. It would not be unfair to suspect significant reporting gaps, at least in some individuals.

6.   Did the system overwhelm you?

The orientation delivered to study participants was complete, but for many, it represented a new way of thinking. Either directly or indirectly, respondents made it known whether they had a feeling of being overwhelmed by the process.

- I remember very little about the system

- Too much to remember

- Personal practice of reminding others on the staff to record time, and how much, on a particular subcategory

- Lack of understanding of the system and its benefits would lead to apathy

- Learning how to use the system was a short learning curve

Many admitted to be a bit overwhelmed, but most of those respondents suggested that they simply needed time to familiarize themselves with the system. At least one of the respondents stated that he did not make the effort to acclimate himself to the system. Other the other extreme, one respondent suggested that she would remind others of opportunities to record time and under which activity.

The 7-15 code memo describing recognized concepts in the five code categories were examined and sorted. Those concepts tended to coalesce around broader categories. The grouped concepts that relate to *diligence* are discussed below:

1. *Discuss the extra burden working with the CoQ recording system.*

Inconvenience of working with the CoQ recording system is important, especially considering that it would be incredibly difficult to ascertain staff compliance with any degree of accuracy.

- System is manageable. 30 seconds to record an item won't kill anybody
- Initially, everyone will feel more burdened
- Took way too much time to record time at the end of the day
- Frustrated because of too many buttons and keystrokes
- Process became burdensome over time
- Recording didn't take a lot of time
- Learning how to use the system was a short learning curve
- Searching for correct CoQ item for the first time might be a bit time consuming
- Supervisor belief that recording CoQ would initially be seen as a nuisance or burden

Respondents' opinion with respect to extra burden or inconvenience varied. Some expressed the recording system as easy to operate and not at all a burden. On the opposite end of the spectrum, those who felt overwhelmed by the CoQ system and recording tool felt an incredible burden. Anticipating the resistance by subordinates, Supervisor who responded by characterizing the recording system initially as burden, but less so over time. One respondent who thought of the system as a burden indicated that he would learn to get used to the system if it were imposed by corporate edict.

2. *Would better understanding of the purpose of the CoQ system lead to more involvement?*

Conversation with a few respondents led to the suggestion that understanding of the CoQ system might elevate compliance.

- Lack of understanding of the system and its benefits would lead to apathy
- Regular progress reports, not just at post mortem, would raise awareness and promote compliance

Companion to that principle is the suggestion that regular output of the CoQ system would be critical to keep up awareness of the system. Project accounting provides real time cost data after each official timesheet posts to the system. Perhaps if CoQ data were made available in the same way, awareness of the system could be maintained among individual members of the staff.

3. *What actually happens when a study participant does not record CoQ data diligently?*

Separate and apart from an individual study participants ability to recognize a particular CoQ activity and understand how to record it using the CoQ recording tool is an individual is conscientious enough to actually remember to regularly record data.

- Forgot to enter time sometimes and had to go back and do it later
- Writing it down would permit entering data later

- Only looked at CoQ recording at the end of the day

- Forgot about CoQ activities by the end of the day

One respondent said that he would write down the activity and its duration so that it could be recorded later. Certainly not as reliable as recording the data immediately, but if the notes are not lost, it could be made to work.

Some said that they forgot to record data, but went back to reconstitute the particulars of the activity and record it. This method is considerably less reliable. Not only is there a loss in fidelity with respect to the actual recording that was temporarily forgotten, but this practice might suggest a carelessness where forgotten activities are never recovered.

Finally, one respondent suggested that he plans to record activities at the end of the day, but by that time the activity is forgotten. This is disturbing in light of another respondent who deliberately waited till the end of the day to record data.

4. What do you think about the conscientiousness of others regarding the recording of CoQ activities?

How individual study participants perceive the rate of compliance among others may ultimately become an incentive for their own compliance. Perceived compliance, particularly a long record of compliance, serves to strengthen the culture surrounding the recording of CoQ activities.

Still, some respondents could not gauge the level of compliance among other members of the staff. Perhaps this might suggest that actual recording of CoQ activities become less discreet without actually divulging personal CoQ data.

- No sense as to compliance level of others

- I wouldn't like it if forced to do it, but I would get used to it

- Compliance would be difficult to enforce

- Recording on timesheets would force more compliance

- Without the ability to track non-use, user-initiated recording would mean that many legitimate CoQ activities would be ignored

- May not have time to record CoQ data on separate data entry device but will never lack time to record time on an official timesheet

- Recording CoQ time would have the paycheck incentive where a separate device would not

One respondent who expressed serious dislike for the system still remarked that he would comply with the system if required. This suggests that there are segments of the staff that regard directives as sacred, despite their personal feelings.

While more than one respondent suggested that compliance would be difficult to enforce, one respondent who was a supervisor suggested that by tracking non-use of the recording tool, it might be possible to address staff that ignore the tool over periods that would likely generate CoQ activity.

Another respondent made indirect reference to the "paycheck" incentive, where individuals have a monetary reason for reporting time on an official timesheet, but no such incentive for reporting activities on the CoQ recording tool. In other words, where there may not be time to record time on the CoQ recording tool, there is always time to record time on official timesheets.

5. What did you do to remind yourself about CoQ activities?

Following along with item 3 (above), how respondents prepared themselves, personally, to be able to reliably recognize and record time… the keep the system in full view so that it is not forgotten throughout the day.

- Category jogged my memory more than subcategory

- The cheat sheet that identified likely persons and project phases for different CoQ items was very helpful to identify opportunities to record CoQ

- Entered time on CoQ recording device and official timesheet at the same time

- I mentally track of CoQ activities and record at the end of the day

- I recorded shorter activities right away

Respondents were across the board on this. Some preferred to report time right away, while others waited till the end of the day. While one respondent said that time on official timesheets and the CoQ recording tool were both updated at the same time, most appeared to follow the same pattern… as a trend. In other words, study participants who updated their official timesheets often did not necessarily update their CoQ reporting simultaneously, but were more diligent than other study participants who updated their time less often. Still for those individuals that say that they remembered most of the time reported CoQ time daily.

One respondent pointed to a "cheat sheet" as a means of providing a "heads up" warning. This researcher published to study participants that consisted of a table with all CoQ activities cross-referenced with titles of individuals. By referring to the table, an individual could get guidance as to which activities he/she could ignore and which would very likely be reporting time. It permitted the study participant to be able to focus attention on a much smaller list of CoQ activities.

6. Did the CoQ recording tool promote recording of CoQ data?

The recording tool was not designed to be a dumb instrument, but to reinforce the organization of CoQ activities and to remind study participants of the elements that were important: the activity, the category, and the duration.

- Entered time on CoQ recording device and official timesheet at the same time

- Official timesheets are not user friendly so recording time separately would be easier

- CoQ items would wreak havoc on official timesheets

- Recording CoQ time would have the paycheck incentive where a separate device would not

- May not have time to record CoQ data on separate data entry device but will never lack time to record time on an official timesheet

While some respondents thought the tool was intuitive and easy to use, those that favored the tool appeared to do so because the prospect of recording CoQ data on official timesheets was so unappealing.

Recording on timesheets would force more compliance Most of respondents thought reporting CoQ on official timesheets was a bad idea, suggesting that official timesheets are not as user friendly as the recording tool. One respondent actually said that adding CoQ to the official timesheet would "wreak havoc".

And as in item 4, the "paycheck" incentive associated with official timesheets provides a powerful inducement for individuals to record time that is simply not present on the CoQ recording device. The call from supervisors to submit timesheets will persuade all staff to assemble 80-hours from bits and pieces

The 7-15 code memo describing recognized concepts in the five code categories were examined and sorted. Those concepts tended to coalesce around broader categories. The grouped concepts that relate to *Veracity* are discussed below:

It is important to examine veracity or honesty from two perspectives: (1) from the respondents view of him/herself and (2) from the respondent's perception of other staff members.

1. Could you see yourself slanting or fudging data?

It may seem unreliable to ask an individual as to their own dishonest behavior. The expected response would most certainly that an individual would deny dishonest behavior. However, within the secrecy of a private interview… an interview that purports to discover root causes and avoid pitfalls, an individual might be more inclined to confess pressures the system may place on the truth.

- I would not slant data because I'm inherently honest

- An embarrassing round of errors would cause me to slant my recording of CoQ activities

One conscientious respondent replied very emphatically to the supposition of dishonest pressures that for her, dishonesty was not a problem.

Another respondent thought that mistakes happen all the time and that everyone should be able to take ownership of his own. Still, it was no surprise to this researcher that this respondent also felt that a rare mistake that turned out to be unusually costly would give him pause with respect to reporting. He reluctantly conceded that in such a circumstance, he might be tempted to slant the reported data so as to not look bad.

2. Could you see others slanting or fudging data?

This researcher also asked respondents about their opinion of the honesty of others. Admitting the dishonesty of others might be a way a respondent convey the pitfalls of dishonesty surrounding collecting self-reported CoQ data without implicating themselves in dishonest behavior… a surrogate question of sorts.

- People would be more inclined to report time honestly if it were to remain anonymous

- Personal feelings about a project could play a large role in an employee's decisions to record CoQ

- People seek to increase pleasure and decrease pain and, thus, would slant data to avoid blame or other adverse consequences

- People would fudge to make themselves look better

- To the extent an employee feels burdened by an error will affect how closely or even if an error made by another is recorded

In all cases, respondents admitted the possibility of fraud among their co-workers in varying degrees. Most cited fear of adverse consequences. Another respondent stated it more clearly: maximizing pleasure and avoiding pain. Shining a light on potential mistakes could be perceived as a source of discomfort, especially if it is perceived that personal CoQ data might possibly not remain protected.

Some respondents explained dishonesty as more closely related to how an individual felt about the CoQ process or the project itself. In one opinion, the respondent suggested individuals might exercise selective discretion (fudging) depending how the error affected them personally. In another opinion, the respondent believed that individuals would attempt to "punish" or "reward" an individual project with generous or restrained reporting of CoQ depending on their personal feelings regarding how the actual course of the project.

7-22-2009 Theme Clustering Notes: Quality Awareness

The 7-15 code memo describing recognized concepts in the five code categories were examined and sorted. Those concepts tended to coalesce around broader categories. The grouped concepts that relate to *Quality Awareness* are discussed below:

It is important to examine quality awareness. There may be a link between an individual study participant's quality focus and their attitude towards a CoQ system.

