Solving the Construction Craftperson Skill Shortage Problem Through Construction Undergraduate and Graduate Education

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This research paper identifies construction undergraduate and graduate education as the only solution to the problem of craftsperson shortage in the construction industry. The paper first identifies the craftsperson shortage problem and easily identifiable problems of low pay, no career incentives, and minimized training. It then analyzes the construction industry structure. Using Information Measurement Theory, it identifies the environment required to increase the number of skilled craftspeople. The analysis identifies the real source of the craftsperson skill shortage in the construction industry as the industry structure, the low-bid procurement system, and the lack of performance information. The current industry structure and procurement systems identify craftsperson skill as a need and not a requirement. It identifies the construction education system as the only way to change the craftsperson skill shortage problem. It proposes that certain topics (industry structure, change mechanisms, performance information, business processes, organizational optimization) must be introduced in construction education and given to facility owner representatives, designers, and construction management to change the industry structure from within and without.

Key Words: Craftperson shortage, industry structure, low-bid procurement, performance information

Introduction

One of the greatest challenges currently facing the construction industry is attracting and retaining skilled craftspeople. Skill levels continue to decline while owners squeeze contractors for lower costs and faster schedules through the low-bid or design-bid-build delivery process. In response, contractors have reduced training and use less skilled craftspeople to be competitive. An aging workforce, low pay, poor image and poor career paths for skilled craftspeople have precipitated the current work shortage. Both owners and contractors must work together to address these issues. One of the methods to accomplish this is to minimize the use of the low bid process and move to a system that will provide more incentive for contractors to have highly qualified craftspeople. Contractors and owners that find a way to attract and retain quality craftspeople will be the successful companies of the future. (CII, 2001).

Skilled Craftsperson Shortage in the Construction Industry

A Construction Industry Institute study shows that 75% of contractors are experiencing labor shortages and that these shortages are costing contractors and owners time and money. The

Business Roundtables Construction Committee found that 25% of their member's projects encountered cost overruns and/or schedule delays caused by a labor shortfall. The Department of Labor estimates that the construction industry needs to attract 240,000 workers each year to replace the aging workforce who are retiring or leaving the industry. The Department of Labor also reports that the current average age of a construction worker is 47 years old and climbing. (Garrity, 1999). In a recent survey done by the Associated General Contractors and Deloitte & Touche that was released March 2nd, 2001, skilled labor shortages were identified by more than 80% of survey respondents as their most significant challenges over the next five years. (AGC, 2000). These astonishing statistics make it clear the problem that the construction industry is currently facing.

Identifiable Problems In Retaining and Attraction of New Talent

Quickly identifiable problems in the recruitment of skilled craftspeople include low wages; no clear-cut career path, a diminishing craftsperson skilled training program.

Low wages is a major reason the construction industry is having problems retaining skilled laborers. Listed below is a list of average wages of different occupations according to the Department of Labor's Survey on Compensation in 1999. (BLS, 2001)

Table 1

Relative Occupational Pay

Occupation	Hourly Rate
Plumber	$20.37
Skilled Craftsmen	$15.60
Meter Readers	$14.75
Secretary	$13.55
Bus Driver	$12.38

Considering the safety issues involved in being in the construction field, it is no wonder that many are opting to pursue other careers.

At a recent meeting for the Construction Industry Institute in San Francisco over Aug. 8-9, 2001, low wages was a major topic of discussion. "If low pay was a felony, I think most of us would be on death row today" said Franklin J. Yancey, a former senior vice-president and now a consultant at Kellogg Brown & Root. Speaking at the conference, Yancey explained that a journeyman trying to support a spouse and two children on $17 an hour ends up with $29 dollars per week in disposable income, after expenses. (Table 2) With poverty level wages, many workers leave the construction industry within two years. (Yancey, 2001.)

Table 2

Expenses/Income of Construction Craftsperson

Expenses for Typical Craftsperson			Total Income for Typical Craftsperson	
Expense	Month	Year	Income	
Rent/Mortgage	$500	$6,000	Gross Annual Pay (2080 hrs X $17)	$35,360
Utilities	$300	$3,600	Less Taxes	
Vehicle	$250	$3,000	Federal	-$2,964
Vehicle Ins.	$125	$1,500	Social Security	-$1,971
Fuel, Oil, Gas	$200	$2,400	Medicare	-$460
Charge Cards	$100	$1,200	Net Annual Pay	$29,965
Grocery/Dining	$600	$7,200	Total Expenses	$28,476
Health Care Ins.	$298	$3,576	Net Disposable Income	$1,489
Total Expenses		$28,476		

There seems to be a lack of image and well defined career path in the construction industry. In a recent survey of high school students by the National Business Employment Weekly, 'Construction Worker' came in #247 out of a possible 250 as an attractive career option. (Table 3) (Kantz, 2001) Young people see construction work as uninteresting work done in harsh conditions by not very talented people. The industry has not been successful in laying out the opportunities and career paths available in construction.