Link between CoQ and quality issues

Respondents were asked their impression of CoQ accounting and its purpose. The responses suggested two things: (1) a level of understanding of the principles behind CoQ, and (2) a level of interest in quality.

- Recording time would call attention to quality activities and promote good quality awareness

- If employees recorded time against errors, they might spend more time doing it right the first time

- System well-suited to the adage "never enough time to do it right, but always enough time to do it over"

- CoQ can be used to maximize efficiency

- The concept of CoQ is not realistic, at least as it relates to architecture

- The costs borne by the client is a rather large part of the CoQ

One respondent correctly noted that client costs are legitimate costs of quality. It is a rather advanced concept advocated by Genichi Taguchi that quality costs include the cost to society.

Several respondents suggested that the CoQ recording process would be valuable because it would serve to remind individuals about quality. The resulting higher awareness could serve to improve quality overall.

Several respondents express a variation on the theme of "doing it right the first time" and that this CoQ system would do well if it exposed the problems in this area.

On respondent did not believe that CoQ was a credible system, at least insofar as his own discipline was concerned.

Other quality issues

Respondents used the opportunity of their interview to express other opinions on quality.

- Quality work is the best marketing tool

- Retaining clients is cheaper than acquiring new ones

- It is frustrating to do a technical task more than once… for whatever the reason

Many respondents expressed the need for a customer focus. Others spoke in general about their frustrations at having to perform technical tasks more than once.

1. Uses of CoQ data

Some respondents pointed out how useful finished CoQ data might be and suggested uses for it. The uses were not out of the ordinary, but demonstrated a basic level of understanding with respect to CoQ. Estimating future work normally involves guessing a level of mistakes that, up to now, was not part of the conversation.

- Historical CoQ data would be useful in fee estimating

- Many CoQ items are not generally part of fee estimates

- CoQ could be valuable in identifying expensive areas or activities

2. Critique of quality at the Company

Impressions of quality by individual respondents were not terrible, but were not great. The company does not pay enough attention to quality in projects because of the construction administration issues we address

- Room for improvement does not mean that work is sloppy

The level of construction administration issues are a window into constructions' problems generated in the design phase. One respondent try to make it clear that, as a company, we have good quality, but that there is enormous room for improvement.

3. Systems perspective

Probably more important than any other expression of quality awareness is the individual's ability to demonstrate systems thinking.

- There is value is a system approach to quality rather that the sole reliance of checking
- Performance of the system is really separate and apart from the overall performance of any individual employee
- Supervisor belief that CoQ data aggregated over an entire group is much more interesting that individual data

4. Thoughts on Checking and other appraisal

One of the more important attitudes to examine is the study participants' perspective of the checking process. Deming and other quality giants placed a great deal of emphasis on the ultimate elimination on appraisal as a means of injecting quality.

- It is obvious that if you don't perform checking, you're in trouble
- The first check identifies 70% of the problems, the second check identifies another 20%, and the third pass yields another 5%
- The last 5% of errors is beyond most processes
- A checker doesn't normally have the specific knowledge of project conditions to do a thorough review
- It is incumbent on the employee to check his own work in order for the checking process to work

Most opinion was slanted towards checking and reviews as a means of raising the quality level of the finished product. One respondent identified checking as an iterative process that requires several passes in order to raise the level of quality to an acceptable level. The same respondent suggested that checking to remove the final 5% of errors would not be economic. While in principle, checking one's own work seems like an obvious way of improving quality, there appears to be an obsession with checking to the exclusion of all else. The focus on checking may obscure solutions that could be easier and cheaper from a systems perspective. Why there is a focus on individuals rather than the system is not clear.

5. Comparison of engineering and manufacturing business models

Some respondents defended the state of quality in engineering firms as the natural result of the engineering business model.

- Engineering cannot be evaluated with time and motion studies as can manufacturing

- While there are repetitive processes, engineering and architecture projects are all unique and, thus, ripe for error

One respondent correctly pointed out that engineering work may consist of repetition of many technical processes; those processes appear in varied ways and varied orders of appearance within engineering projects and, thus, could not be finely tuned to eliminate error. Another respondent lamented the mechanics of engineering work and that it did not lend itself well to time and motion studies in the same way as manufacturing firms.

6. Thought on quality audits

The quality audit is a cornerstone of the quality process at the company. According to a respondent, the quality audit is a means of ensuring that design projects adhere to the company's quality procedures. One respondent who performs quality audits finds the process a bit of a "false front".

First, the audit is reactive. The respondent stated that projects selected for audit are complete or in their final hours. Audit findings do not raise the quality level of the audited project, but merely identify the project's level of compliance. The selection process is biased towards larger projects. This means smaller projects have less chance of any objective scrutiny.

- Quality audits confirm that the quality process has been applied to a project, not whether there is a quality project
- Shorter projects are not normally selected for audit
- A system where the employees buy into quality is a bit of a false front
- Quality audits never distinguish high or low quality projects, only whether staff conformed to the quality process

The respondent suggests that audits are not designed to distinguish between the quality levels among design projects; merely a confirmation that staff conformed to published quality processes. Since quality processes are appraisal-based, they are limited in how they can transform quality.

7. Communication issues

Lastly, comments from respondents addressed communication in small part.

- Project managers don't share information with the staff regarding lessons learned from construction administrators
- Principle disciplines should communicate when the design is in its earliest stages before there is a huge commitment in drafting time
- I review lessons learned from last year's projects and go over it with people working on my projects
- I sit down and make preliminary lists… I make lists of the equipment, I make lists of anything special, I make lists of details, I make lists of schedules… it's all preliminary and it's all the first week of the project

Communication issues came from several quarters: (1) between construction staff and design staff, (2) between project management and project staff, (3) between staffs of different disciplines, (4) and between current work and lessons learned from previous work.

One respondent described how she used lessons learned to plan current work. Her story on design planning is interesting because it describes an effective means of providing quality that does not involve checking/appraisal.

The coding memo from the Group 1 interviews collates respondents' remarks in the following categories: anxiety, cognition, diligence, veracity, and quality awareness. As the coding progressed, this researcher noticed a pattern that suggested an additional property: *self awareness.*

I found a fairly interesting pattern between several respondents having to do with ostensibly conflicting statements that would call into question the veracity of a respondent during the interview, or at least a distorted perspective.

Keep in mind that drafters receive instructions from engineers and architects. Engineers and architects provide technical solutions to real world problems, and drafters depict those solutions graphically. The following are quotes from a respondent drafter:

- I probably did most of my stuff to the "rework internal errors" activity; it was back-check things; changes that the architect would make that would cause us to change our plans; or just plain mistakes that the engineer had to redo which therefore I had to redo.

- It would just take more time to learn what categories are and who initiated the change.

- You make mistakes every day. As long as it's not an extremely expensive mistake, it's not that big a deal. I mean if it's five or ten minutes, that's not going to hurt anybody.

Nowhere in this discussion (or any other part of the interview) does this drafter confess an error that required fix time… placing the blame, instead, on engineers, architects, or other persons unknown.

In the following, an architect speaks of the nature of errors. He does not describe his own errors but describes an incident where he was 'forced' to perform error-prone work conceived by others.

- I realized when I worked in the building trades, and you realized something was built incorrectly, and on Monday you put in a wall, and on Tuesday the boss says 'take it out'… If people doing the thinking on the front end can get it right, then you can avoid paying three times, putting the wall up in the wrong place.

- Their boss is the one that made the screw-up, which is just as likely to be told to do the wrong thing, and you say, 'he's the boss, he knows what he's doing, he's leading the way, leading the show', and then the next week you've got to undo.

One respondent who was a designer suggested that he/she did not charge to error activities because he/she only checked plans. Despite the fact that she directs the actions of drafters, this statement suggests that only the drafter make the mistakes.

- I didn't use the ones for correcting errors because I was usually doing the checking on it

And finally, an engineer discusses an error at length, but in the end, places the blame squarely on the indecisiveness of the authority having jurisdiction.

- And that was more of an error on the part of the authority having jurisdiction.

- I think that others may tend to seek something that would detour blame or detour the mistake and see if there was another method of placing elsewhere instead of themselves.

Interestingly, this respondent describes the mental process at work for this phenomenon of deflecting responsibility.

It is not clear at this point if this phenomenon suggests that staff may not recognize their own mistakes and therefore not record them, or they will simply deny responsibility.

APPENDIX L

CREDIBILITY SURVEYS OF SIGNIFICANT STATEMENTS

ASSESSMENT OF AGREEMENT AMONG PARTICIPANTS

In this analysis, the agreement among study participants will be calculated by standard deviation (SD$_X$) to index agreement.

The standard deviation is calculated by:

(1)
$$SD_M = \sqrt{\sum_{k=1}^{K} \frac{\left(X_k - \overline{X}\right)^2}{K-1}}$$
standard deviation about the mean rating

The standard error in which to establish 95% confidence interval about the mean rating is calculated by:

(2)
$$SE_M = \frac{SD_M}{\sqrt{K}}$$
standard error

where

K = Number of participants who responded to the statement

X_k = Rating of the kth participant who responded to the statement

$\overline{X}$ = Mean rating of all participants who responded to the statement

CONSENSUS

Response less than 3 indicates agreement and a response greater than 3 indicates disagreement. Consensus will be judged according to the following:

(3)   **AGREEMENT** → MEAN RESPONSE + STANDARD ERROR < 3

(4)   **DISAGREEMENT** → MEAN RESPONSE - STANDARD ERROR > 3

(3)   **WEAK AGREEMENT** →   MEAN RESPONSE < 3,
                        BUT NOT: MEAN RESPONSE + STANDARD ERROR < 3

(3)   **WEAK DISAGREEMENT** →   MEAN RESPONSE > 3,
                        BUT NOT: MEAN RESPONSE - STANDARD ERROR > 3

PARTICIPANT JUDGE GROUP 1

		Q53	L24	B11	D21	S24	H67	R88	L38	F33	R98	N72	P54	H50	Q60	G35	E98	K	mean	SD$_X$	SE$_M$	
	total	98	97	90	90	96	98	86	88	98	97	98	63	98	97	98	89					
1	1	2	4	2	2	2	2	1	2	2	2	2	3	2	2	2	1	16	2.1	0.7	0.2	AGREE
	2	3	1	2	2	2	1	2	4	4	3	3	2	4	4	5	2	16	2.8	1.2	0.3	WEAK AGREE
	3	4	1	1	4	2	1	4	2	1	4	4	2	4	3	2	4	16	2.7	1.3	0.3	WEAK AGREE
	4	2	2	1	2	1	1	1	1	1	2	3	1	2	1	1	1	16	1.4	0.6	0.2	AGREE
	5	2	4	2	2	2	2	2	2	2	4	2	-	2	1	2	3	15	2.3	0.8	0.2	AGREE
	6	2	2	2	2	2	4	4	2	5	2	4	4	4	4	1	2	16	2.9	1.2	0.3	WEAK AGREE
	7	2	4	1	2	2	2	3	1	3	2	1	2	2	1	1	5	16	2.1	1.1	0.3	AGREE
	8	2	1	1	4	1	1	2	2	1	3	2	-	4	1	1	5	15	2.1	1.3	0.3	AGREE
	9	3	2	1	4	2	5	3	2	5	2	4	-	4	5	4	4	15	3.3	1.3	0.3	WEAK DISAGREE
	10	3	2	2	4	1	5	4	5	5	3	5	-	4	5	5	3	15	3.7	1.3	0.3	DISAGREE
	11	4	3	4	4	1	2	1	1	2	3	1	-	2	1	5	3	15	2.5	1.4	0.4	AGREE
	12	4	4	3	4	2	3	-	-	5	3	5	-	4	5	5	5	13	4.0	1.0	0.3	DISAGREE
2	13	2	3	4	2	4	2	2	2	1	1	1	-	2	2	2	1	15	2.1	1.0	0.2	AGREE
	14	2	5	2	4	2	3	2	1	4	2	2	-	2	2	1	1	15	2.3	1.2	0.3	AGREE
	15	2	4	2	2	2	2	2	1	1	1	2	-	2	2	1	1	15	1.8	0.8	0.2	AGREE
	16	2	2	1	2	1	2	4	1	2	2	2	2	2	2	1	1	16	1.8	0.8	0.2	AGREE
3	17	2	3	1	2	1	2	4	1	1	1	2	-	2	1	1	1	15	1.7	0.9	0.2	AGREE
	18	3	4	4	5	2	2	3	4	4	5	4	-	4	5	5	4	15	3.9	1.0	0.3	DISAGREE
	19	2	2	2	2	2	3	1	1	1	3	1	-	2	1	1	1	15	1.7	0.7	0.2	AGREE
	20	2	2	2	2	2	4	2	1	1	2	2	-	2	1	1	1	15	1.8	0.8	0.2	AGREE
	21	2	2	4	2	2	2	1	1	1	1	1	-	2	1	1	2	15	1.7	0.8	0.2	AGREE
	22	4	5	4	4	4	5	5	4	4	2	5	-	4	1	2	2	15	3.7	1.3	0.3	DISAGREE
	23	4	2	2	2	1	2	2	2	1	2	2	-	4	1	1	2	15	2.0	0.9	0.2	AGREE
	24	3	1	2	2	1	2	2	2	1	2	1	-	4	1	1	2	15	1.8	0.9	0.2	AGREE
	25	2	5	1	4	4	4	2	4	5	4	2	-	4	5	2	3	15	3.4	1.3	0.3	DISAGREE
	26	2	3	4	4	2	4	5	2	1	2	1	-	2	1	1	1	15	2.3	1.3	0.3	AGREE
	27	2	2	2	2	1	1	5	1	1	2	1	-	2	1	1	1	15	1.7	1.0	0.3	AGREE
	28	3	1	4	-	-	4	-	-	1	-	4	-	2	1	1	-	9	2.3	1.4	0.5	AGREE
4	29	3	3	3	4	1	4	4	4	4	3	4	5	4	4	4	4	16	3.6	0.9	0.2	DISAGREE
	30	4	3	4	5	1	4	2	4	4	4	5	4	4	5	2	5	16	3.8	1.2	0.3	DISAGREE
	31	4	2	-	-	1	4	-	-	2	2	4	2	2	2	1	-	11	2.4	1.1	0.3	AGREE
	32	2	-	-	-	4	3	-	-	2	5	4	3	3	5	2	-	10	3.3	1.2	0.4	WEAK DISAGREE
	33	2	3	-	-	2	2	-	-	2	1	2	1	2	1	1	-	11	1.7	0.6	0.2	AGREE
	34	2	2	-	-	2	5	-	-	2	1	2	3	4	1	1	-	11	2.3	1.3	0.4	AGREE
	35	2	2	-	-	2	4	-	-	2	1	1	2	2	1	2	-	11	1.9	0.8	0.3	AGREE
	36	2	1	-	-	1	2	-	-	4	1	1	3	2	3	1	-	11	1.9	1.0	0.3	AGREE
5	37	4	3	4	4	2	1	2	1	4	3	2	2	2	1	1	4	16	2.5	1.2	0.3	AGREE
	38	2	3	2	4	5	4	4	4	4	2	5	4	2	4	2	5	16	3.6	1.1	0.3	DISAGREE
	39	2	5	2	2	4	2	1	3	2	2	2	2	2	5	2	1	16	2.5	1.2	0.3	AGREE
	40	3	4	4	4	4	4	4	4	4	3	2	4	4	5	2	4	16	3.7	0.8	0.2	DISAGREE
	41	5	3	5	4	2	4	4	2	4	3	4	4	2	5	1	5	16	3.6	1.3	0.3	DISAGREE
	42	2	2	4	2	2	4	2	2	3	2	3	2	2	5	2	2	16	2.6	1.0	0.2	AGREE
	43	3	2	4	4	1	4	3	2	2	2	4	2	4	4	2	4	16	2.9	1.1	0.3	WEAK AGREE
	44	2	4	4	5	2	5	2	5	2	3	4	4	4	5	1	4	16	3.5	1.3	0.3	DISAGREE
	45	3	3	4	5	2	5	5	5	2	2	5	4	4	4	5	3	16	3.8	1.2	0.3	DISAGREE
	46	2	3	1	2	-	2	1	1	2	1	2	2	2	1	1	4	15	1.8	0.9	0.2	AGREE
	47	3	3	4	4	1	5	4	5	4	3	5	5	4	5	4	5	16	4.0	1.1	0.3	DISAGREE
	48	2	3	4	4	1	4	1	1	2	2	2	2	3	5	1	1	16	2.4	1.3	0.3	AGREE
	49	2	3	4	2	1	1	2	1	2	2	1	3	2	1	1	1	16	1.8	0.9	0.2	AGREE
	50	2	3	2	4	2	2	2	1	2	2	2	3	2	3	2	4	16	2.4	0.8	0.2	AGREE
	51	2	2	2	2	1	1	1	1	2	3	1	-	2	4	1	2	15	1.8	0.9	0.2	AGREE
	52	2	3	4	4	1	1	2	2	4	5	1	-	2	5	1	2	15	2.6	1.5	0.4	AGREE
	53	2	5	2	2	5	4	5	5	2	3	2	-	4	5	5	5	15	3.7	1.4	0.4	DISAGREE