Table 3

Jobs Rated Almanac (National Business Employment Weekly

No.	Job Title
245.	Dancer
246.	Cowboy
247.	Construction Worker
248.	Fisherman
249.	Lumberjack
250.	Oil Field Laborer

There has also been a decrease in training by the unions. The unions have moved their effort from improving their training programs and identifying the difference in performance to having owners specify labor agreements where craftspeople used by contractors are union trained. Job training has been traditionally handled by the trade unions in the construction industry. Apprenticeship programs played a central role in this training to ensure that workers had received the proper training in their field. In the early 1980s as union power faded, many contractors began to pursue open shop agreements. (Kadlub, 1998) According to the Bureau of labor, Union membership went from 40% of the total workforce in the 1970s to only 18.3% in 2000. (ABC, 2001) When this happened, the impact of successful job training programs of the unions went to the wayside. The new open shop agreements did not have provisions for on going training and apprenticeships. Although, some open shop environments tried to include

training, they did not have the job placement abilities that the unions had and subsequently lost trainees.

Industry Structure and Information Measurement Theory (IMT)

The construction industry can be graphed using two major components: competition and performance (Figure 1). The industry is divided into four quadrants:

1. Quadrant I. High competition and low performance. This is where the award is based on price. A minimum performance (low performance) is required. The contractors force the owner to identify when the performance does not meet minimum standards. The award is based on price. The lowest price is usually awarded the contract. In many instances the low bid may also go to contractors who forget to include activities, force subcontractors and manufacturers to lower their price, and employ the least expensive management and craftspeople.

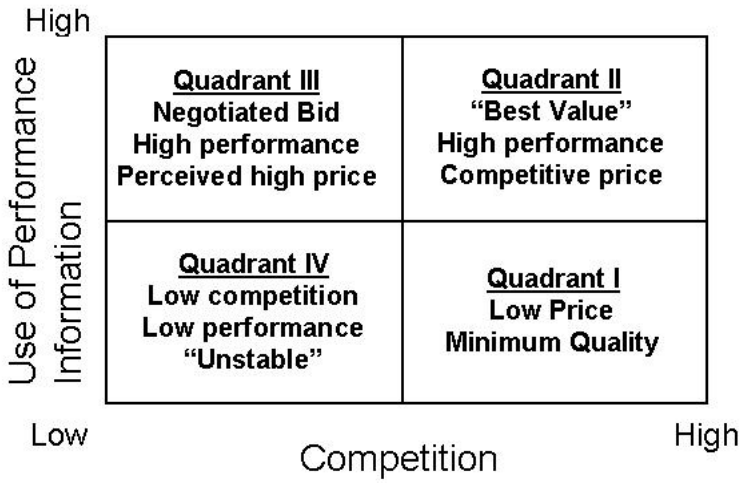

Figure 1: Construction Industry Structure

2. Quadrant II. High competition, high performance. This is the best value quadrant. Users consider both performance and price. It differs from both Quadrants I and III in that it requires performance information that minimizes risk (not being on-time, on-budget, and meeting quality expectations).

3. Quadrant III. High performance and low competition. This is the negotiated contract. Users usually pre-qualify contractors, and subjectively select the best value. There is no way to identify the value of construction unless more than one contractor is employed.

4. Quadrant IV. Low competition and low performance. This quadrant is unstable and cannot maintain itself. If a contractor has no competition, and cannot perform, they will not remain in business for a prolonged period of time. When a performer appears, the

nonperformers will disappear. If competition appears, the noncompetitive will disappear. An industry requires performance, competition, or both to maintain itself.