PARTICIPANT JUDGE GROUP 1

		Q53	L24	B11	D21	S24	H67	R88	L38	F33	R98	N72	P54	H50	Q60	G35	E98	K	mean	SD$_X$	SE$_M$	
total		98	97	90	90	96	98	86	88	98	97	98	63	98	97	98	89					
6	54	2	5	2	2	1	1	1	2	2	4	2	-	2	5	1	4	15	2.4	1.4	0.4	AGREE
	55	4	3	2	2	5	4	2	2	2	2	2	-	2	-	1	2	14	2.5	1.1	0.3	AGREE
	56	2	4	2	4	2	5	5	4	4	2	3	-	4	2	1	1	15	3.0	1.4	0.4	WEAK DISAGREE
	57	2	2	4	5	5	4	4	2	4	3	2	-	4	2	2	2	15	3.1	1.2	0.3	WEAK DISAGREE
	58	2	4	4	4	1	5	1	4	2	5	4	-	4	5	4	5	15	3.6	1.4	0.4	DISAGREE
	59	2	4	2	-	2	5	4	2	4	2	2	-	2	1	2	2	14	2.6	1.2	0.3	AGREE
	60	4	2	2	4	5	1	5	5	1	3	2	-	4	2	4	3	15	3.1	1.4	0.4	WEAK DISAGREE
	61	2	3	2	2	4	1	2	2	5	2	2	-	2	4	5	2	15	2.7	1.2	0.3	AGREE
7	62	4	3	2	4	5	2	3	2	2	3	2	-	2	1	2	1	15	2.5	1.1	0.3	AGREE
	63	3	2	2	2	2	4	5	2	2	2	1	-	2	1	1	2	15	2.2	1.1	0.3	AGREE
	64	2	2	2	4	1	2	1	2	2	2	2	2	2	1	1	2	16	1.9	0.7	0.2	AGREE
	65	4	4	4	4	4	2	1	4	5	4	4	-	4	5	5	3	15	3.8	1.1	0.3	DISAGREE
	66	3	2	-	2	5	4	-	-	2	2	2	2	2	2	2	-	12	2.5	1.0	0.3	AGREE
	67	4	2	2	3	2	2	1	2	2	2	3	2	2	4	4	5	16	2.6	1.1	0.3	AGREE
8	68	4	2	2	5	1	2	-	2	4	2	2	2	2	4	1	3	15	2.5	1.2	0.3	AGREE
	69	2	2	2	2	2	3	-	4	2	2	1	1	2	2	1	3	15	2.1	0.8	0.2	AGREE
	70	2	2	3	4	4	1	1	1	1	3	4	1	4	4	4	2	16	2.6	1.3	0.3	AGREE
	71	2	4	4	4	2	3	5	4	1	3	2	4	2	5	1	3	16	3.1	1.3	0.3	WEAK DISAGREE
	72	4	3	3	4	2	4	2	1	1	5	4	3	3	5	5	5	16	3.4	1.4	0.3	DISAGREE
	73	2	3	4	4	1	4	1	2	2	4	4	2	4	5	2	4	16	3.0	1.3	0.3	WEAK DISAGREE
	74	2	3	4	5	2	4	3	4	4	4	4	2	4	5	3	3	16	3.5	1.0	0.2	DISAGREE
9	75	1	2	2	2	2	2	2	4	2	3	4	2	2	4	1	2	16	2.3	0.9	0.2	AGREE
	76	2	2	2	2	2	1	3	1	2	1	2	1	2	1	1	2	16	1.7	0.6	0.2	AGREE
	77	2	3	4	4	4	4	2	4	4	5	5	5	4	5	4	4	16	3.9	0.9	0.2	DISAGREE
	78	2	3	3	2	1	4	2	5	2	1	4	3	3	4	1	2	16	2.6	1.2	0.3	AGREE
	79	2	4	4	4	5	5	1	2	4	2	5	2	4	5	2	4	16	3.4	1.4	0.3	DISAGREE
10	80	2	2	2	2	2	2	1	2	2	2	1	1	2	1	1	2	16	1.7	0.5	0.1	AGREE
	81	2	3	2	2	2	3	5	2	4	2	2	1	2	1	1	4	16	2.4	1.1	0.3	AGREE
	82	2	2	4	4	4	5	5	1	4	3	2	1	4	1	1	3	16	2.9	1.5	0.4	WEAK AGREE
	83	2	4	2	2	2	2	2	3	2	3	2	1	2	1	2	2	16	2.1	0.7	0.2	AGREE
	84	4	1	2	4	3	3	4	2	3	3	4	2	2	2	2	2	16	2.7	0.9	0.2	AGREE
	85	4	1	4	4	2	2	4	4	4	4	5	5	4	5	5	4	16	3.8	1.2	0.3	DISAGREE
	86	2	4	2	2	3	4	4	4	3	2	2	3	4	4	1	2	16	2.9	1.0	0.3	WEAK AGREE
	87	2	2	2	2	2	2	1	3	2	2	1	2	2	5	1	2	16	2.1	0.9	0.2	AGREE
	88	2	1	-	2	2	2	-	-	2	3	2	2	2	2	1	-	12	1.9	0.5	0.1	AGREE
11	89	2	1	2	1	1	1	1	1	2	1	4	1	1	1	1	1	16	1.4	0.8	0.2	AGREE
	90	4	1	2	2	1	1	4	2	2	5	2	1	2	2	2	1	16	2.1	1.2	0.3	AGREE
	91	2	4	2	2	2	2	3	2	2	2	1	1	2	1	1	3	16	2.0	0.8	0.2	AGREE
	92	4	2	2	2	2	1	4	1	2	4	4	2	4	1	1	3	16	2.4	1.2	0.3	AGREE
	93	2	1	2	1	2	2	2	2	2	3	2	2	4	2	1	1	16	1.9	0.8	0.2	AGREE
	94	3	4	2	5	2	2	3	2	2	4	4	1	4	2	1	3	16	2.8	1.2	0.3	WEAK AGREE
	95	2	1	1	1	2	3	2	1	1	1	1	1	1	1	1	1	16	1.3	0.6	0.2	AGREE
	96	4	2	2	4	3	2	4	3	2	1	2	1	2	1	1	3	16	2.3	1.1	0.3	AGREE
	97	2	4	1	4	1	4	4	2	1	1	2	1	2	4	2	4	16	2.4	1.3	0.3	AGREE
	98	2	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	16	1.1	0.3	0.1	AGREE

Standard deviation refers to the amount you expect an individual measurement to vary from the average.

Standard error of the mean is how much you expect a value averaged from several measurements to vary from the true mean.

PARTICIPANT JUDGE GROUP 2

		M53	S12	H67	L38	F33	N72	P54	H50	G35	K	mean	SD_X	SE_M	
	total	6	6	6	6	6	6	6	6	6					
STATEMENT 12	99	1	2	2	1	4	2	1	4	2	9	2.1	1.2	0.4	AGREE
	100	2	2	2	2	2	2	2	2	4	9	2.2	0.7	0.2	AGREE
	101	2	1	2	2	1	1	2	1	1	9	1.4	0.5	0.2	AGREE
	102	2	4	2	2	1	2	5	2	1	9	2.3	1.3	0.4	AGREE
	103	2	1	1	2	2	2	2	2	1	9	1.7	0.5	0.2	AGREE
	104	2	1	1	2	4	2	2	1	1	9	1.8	1.0	0.3	AGREE

Significant Statements (Group 1 and Group 2)

There were 48 cost-of-quality activities to which you could record your time during the study. For some, understanding all 48 may have been a problem. Indicate whether you agree or disagree with the following statements that relate to the descriptions of the 48 cost-of-quality activities found in the color guide and your ability to apply them to your own activities during the study.

#	Statement									
1	*I found the activity descriptions to be confusing at first, but the orientation session was helpful and clarified many of my concerns*									
	agree	mean =	2.1	K=	16	SD_x =	0.7	SE_x =	0.2	
2	*I found that the 5 broad categories were easy to understand, but there were too many individual cost-of-quality activities for me to comprehend*									
	weak agree	mean =	2.8	K=	16	SD_x =	1.2	SE_x =	0.3	
3	*There were too many activities for the average designer to understand*									
	weak agree	mean =	2.7	K=	16	SD_x =	1.3	SE_x =	0.3	
4	*The 5 broad categories were easier to understand*									
	agree	mean =	1.4	K=	16	SD_x =	0.6	SE_x =	0.2	
5	*I was not intimidated by the 48 individual cost-of-quality activities because I only needed to focus a few of them*									
	agree	mean =	2.3	K=	15	SD_x =	0.8	SE_x =	0.2	
6	*I found some of the activity descriptions were confusing because only small nuances separated one description from another so how an activity would be classified would vary between individuals*									
	weak agree	mean =	2.9	K=	16	SD_x =	1.2	SE_x =	0.3	
7	*With a short grace period, I think that I could learn all I needed to know about applying the cost-of-quality activities to my own work*									
	agree	mean =	2.1	K=	16	SD_x =	1.1	SE_x =	0.3	
8	*I ended up reporting only a few of the 48 available activities*									
	agree	mean =	2.1	K=	15	SD_x =	1.3	SE_x =	0.3	
9	*It was difficult to correctly classify my activities because it was not always clear to me whether my rework was due to an internal or external mistake*									
	weak disagree	mean =	3.3	K=	15	SD_x =	1.3	SE_x =	0.3	
10	*By the time I got to where I thought I should be reporting cost-of-quality activities, I remembered very little about what I learned in the orientation session*									
	disagree	mean =	3.7	K=	15	SD_x =	1.3	SE_x =	0.3	
11	*On balance, I correctly identified and reported more than half of my activities that matched one or more of the listed cost-of-quality activities*									
	agree	mean =	2.5	K=	15	SD_x =	1.4	SE_x =	0.4	
12	*Since I only normally only check plans, I didn't report any time to error activities*									
	disagree	mean =	4.0	K=	13	SD_x =	1.0	SE_x =	0.3	

You were provided a color guide with descriptions of 48 cost-of-quality activities from which you were to refer when recording data. In addition, you received a "cheat sheet" listing each activity and identifying persons most likely to encounter them. This way, you could focus only on the activities that you were most likely to encounter and avoid the other activities. Indicate whether you agree or disagree with the following statements related to how the color guide and cheat sheet may have helped you during the study.

#	Statement									
13	*Explanations under each activity in the color guide made classifying my own work much easier*									
	agree	mean =	2.1	K=	15	SD_x =	1.0	SE_x =	0.2	
14	*I referred to the cheat sheet to help me focus only on the activities that would affect me during the project*									
	agree	mean =	2.3	K=	15	SD_x =	1.2	SE_x =	0.3	

15	*The descriptions of the activities in the color guide were instructive and helped me select the correct activity*							
	agree	mean =	1.8	K=	15	SD_x =	0.8	SE_x =	0.2
16	*Without the color guide's descriptions of the individual activities, I may not have been able to correctly select the correct category from among the 5 broad categories.*							
	agree	mean =	1.8	K=	16	SD_x =	0.8	SE_x =	0.2

Rather than record time on a company timesheet, the study used a separate means of recording data. A network database designed to collect and sort data recorded by you, the individual study participant devised. Your tangible connection to the database was a recording tool in the form of a pop-up installed on your workstation. It permitted you to select the individual cost-of-quality activity, and to record the time spent on that activity. Indicate whether you agree or disagree with the following statements related to how the desktop recording tool affected your experience recording data during the study.

17	*I found the separate recording tool to be useful for selecting and recording cost-of-quality activities*							
	agree	mean =	1.7	K=	15	SD_x =	0.9	SE_x =	0.2
18	*The recording tool was too complicated… too many buttons and too many steps*							
	disagree	mean =	3.9	K=	15	SD_x =	1.0	SE_x =	0.3
19	*If I had to record cost-of-quality activities on the company timesheet, some activities might not have been reported because some project tasks close before work was complete*							
	agree	mean =	1.7	K=	15	SD_x =	0.7	SE_x =	0.2
20	*Recording tool was easy to use, convenient, and fairly intuitive*							
	agree	mean =	1.8	K=	15	SD_x =	0.8	SE_x =	0.2
21	*If I had to record cost-of-quality activities on the company timesheet, some activities might not have been reported because I have to complete the company timesheet before the end of the timesheet period*							
	agree	mean =	1.7	K=	15	SD_x =	0.8	SE_x =	0.2
22	*I recorded my cost-of-quality activities down to the minute*							
	disagree	mean =	3.7	K=	15	SD_x =	1.3	SE_x =	0.3
23	*My learning curve for using the recording tool was very short*							
	agree	mean =	2.0	K=	15	SD_x =	0.9	SE_x =	0.2
24	*Using the recording tool took very little time*							
	agree	mean =	1.8	K=	15	SD_x =	0.9	SE_x =	0.2
25	*Using the recording tool for the first time was way too time consuming*							
	disagree	mean =	3.4	K=	15	SD_x =	1.3	SE_x =	0.3
26	*recording time on the separate recording tool was easier because the company timesheet is not particularly user-friendly*							
	agree	mean =	2.3	K=	15		1.3	SE_x =	0.3
27	*If I didn't have the separate recording tool, I think that recording cost-of-quality activities on my company timesheet would be very messy*							
	agree	mean =	1.7	K=	15	SD_x =	1.0	SE_x =	0.3
28	*As a supervisor, I know that time charged to cost-of-quality activities might cause a problem if clients saw them on timesheet records that are seen by clients*							
	agree	mean =	2.3	K=	9	SD_x =	1.4	SE_x =	0.5

Despite its benefits, a cost-of-quality system asks participants to report their time spent on activities, some of which include time spent correcting mistakes. Indicate whether you agree or disagree with the following statements that refer to your thoughts on personally-recorded cost-of-quality data in the hands of your supervisor and other management.

29	*I'm not worried because I don't think that my personally-recorded data, or the cost-of-quality system, would have any value*							
	disagree	mean =	3.6	K=	16	SD$_x$ =	0.9	SE$_x$ =	0.2
30	*As a supervisor, I believe that disclosing personally-recorded data would undermine the cost-of-quality system and, ultimately, do more harm than good*							
	disagree	mean =	3.8	K=	16	SD$_x$ =	1.2	SE$_x$ =	0.3
31	*As a supervisor, I would find personally-recorded cost-of-quality data to be useful as I process performance reviews for my subordinates*							
	agree	mean =	2.4	K=	11	SD$_x$ =	1.1	SE$_x$ =	0.3
32	*As a supervisor, I believe that personally-recorded data is a critical component of cost-of-quality system and I believe that protecting the anonymity of the individual staff member that records his/her activities serves that purpose*							
	weak disagree	mean =	3.3	K=	10	SD$_x$ =	1.2	SE$_x$ =	0.4
33	*As a supervisor, I believe that disclosure of personally-recorded cost-of-quality data might cause unnecessary conflicts over ownership of errors*							
	agree	mean =	1.7	K=	11	SD$_x$ =	0.6	SE$_x$ =	0.2
34	*As a supervisor, I know that there are more effective means to rank employees than using their personally-recorded cost-of-quality data*							
	agree	mean =	2.3	K=	11	SD$_x$ =	1.3	SE$_x$ =	0.4
35	*As a supervisor, I believe that aggregated data (data collected from many individuals) would be considerably more useful than personally-recorded data that is traceable to a single individual*							
	agree	mean =	1.9	K=	11	SD$_x$ =	0.8	SE$_x$ =	0.3
36	*Since I only normally only check plans, I didn't report any time to error activities*							
	agree	mean =	1.9	K=	11	SD$_x$ =	1.0	SE$_x$ =	0.3

Indicate whether you agree or disagree with the following statements that refer to whether or not you believe that your personally-recorded data should be protected.

37	*Everyone makes mistakes; my personally-recorded data should not be a cause for concern*							
	agree	mean =	2.5	K=	16	SD$_x$ =	1.2	SE$_x$ =	0.3
38	*I'm not concerned at all because I don't think that it's possible to abuse my personally-recorded data*							
	disagree	mean =	3.6	K=	16	SD$_x$ =	1.1	SE$_x$ =	0.3
39	*If my personally-recorded error activities were disclosed, it might help others avoid my mistakes*							
	agree	mean =	2.5	K=	16	SD$_x$ =	1.2	SE$_x$ =	0.3
40	*I fear that personally-recorded data might reveal the magnitude of a major mistake for which I was responsible*							
	agree	mean =	3.7	K=	16	SD$_x$ =	0.8	SE$_x$ =	0.2
41	*Mistakes are made every day; as long as it's not an extremely expensive mistake, it's not a big deal.*							
	agree	mean =	3.6	K=	16	SD$_x$ =	1.3	SE$_x$ =	0.3
42	*I suspect that my personally-recorded data could somehow be abused*							
	agree	mean =	2.6	K=	16	SD$_x$ =	1.0	SE$_x$ =	0.2
43	*I believe that management would use personally-recorded cost-of-quality data to rate and rank employees during the salary review process*							
	weak agree	mean =	2.9	K=	16	SD$_x$ =	1.1	SE$_x$ =	0.3
44	*We should all be able to admit our own mistakes, but I might, on occasion, have trouble owning up to my own errors*							
	disagree	mean =	3.5	K=	16	SD$_x$ =	1.3	SE$_x$ =	0.3
45	*I believe that disclosure of personally-recorded cost-of-quality data would be viewed as a direct challenge to my professional competence*							
	disagree	mean =	3.8	K=	16	SD$_x$ =	1.2	SE$_x$ =	0.3

46	*Since many of the errors that I correct are out of my control, I should not be stigmatized if I report error activities*								
	agree	mean =	1.8	K=	16	SD$_x$ =	0.9	SE$_x$ =	0.2
47	*I believe that personally-recorded cost-of-quality data would be used as a "whipping tool" to control employee behavior*								
	disagree	mean =	4.0	K=	16	SD$_x$ =	1.1	SE$_x$ =	0.3
48	*I would be much more candid in recording cost-of-quality activities if my personal data remained anonymous*								
	agree	mean =	2.4	K=	16	SD$_x$ =	1.3	SE$_x$ =	0.3
49	*I might be considerably less suspicious that someone might misuse my personally-recorded data if the company made the purpose of the cost-of-quality system very clear*								
	agree	mean =	1.8	K=	16	SD$_x$ =	0.9	SE$_x$ =	0.2
50	*Since many of the errors that I correct are out of my control, my personally-recorded error activities might be misunderstood if they were disclosed to management*								
	agree	mean =	2.4	K=	16	SD$_x$ =	0.8	SE$_x$ =	0.2

How did you remember to report your activities? Personal styles differed quite a bit. Indicate whether you agree or disagree with the following statements related to your personal style in remembering to record your own cost-of-quality activities.

51	*I tried, but I couldn't catch every cost-of-quality activity*								
	agree	mean =	1.8	K=	15	SD$_x$ =	0.9	SE$_x$ =	0.2
52	*My accuracy went down the longer it took me to record my cost-of-quality activities*								
	agree	mean =	2.6	K=	15	SD$_x$ =	1.5	SE$_x$ =	0.4
53	*I reminded others to record time when I found a cost-of-quality activity that affected more than just me*								
	disagree	mean =	3.7	K=	15	SD$_x$ =	1.4	SE$_x$ =	0.4
54	*I forgot to record data sometimes*								
	agree	mean =	2.4	K=	15	SD$_x$ =	1.4	SE$_x$ =	0.4
55	*When I forgot to record an activity immediately, I would sometimes go back and reconstruct the information on my cost-of-quality from memory*								
	agree	mean =	2.5	K=	14	SD$_x$ =	1.1	SE$_x$ =	0.3
56	*Writing notes to myself helped me to remember to record the activity later*								
	weak disagree	mean =	3.0	K=	15	SD$_x$ =	1.4	SE$_x$ =	0.4
57	*I mentally tracked my cost-of-quality activities and recorded them at the end of the day*								
	weak disagree	mean =	3.1	K=	15	SD$_x$ =	1.2	SE$_x$ =	0.3
58	*By the end of the day I forgot most of my cost-of-quality activities*								
	disagree	mean =	3.6	K=	15	SD$_x$ =	1.4	SE$_x$ =	0.4
59	*I recorded short activities almost immediately*								
	agree	mean =	2.6	K=	14	SD$_x$ =	1.2	SE$_x$ =	0.3
60	*I recorded my activities on the recording tool at the same time as I made entries onto the company timesheet*								
	weak disagree	mean =	3.1	K=	15	SD$_x$ =	1.4	SE$_x$ =	0.4
61	*The description of the 5 broad categories jogged my memory more so than descriptions of individual cost-of-quality activities*								
	agree	mean =	2.7	K=	15	SD$_x$ =	1.2	SE$_x$ =	0.3

Indicate whether you agree or disagree with the following statements that refer to the burden of recording your personal cost-of-quality data

62	*I classified and recorded my time very accurately*								
	agree	mean =	2.5	K=	15	SD$_x$ =	1.1	SE$_x$ =	0.3
63	*I found that the system was very manageable. 30 seconds to record data won't kill you*								
	agree	mean =	2.2	K=	15	SD$_x$ =	1.1	SE$_x$ =	0.3

64	I think that, at least initially, everyone will feel more burdened							
	agree	mean =	1.9	K=	16	SD_x =	0.7	SE_x =	0.2

65	I found that it was taking way too much time at the end of the day to record my cost-of-quality activities
	disagree mean = 3.8 K= 15 SD_x = 1.1 SE_x = 0.3

66	As a someone who supervises others, I think that recording cost-of-quality activities will initially be seen as a burden
	agree mean = 2.5 K= 12 SD_x = 1.0 SE_x = 0.3

67	I wouldn't like it if the company forced the system on me, but I would get used to it.
	agree mean = 2.6 K= 16 SD_x = 1.1 SE_x = 0.3

Indicate whether you agree or disagree with the following statements that refer to your thoughts on improving personal compliance of recording cost-of-quality data

68	Staff will tend to avoid using the cost-of-quality system because they don't understand it or its benefits
	agree mean = 2.5 K= 15 SD_x = 1.2 SE_x = 0.3

69	The staff would tend to be more complaint if they saw regular reports that included cost-of-quality data, not just a single report at post mortem time
	agree mean = 2.1 K= 15 SD_x = 0.8 SE_x = 0.2

70	I have no sense of the compliance level of others on the staff
	agree mean = 2.6 K= 16 SD_x = 1.3 SE_x = 0.3

71	I believe that it would be difficult for the company to track my compliance
	weak disagree mean = 3.1 K= 16 SD_x = 1.3 SE_x = 0.3

72	I would be more diligent in recording cost-of-quality data if I had to report it on my company timesheet
	disagree mean = 3.4 K= 16 SD_x = 1.4 SE_x = 0.3

73	Since the company cannot track when I don't use the system, I am more likely to ignore legitamate opportunities to report cost-of-quality activities
	weak disagree mean = 3.0 K= 16 SD_x = 1.3 SE_x = 0.3

74	Of course I can always find time to record my time on the company timesheet, but I have little or no time to record activities on a separate recording tool
	disagree mean = 3.5 K= 16 SD_x = 1.0 SE_x = 0.2

Indicate whether you agree or disagree with the following statements that refer to the temptation to conceal or exaggerate when reporting cost-of-quality data.