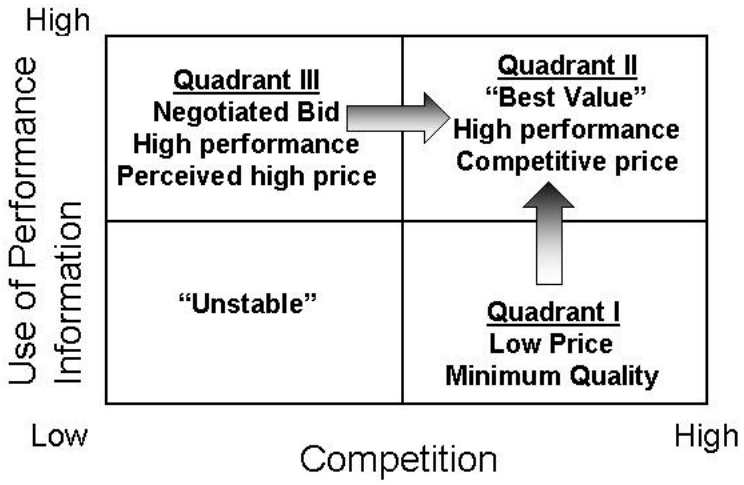

Figure 2: Movement Due to Poor Performance and Worldwide Competitive Price Pressure

Movement over time will include the following (Figure 2):

Quadrant I to II. The low performance of contractors will force facility owners to seek a performance-based process. This is evident over the last five years as facility owners have gone to alternate delivery processes and the Federal government has mandated the use of performance contracts to do construction renovation. Quadrant I also is the location of the following:

1. Construction workers are being asked to do work faster for the same pay.
2. Construction workers skill levels are decreasing due to a lack of training programs and the retirement of the more experienced.
3. The construction industry is having a difficult time recruiting talented individuals.
4. Construction now requires more management for each construction craftsperson.

Quadrant III to II. This movement is caused by the worldwide competitive marketplace and the resulting price pressure. It is also exacerbated by the lack of performance and life cycle performance information, which can justify long-term partnerships and relationships independent of price pressure. The price pressure will force owners to direct construction and facility managers to get more competition with the assumption that performance can be maintained and competition will bring a lower price.

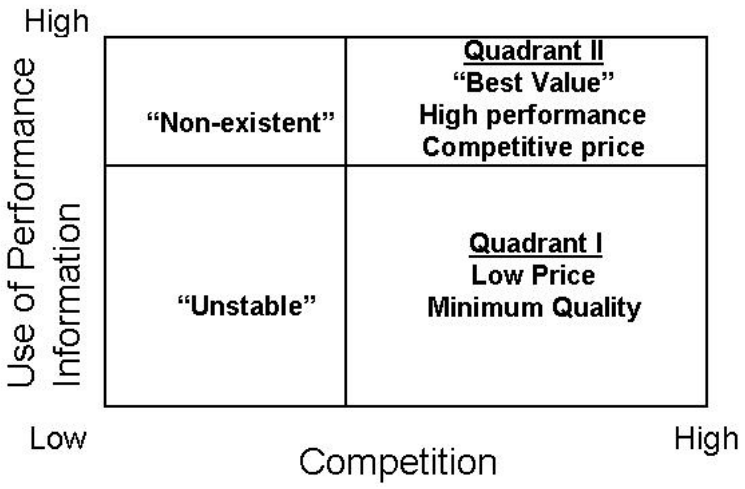

Figure3: Future Structure of the Construction Industry Without Performance Information

Quadrant III to I. As a result of the price pressure, if the construction industry does not use performance information which differentiates value (performance and price), the movement will go to Quadrant I which will further erode the characteristics that are associated with performance: training, quality, quality control, value, lower life cycle costs, and customer satisfaction. The result of these movements will leave the industry to Quadrants I and II and the other Quadrants being unstable or nonexistent (Figure 3). The industry is finding itself defined by Quadrant I. To move to Quadrant II the industry needs performance information. This is a concept that has been misunderstood by union groups, end users, and designers who have tried to make the move using minimum training standards or proprietary specifications.

Information Measurement Theory (IMT) was developed at Arizona State University in 1994 (Kashiwagi, 2001). It is used to show relationships between factors when there is insufficient data to use statistical analysis techniques. IMT has the following theoretical foundation:

1. Everything is cause and effect.
2. All factors are related and relative.
3. Information predicts the future outcome.
4. Information, or laws that predict the future state, always exist, but must be perceived.
5. The more perceptive an entity is, the faster the rate of change. The rate of change becomes exponential over time.
6. Statistical analysis requires a relative random sample.
7. Some information is better than no information.

The above deductive theories result in Figure 4. Figure 4 includes a representation of the relationship between perception of information over time or change. Figure 4 also includes two-way Kashiwagi Solution Models (KSM). By definition of the vertical axis, 'Level of Use of Information', entity 'A' has much more perception of information than entity 'C'. A decision is defined by the authors is when an entity perceives that there are two future states for one current state or exists when there is uncertainty. Entity 'A' makes far fewer decisions than entity 'C'.

Decisions are caused by the lack of information, or the use of one's biases to compensate for the lack of information.