75	It is human nature to increase pleasure and decrease pain; employees will slant data to avoid blame or to make themselves look good
	agree mean = 2.3 K= 16 SD_x = 0.9 SE_x = 0.2

76	I would not conceal or exaggerate my personally-recorded data because I'm inherently honest
	agree mean = 1.7 K= 16 SD_x = 0.6 SE_x = 0.2

77	Embarrassing errors might induce me to conceal some or all of my personal error activities
	disagree mean = 3.9 K= 16 SD_x = 0.9 SE_x = 0.2

78	I would be more inclined to report my personally-recorded data honestly if it would remain anonymous
	agree mean = 2.6 K= 16 SD_x = 1.2 SE_x = 0.3

79	If I had to personally correct my own work due to the negligence or carelessness of others, I might exaggerate my personally-recorded error activities in order to call attention their mistake
	disagree mean = 3.4 K= 16 SD_x = 1.4 SE_x = 0.3

Indicate whether you agree or disagree with the following statements that refer to using a cost-of-quality system in your office to promote higher quality

80	*Recording our time against cost-of-quality activities would promote good quality awareness in the office*							
	agree	mean =	1.7	K=	16	SDx =	0.5	SEx =	0.1
81	*If I had to specifically record time spent correcting errors, I would be more inclined to perform work correctly in the future*							
	agree	mean =	2.4	K=	16	SDx =	1.1	SEx =	0.3
82	*Time spent performing cost-of-quality activities demonstrates the old adage, "there is never enough time to do it right, but there is always enough time to do it over"*							
	weak agree	mean =	2.9	K=	16	SDx =	1.5	SEx =	0.4
83	*Monitoring cost-of-quality activities can help maximize efficiency*							
	agree	mean =	2.1	K=	16	SDx =	0.7	SEx =	0.2
84	*Engineering work cannot be evaluated with tools that are used in manufacturing firms, such as time-and-motion studies*							
	agree	mean =	2.7	K=	16	SDx =	0.9	SEx =	0.2
85	*The principle behind a cost-of-quality system is not realistic, at least as it relates to projects on which I work*							
	disagree	mean =	3.8	K=	16	SDx =	1.2	SEx =	0.3
86	*I believe that excessive costs-of-quality on a project suggests that clients are likely to experience added costs after plans are delivered*							
	weak agree	mean =	2.9	K=	16	SDx =	1.0	SEx =	0.3
87	*Cost-of-quality accounting might be useful in identifying expensive areas or activities*							
	agree	mean =	2.1	K=	16	SDx =	0.9	SEx =	0.2
88	*As a supervisor, I think that historical cost-of-quality data could be useful for fee estimates*							
	agree	mean =	1.9	K=	12	SDx =	0.5	SEx =	0.1

Indicate whether you agree or disagree with the following statements that refer to quality subjects in general as they apply in your office

89	*If you don't check plans and specifications, you're in trouble*							
	agree	mean =	1.4	K=	16	SDx =	0.8	SEx =	0.2
90	*The first plan check is designed to reveal 70% of the problems, the second check reveals another 20%, and the third check reveals yet another 5%; the remaining 5% of error is beyond the capability of most processes*							
	agree	mean =	2.1	K=	16	SDx =	1.2	SEx =	0.3
91	*There is a value to a "systems" approach to quality that relies more heavily on preventing errors rather than finding and fixing errors through a plan checking/design review process*							
	agree	mean =	2.0	K=	16	SDx =	0.8	SEx =	0.2
92	*I believe that the performance of a work system is not the same as the overall performance of all employees that work in the work system*							
	agree	mean =	2.4	K=	16	SDx =	1.2	SEx =	0.3
93	*While there are certain activities that are repetitive, engineering and architecture projects are all unique and, thus, more prone to error*							
	agree	mean =	1.9	K=	16	SDx =	0.8	SEx =	0.2
94	*A plan checker rarely has the specific knowledge of project conditions to perform a thorough review*							
	weak agree	mean =	2.8	K=	16	SDx =	1.2	SEx =	0.3
95	*It is my job to check my own work in order for the checking process to be effective*							
	agree	mean =	1.3	K=	16	SDx =	0.6	SEx =	0.2
96	*Quality audits never distinguish high or low quality projects, only whether the staff conformed to the quality process*							
	agree	mean =	2.3	K=	16	SDx =	1.1	SEx =	0.3

97	*Project managers don't share with the staff information they obtain from construction administrators regarding lessons learned*							
	agree	mean =	2.4	K=	16	SD$_x$ =	1.3	SE$_x$ =	0.3
98	*Principle disciplines should communicate when the design is in the early stages before there is a large commitment in drafting and design time*							
	agree	mean =	1.1	K=	16	SD$_x$ =	0.3	SE$_x$ =	0.1

Refer to the attached Quality Management Procedure

99	*This quality management procedure addresses the minimum requirements for activities that are critical to delivering quality architectural services to our clients and internal customers*							
	agree	mean =	2.1	K=	16	SD$_x$ =	1.2	SE$_x$ =	0.4
100	*It has the ability to improve the product quality at the end level. It does not verify that everything shown on the drawing is correct, but that it does coordinate*							
	agree	mean =	2.2	K=	16	SD$_x$ =	0.7	SE$_x$ =	0.2
101	*It only injects quality into the format of the end product. It does not look at the quality of the input to the end product and it does not evaluate whether all of the decisions that lead up to what's reflected in that end product were appropriate decisions. It only reflects an evaluation of the document itself*							
	agree	mean =	1.4	K=	16	SD$_x$ =	0.5	SE$_x$ =	0.2
102	*In one version or another, it's been in effect since I've been here. They've changed it… periodically revise it… but it's basically the same…. First of all, it's very hard to implement on a fast moving project and on a project where you don't have a lot of money to spend on getting it done*							
	agree	mean =	2.3	K=	16	SD$_x$ =	1.3	SE$_x$ =	0.4
103	*Certain tasks shown in here are done almost automatically by any ethically conscientious project manager*							
	agree	mean =	1.7	K=	16	SD$_x$ =	0.5	SE$_x$ =	0.2

Refer to the attached Quality Assurance Review Certification

104	*As this form exists, there is no verification of any of these certifications. It's just a statement that 'yes, I did this… or we did this.' As such, I think the form as you presented it does nothing to improve quality. It's just a statement that says 'we did something'*							
	agree	mean =	1.8	K=	16	SD$_x$ =	1.0	SE$_x$ =	0.3

APPENDIX M

GROUP QUALITY MANAGEMENT PROCEDURE MEMO

(Reprinted with permission: Tom Brooks-Pilling, AIA, Parsons Brinckerhoff, Inc.)

PB
—100
YEARS ®

To: Architectural Practice Leaders / AB TRC Managers

From: Tom Brooks-Pilling

Date: April 15, 2009

Subject: Architecture and Buildings Quality Management Procedure

Purpose

Consistent with PB's BMS (Business Management System), this quality management procedure addresses the minimum requirements for activities that are critical to delivering quality architectural service to our clients and internal customers.

Scope

This quality management procedure shall apply to all projects that include architectural services regardless of scope or scale.

Roles and Responsibilities

- Project Manager – Manages personnel, solves problems, writes contracts and interfaces with client and PIC/LBE/LTM. The PM resolves conflicts, sets deadlines, monitors progress and secures approvals from the client and AHJ. The PM may perform the QA check on small / fast paced projects.

- Project Architect – Work plan, code review, mock-up, develop typical details, observe office standards, conduct weekly team meetings, periodic QC checks, interface with other disciplines and develop specifications. The PA is responsible for QC checks at the end of SD, DD and CD phases.

- Architect / Designer / Intern (Architectural Team) – Draws plans, elevations, sections, details and schedules at the direction of the Project Architect and is responsible for conducting a check on his or her assigned task periodically and prior to the PA's end of phase QC check.

- Peer Reviewer – Senior Architect who is assigned to performs the QA check _prior_ to issuance of Construction Documents / Final Report to our client and / or AHJ.

Procedures

1. Project Manager shall document the Project Quality Control Plan (PQCP) and distribute it to all team members prior to project initiation. The PQCP shall include the ABTRC Quality Assurance / Quality Control Checklist which identifies the scope, budget and assignment for quality control and quality assurance. Where practical, selected projects shall have the Peer Review performed by Senior Architect from another PB Office.

2. Architectural team members shall perform a QC check of their assigned tasks prior to submitting to the Project Architect for an end of phase QC check.

3. Project Architect performs QC check and architectural team corrects the work in accord with PB's Checking Procedure.

4. Peer Reviewer (or PM on small projects) performs QA check in accord with PB's Checking Procedure.

5. Reproductions (Prints / Specs / Reports) are checked for visual quality PRIOR to issuance to our client or AHJ.

Checking Procedure

Checking of design deliverables is to be done by each discipline for each deliverable. Each discipline quality control review is to involve a minimum of 2 staff; a checker/verifier and an originator/backchecker/corrector. The following is an abbreviated description of the procedure:

1. The Checker uses the color YELLOW for items that are correct and RED to indicate items that are not correct. Note that comments are not done in a color since the checking process uses the colors as part of the process. Indicate comments in black with a cloud around the comment.

2. The Backchecker (originator of the document) reviews the checker's markups and comments checking agreed upon items with a GREEN checkmark and adding any additional changes in GREEN to be added to the corrections. After reviewing items of disagreement with the Checker, the Backchecker marks through the item with a GREEN X on all items that are agreed not to be changed.

3. The Corrector corrects all items and circles each item with BLUE. The corrector may be the Checker, the Backchecker or a third party.

4. The Corrections Checker shall be provided with a clean copy of the corrected document and marks in YELLOW each item that was corrected and marks those in RED that were not corrected as well as circling the not corrected item in GREEN on the original QC set. The process described in item 3 & 4 is repeated for any items that have not been corrected and indicated in RED (THIS SHOULD NEVER HAPPEN).

5. Any items that are found that are not part of the original mark up are marked in ORANGE and must go through the same procedures as described in items 2 thru 4 above.

6. On documents that are 100% complete the Peer Reviewer will check the entire project set of documents using a final corrected set and the QC set of markups. The process will follow the same procedures as described in items 1 thru 4 above.

The final quality control document is to include each discipline check set including the corrected document review with all assembled into one set for the file.

Definitions

PQCP: Project Quality Control Plan. A project-specific plan that defines PB's quality related project requirements for the professional services.

QC: Quality Control. The project-level actions, procedures and methods that are used usually within the technical disciplines under the jurisdiction of the PM, to produce quality professional services.

QA: Quality Assurance. Those management level actions, procedures and methods used to observe and assure senior management and clients that prudent quality controls are employed and required professional services are produced at the program level.

PQA: Project Quality Audit. A systematic and independent examination of the work processes and documentation of actual practices to determine the level of compliance at the project level. The Architectural Practice Leader or designee shall perform a PQA on selected projects once every six months.

APPENDIX N

QUALITY ASSURANCE REVIEW CERTIFICATION

Quality Assurance Review Certification

Client:
Project:
PB Project No:
Document(s) / Task(s) Reviewed**:**

A Quality Assurance Review has been completed by the QA Reviewer(s) indicated below. The specific project document(s) and/or task(s) stated above were reviewed with the intention that the design and associated tasks regarding this project were undertaken in accordance with accepted engineering practices and requirements set forth by the Client. All work has been reviewed in regards to its technical soundness, ethical content, and cost effectiveness.

Project Manager:

Name (print)	Signed	Date

Quality Assurance Reviewer (Civil):

Name (print)	Signed	Date

Quality Assurance Reviewer (Structural):

Name (print)	Signed	Date

Quality Assurance Reviewer (Architectural):

Name (print)	Signed	Date

Quality Assurance Reviewer (Mechanical):

Name (print)	Signed	Date

Quality Assurance Reviewer (Electrical):

Name (print)	Signed	Date

Quality Assurance Reviewer (Plumbing):

Name (print)	Signed	Date

Quality Assurance Reviewer (Fire Protection):

Name (print)	Signed	Date

BIBLIOGRAPHY

Abdul-Rahman, Hamzah. "The Cost of Non-Conformance During a Highway Project: a Case Study," *Construction Management and Economics* 13 (1995): 23-32.

Abdul-Rahman, H, P. A. Thompson, and I. L. Whyte. "Capturing the Cost of Non-Compliance on Construction Sites: an Application of the Quality Cost Matrix," *The International Journal of Quality & Reliability Management* 13 (1996): 48-60.

Abdul-Rahman, Hamzah. "Some Observations on the Issues of Quality Cost in Construction," *International Journal of Quality & Reliability Management* 14 (1997): 461-481.

Americas Project Delivery Management System. "Checking of Design Deliverables," Rev 1, Parsons Brinckerhoff, Nov 2009. TEC 301.

Americas Project Delivery Management System. "Quality Assurance Review Certification," Rev 1, Parsons Brinckerhoff, Feb 2009. PD 206.

Aoieong, Raymond T., S. L. Tang, and Syed M. Ahmed. "A Process Approach in Measuring Quality Costs of Construction Projects: Model Development," *Construction Management and Economics* 20 (2002): 179-192.

ASQC Quality Cost Committee, Guide for Managing Supplier Quality Costs, Edited by W. O. Winchell, Milwaukee: ASQC Quality Press, 1987. (1st ed. 1980)

ASQC Quality Cost Committee, Guide for Reducing Quality Costs, Edited by J. Campanella, Milwaukee: ASQC Quality Press, 1977.

ASQC Quality Cost Committee, Quality Costs: What and How, Milwaukee: ASQC Quality Press, 1971. (1st ed. 1967)

Ashcraft, Howard W. "Understanding Design/Build Risk," Issue brief. San Francisco: Hanson, Bridgett, Marcus, Vlahos & Rudy, LLP, February 2002.

Austin, Robert D. Measuring and Managing Performance in Organizations, 1st ed. New York: Dorset House Publishing, 1996.

British Standards Institute. BSI 6143: Guide to the Economics of Quality Part 1: Process Cost Model, 1992.

British Standards Institute. BSI 6143: Guide to the Economics of Quality Part 2: Prevention, Appraisal, and Failure Model, 1990.

Burati, Jim. Quality Management Task Force. Construction Industry Institute. <u>Pub 10-1: Costs of Quality Deviations in Design and Construction</u>, Ed. Rusty Haggard. Austin: University of Texas, Bureau of Engineering Research, 1989.

Burke, Michael J., Lisa M. Finkelstein, and Michelle S. Dusig. "On Average Deviation Indices for Estimating Interrater Agreement." *Organizational Research Methods* 2.1 (1999): 49-68.

Campanella, Jack. <u>Principles of Quality Costs: Principles, Implementation and Use</u>, 3rd ed. Milwaukee: ASQ Quality Press, 1999.

Carney, John H., Joseph F. Joiner, and Helen Tragou. "Categorizing, Coding, and Manipulating Qualitative Data Using the WordPerfect®+ Word Processor," *The Qualitative Report* 3:1, March (1997) <http://www.nova.edu/ssss/QR/QR3-1/carney.html>

Civitello, Andrew M., William D. Locher, and Andrew M. Civitello. <u>Contractor's Guide to Change Orders: How to Resolve Disputes and Get Paid</u>, Anaheim: BNI Publications, Inc., 2002.

Cohen, J. "A Coefficient for Agreement for Nominal Scales," *Education and Psychological Measurement* 20 (1960).

Cohen, J. "Weighted Kappa: Nominal Scale Agreement with Provision for Scaled Disagreement or Partial Credit," *Psychological Bulletin* 70 (1968).

Colaizzi, P. "Psychological Research as a Phenomenologist Views It", in Valle, R. and King, M. (Eds), <u>Existential Phenomenological Alternatives for Psychology</u>, Oxford University Press, New York, NY, 1978.

Corbin, Juliet. <u>Basics of Qualitative Research</u>. 3rd Ed. Thousand Oaks: Sage, 1998.

Cox, B. "Interface of Quality Costing and Technology." *The Accountant* 180(June) (1979): 800-801.

Crawford, Raymond R. "PB Quality Program Update," PowerPoint Presentation, St. Louis Office of Parsons Brinckerhoff, Inc., St. Louis. 27 Mar. 2006. Staff Meeting.

Creswell, John W. <u>Qualitative Inquiry and Research Design: Choosing Among Five Traditions</u>. Thousand Oaks: Sage, 1998.

Crockett, Lisa J., John E. Schulenberg, and Anne C. Petersen. "Congruence between Objective and Self-Report Data in a Sample of Young Adolescents," *Journal of Adolescent Research* 2:4 (1987): 383–392.

Cronbach, L. J. <u>Essentials of Psychological Testing</u>, 3rd ed. NY: Harper & Row, 1970.

Crosby, Philip B. Quality Is Free: The Art of Making Quality Certain, NY: New American Library, 1980.

Crosby, Philip B. Quality without Tears: The Art of Hassle-Free Management, NY: McGraw-Hill, 1995.

Dale, Barrie G., and Jim J. Plunkett. Quality Costing, 3rd ed. Hampshire, England: Gower LTD, 1999.

Davis, K., W.B. Ledbetter, J.L. Burati, "Measuring Design and Construction Quality Costs," *ASCE Journal of Construction Engineering and Management* 115 (1989): 389-400.

Deming, W Edwards. Out of the Crisis, Cambridge: MIT Press, 2002.

Deming, W Edwards. The New Economics, Cambridge: MIT Press, 2000.

Denscombe, Martin. The Good Research Guide for Small-Scale Social Research Projects, 3rd ed., Berkshire, England: Open University Press, 2007

Denzin, Norman K. Interpretive Biography, London: Sage, 1989.

Denzin, Norman K., and Yvonna S. Lincoln. The Sage Handbook of Qualitative Research, 3rd Ed. Thousand Oaks: Sage, 2005.

Faith Church Roof Collapse. News and Information. NBC. KSDK, St. Louis, Missouri. KSDK.com. 30 Sept. 2010. Web. 7 Oct. 2010. <http://www.ksdk.com/news/local/story.aspx?storyid=219097>.

Feigenbaum, Armand V. Quality Control: Principles, Practices, and Administration, 1st ed. New York: McGraw-Hill, 1951.

Feigenbaum, Armand V. "Total Quality Control," *Harvard Business Review* 34 (1956): 93-101.

Feigenbaum, Armand V. Total Quality Control: Engineering and Management; the Technical and Managerial Field for Improving Product Quality, including its Reliability, and for Reducing Operating Costs and Losses, NY: McGraw-Hill, 1961.

Feigenbaum, Armand V. Total Quality Control, 3rd ed. NY: McGraw-Hill, 1991.

Fleiss, J. L. "Measuring Nominal Scale Agreement among Many Raters" *Psychological Bulletin* 76:5 (1971).

Freeman, H. L. "How to Put Quality Costs to Use," *Transactions of the American Society for Quality Control (ASQC)*. Proc. of 12th Metropolitan Conference. NY: McGraw-Hill, 1960. 15-18.

Freiesleben, Johannes. "The Opportunity Costs of Poor Quality," *Qual Assur* J 9 (2005): 3-10.

Gabor, Andrea. The Man Who Discovered Quality: How W. Edwards Deming Brought the Quality Revolution to America, NY: Penguin Books, 1992.

Goulding, Christina. "Grounded Theory, Ethnography and Phenomenology a Comparative Analysis of Three Qualitative Strategies for Marketing Research," *European Journal of Marketing* 39:3/4 (2005): 294-308.

Haley, Thomas J. "Software Process Improvement at Raytheon," *IEEE Software* Nov (1996): 33-41.

Harry, Mikel, and Richard Schroeder. The Breakthrough Management Strategy Revolutionizing the World's Top Corporations, NY: Doubleday, 1999.

Hart, Roger D. Quality Handbook for the Architectural, Engineering, and Construction Community, 1st ed. Milwaukee: ASQC Quality P, 1994.

Hayes, A. F. and K. Krippendorff. "Answering the Call for a Standard Reliability Measure for Coding Data," *Communication Methods and Measures* 1 (2007).

Houston, Dan, and J. B. Keats. "Cost of Software Quality: a Means of Promoting Software Process Improvement," *Quality Engineering* 10 (1998): 563-573.

Huizinga, David and Delbert S. Elliot. "Reassessing the Reliability and Validity of Self-Report Delinquency Measures," *Journal of Quantitative Criminology* 2 NY: Plenum Publishing Corporation, 1986

Husserl, Edmund. The Crisis of the European Sciences and Transcendental Phenomenology. Evanston: Northwestern University Press, 1970.

Hycner, Richard H. "Some Guidelines for the Phenomenological Analysis of Interview Data," *Human Studies* 8 (1985): 279-303.

International Organization for Standardization. Guidelines for Managing Quality System Elements. Geneva, 1994. ISO 9004-1.

Jones, C. Programming Productivity, McGraw-Hill, NY, 1986.

Juran, Joseph. M. Quality-Control Handbook, 1st edition. NY: McGraw-Hill, 1951.

Juran, Joseph. M., Frank M. Gryna, and Richard S. Bingham. Quality Control Handbook, 3rd ed. NY: McGraw-Hill, 1974.

Juran, Joseph. M., and Frank M. Gryna. Quality Control Handbook, 4th ed. NY: McGraw-Hill, 1988.

Kennedy, C. W. "The Gold Mine in Quality Control," *Purchasing* 26.6 (1949) 96-99.

Knocke, J, "Post Construction Liability and Insurance," *E & F Spon*, London, 1992.

Knox , S.T., "Modeling the Cost of Software Quality," *Digital Technical Journal* 5 (1993): 9-16.

Kvale, Steinar. Interviews: An Introduction to Qualitative Research Interviewing, Thousand Oaks: Sage, 1996.

LeBreton, James M. and Jenell L. Senter. "Answers to 20 Questions about Interrater Reliability and Interrater Agreement," *Organizational Research Methods* 11 (2008).

Ledbetter, Bill. Quality Management Task Force. Construction Industry Institute. Pub 10-2: Measuring the Cost of Quality, Ed. Rusty Haggard. Austin: University of Texas, Bureau of Engineering Research, 1989.

Lesser, W. H. "Cost of Quality," *Industrial Quality Control*, November (1954): 11-14.

Liebert, F. P. "Guidelines on the Gathering and Implementation of Quality Costs," *The Quality Engineer* 32.2 (1968): 39-43.

Lincoln, Y. S., & E Guba. Naturalistic Inquiry. Newbury Park, CA: Sage Publications, 1985.

Lombard, M., Snyder-Duch, J., & Bracken, C. C. "Content Analysis in Mass Communication: Assessment and Reporting of Intercoder Reliability," *Human Communication Research* 28 (2002): 587-604.

Love, P.E.D., H. Li, "Quantifying the Causes and Costs of Rework in Construction," *Construction Management and Economics* 18/4 (2000): 479-490.

Love, P.E.D., P. Mandal, H. Li, "Determining the Causal Structure of Rework in Construction Projects," *Construction Management and Economics* 17/4 (1999): 505-517.

Low, Sui Pheng, and K C. Yeo. "A Construction Quality Costs Quantifying System for the Building Industry," *The International Journal of Quality & Reliability Management* 15 (1998): 329-349.

March J G, Guetzkow H & Simon H. Organizations. NY: John Wiley & Sons, 1958.

Marsh, J. "Process Modeling for Quality Improvement," *Total Quality Management: Proc. of 2nd International Conference*, UK. June ed. IFS LTD, 1989. 111-125.

Masser, W. J. "The Quality Manager and Quality Costs," *Industrial Quality Control* October (1957): 5-8.

McBride, David. "The 7 Manufacturing Wastes," EMS Consulting Group, 29 Aug. 2003. <www.emsstrategies.com>

Mead, Margaret. Cultural Patterns and Technical Change: a Manual, Westport, CT: Greenwood, 1985.

Morley, James J., "The Private Theater: An Empirical Phenomenological Inquiry into Daydreaming," *Journal of Phenomenological Psychology* (1998) 116-135

Morse J.M. Strategies for sampling. In: Morse J.M., editor. Qualitative Nursing Research: A Contemporary Dialogue. Newbury Park, CA: Sage; 1991.

Moustakas, Clark E. Phenomenological Research Methods, Thousand Oaks: Sage Publications, Inc., 1994.

Ohno, Taiichi. Toyota Production System Beyond Large-scale Production. Portland: Productivity Press, 2002.

Pace, C. R., Barahona, D., & Kaplan, D. The Credibility of Student Self-Reports, Los Angeles: Center for the Study of Evaluation, 1985.

Petroski, Henry. To Engineer Is Human: the Role of Failure in Successful Design, NY: Vintage, 1992.

Plunkett, J. J., and B. G. Dale. "A Review of the Literature on Quality-Related Costs," *International Journal of Quality & Reliability Management* 4.1 (1987) 40-52.

Porter, L. J., and P. Raynor. "Costing for Total Quality Management," *International Journal of Production Economics* 27 (1992): 69-81.

Project Management Policies and Procedures Manual, Parsons Brinckerhoff, Dec 2001.

"Protection of Human Subjects", CFR Part 46. Department of Health and Human Services. Title 45: Public Welfare (2009).

Quality in the Constructed Project: a Guide for Owners, Designers, and Constructors, Manuals and Reports on Engineering Practice. 2nd ed. Reston, Virginia: ASCE, 2000.

Ragsdell, Kenneth M. "QE11: Loss Function," E.Mgt 475: Quality Engineering. Engineering Management, Rolla. Winter 2005. Lecture.

Sandoval-Chavez, Diego A., and Mario G. Beruvides. "Using Opportunity Costs to Determine the Costs of Quality," *Institute of Industrial Engineers* Winter (1998).

Sandretto, Michael J. "What Kind of Cost System Do You Need?" *Harvard Business Review* January/February (1985): 110-18.

Schiffauerova, Andrea, and Vince Thomson. "A Review of Research on Cost of Quality Models and Best Practices," *International Journal of Quality & Reliability Management* 23 (2006).

Schmidt, F.L. and J.E. Hunter. "The Validity and Utility of Selection Methods in Personnel Research: Practical and Theoretical Implications of 85 Years of Research Findings," *Psychological Bulletin* 124 (1998): 262-274.

Sleeper, Harold Reeve, Andy Pressman, and Charles George Ramsey. Architectural Graphic Standards, 11th ed. Hoboken, NJ: John Wiley & Sons, 2007.

Smith, David Woodruff, Husserl, London-New York: Routledge, 2007.

Speziale, H. J. S., and Carpenter, D. R. Qualitative Research in Nursing: Advancing the Humanistic Imperative, 4th ed. Philadelphia: Lippincott Williams & Wilkins, 2007.

Staub, Robert. "Accountability and Its Role in the Workplace," *The Business Journal of the Greater Triad Area* [Greensboro] 14 Jan. 2005. American City Business Journals, Inc., 17 Jan. 2005. Web. 22 Sept. 2010. <http://www.bizjournals.com/triad/stories/2005/01/17/smallb3.html>.

Strauss Anselm, and Juliet Corbin. Basics of Qualitative Research: Grounded Theory Procedures and Techniques, Thousand Oaks: Sage, 1990.

Streubert-Speziale HJ. "Designing Data Generation and Management Strategies," *Qualitative Research in Nursing: Advancing the Humanistic Imperative* 4 (2007): 35-36, Philadelphia, PA: Lippincott Williams & Wilkins.

Taguchi, Genichi. Introduction to Quality Engineering, 1st ed. White Plains: UNIPUB/Kraus International Publications, 1987.

"The Cost of Quality," *IIE Solutions*, September 28.9 (1996): 9.

Thompson, C. J. "Interpreting Consumers: a Hermeneutic Framework for Deriving." *Journal of Marketing Research* 34, November (1997): 438-55.

Tinsley, H. E. A. and D. J. Weiss. "Interrater Reliability and Agreement of Subjective Judgments," *Journal of Counseling Psychology* 22 (1975): 358-376.

Trochim, William M. The Research Methods Knowledge Base, 2nd Edition. Cincinnati: Atomic Dog Pub., 2001.

U. S. Department of Defense. Military Specification: Quality Program Requirements, 1963. MIL-Q-9858A.

U. S. Department of Defense. Military Standard: Standard Practice for Engineering Drawings, 1997. MIL-STD-100G.

Uebersax, John S. "Diversity of Decision Making Models and the Measurement of Interrater Agreement" *Psychological Bulletin* 101:1 (1987): 140-146.

"Understanding the Design and Construction Process." *AIA East Tennessee*. The American Institute of Architects, East Tennessee Chapter. Web. 07 Oct. 2010. <http://www.aiaetn.org/mc/page.do?sitePageId=61811&orgId=aiaetc>.

VITA

David Patrick Loduca was born in St. Louis, Missouri in 1959, second of four children of Carolyn Josephine and Samuel Salvatore Loduca. After completing high school in 1977 at Christian Brother College High School in Clayton, Missouri, he attended the Virginia Military Institute in Lexington, graduating in 1981 with a Bachelor of Science degree in Electrical Engineering. David continued his studies in management, graduating summa cum laude in 1994 with an Associate of Applied Science degree in Management from Virginia Western Community College in Roanoke. In 2002, he entered the Engineering Management curriculum at the Missouri University of Science and Technology in Rolla and was accepted by *Epsilon Mu Eta*, the honor society for engineering management, before graduating with his Master of Science degree in 2005; and finally in 2011, was conferred his Doctorate in Engineering Management.

Since obtaining his baccalaureate in 1981, David worked at several professional engagements, including two years in Keokuk, Iowa as a facility engineer for Sheller-Globe, a manufacturer of rubber and thermoplastic components for the auto industry; five years as an electrical and electromagnetic compatibility engineer for Brunswick's Defense Division, a manufacturer of military hardware in Marion, Virginia; ten years in Roanoke, Virginia as an engineering manager for VFP, Inc., maker of manufactured buildings for the satellite and cellular industry; and for the past eleven years at Parsons Brinckerhoff, a world-wide engineering firm where David currently serves as a supervising engineer at their local office in St. Louis, Missouri.

First registered in Virginia in 1990, David is now licensed as a professional engineer in eighteen states and in the province of Ontario. He is certified as a LEED accredited professional, a member of the American Society of Engineering Management, and a Senior Member of the Institute of Electrical and Electronic Engineers. David has served three years as a volunteer examiner with the Excellence in Missouri Foundation, an organization chartered in 1992 to administer the Missouri Quality Award. Locally, he volunteered on the Allocation Committee for the St. Louis United Way, and as a Eucharistic minister at a skilled nursing facility. David lives in Olivette, Missouri with his wife, Linda. He has a daughter, Rachel, and a granddaughter, Madeline.