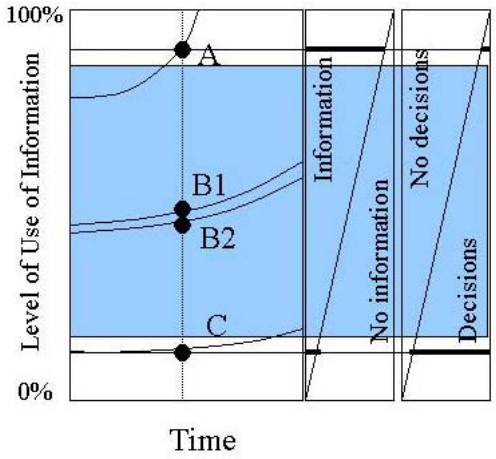

Figure 4: Use of Information/Change Rate

KSMs also make the following assumptions:

1. To differentiate between B1 and B2 requires too much data, data that cannot be collected. Therefore the shaded areas are where statistical analysis is required to differentiate. These areas are not considered.
2. The slope of the line dividing the opposite sides is not important due to the fact that the shaded areas are not being considered.
3. The only important objective is to locate the two sides of the KSM accurately. This must be done by deduction, and supported by documentation of the construction industry.

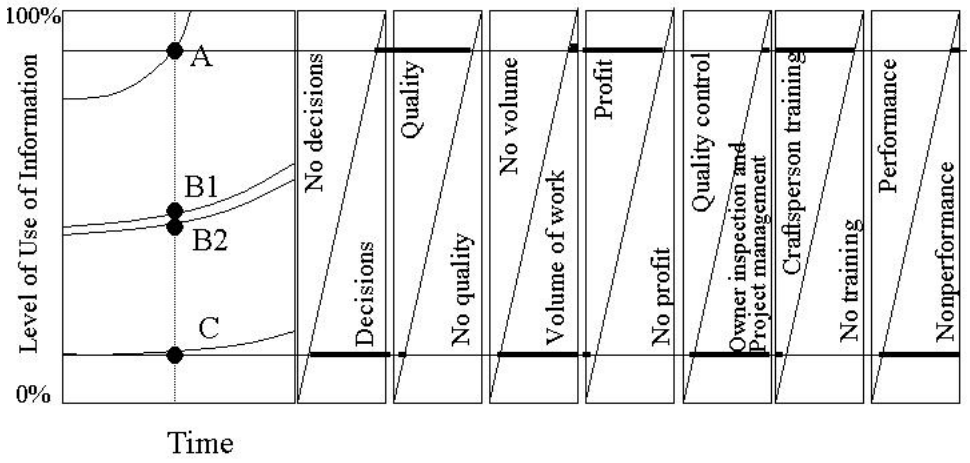

Figure 5: Use of Information/Change Rate &Accompanying Information Related Performance Factors

The KSMs for decisions, quality, volume of work, profit, quality control, craftsperson training, and external control (external management and inspection) are shown in Figure 5. These graphs were validated by a recent research thesis where 2,312 contractors located in Arizona, California, Florida, Michigan, New York, and Texas were asked to verify the relationship of criteria. Response rate was 14% (313 responded) (Erdmann, 2001). The explanation and documentation is shown below:

1. Decisions. Decisions are made due to a lack of performance information. The low-bid process forces the managers to make a decision that all the contractors are the same. If performance information was made available, it becomes obvious that some of the previously acceptable contractors may not be able to perform (time, cost, and quality). This is the motivation to move away form low-bid or Quadrant 1.

2. Quality. Performance information identifies quality. More performance information will identify the higher quality.

3. Volume of work. Higher volume of work requires contractors to do lower quality of work. With a shortage of quality craftspeople, more volume leads to lower quality. Higher volume of work requires more craftspeople. However, contractors are leveraging volume, therefore they get more work by offering it for a lower price per unit. This is commonplace in the manufacturing sector where automation and predictability have been implemented.

4. Profit. Profit margins are lower when contractors do more work for a lower unit price. Difficulty in closing out projects also forces contractors to 'rob Peter to pay Paul'. Business failures are the primary cause of contractor bankruptcy. (Schleifer, 1994)

5. Quality control. Contractors who quality control their own work do not need inspectors inspecting their quality. High quality contractors do less work, quality control their own work, and minimize the need for inspection.

6. Craftsperson training. Craftsperson training is driven by the requirement for trained craftspeople who will be rewarded for their high level of skill. Training cannot be sustained in a Quadrant I environment overtime. This is verified by the tremendous need for trained craftspeople.

7. Inspection and construction management. Inspection and management is required less for quality contractors and craftspeople. The less craftperson skill, quality control, and pay, the more inspection and management are required.

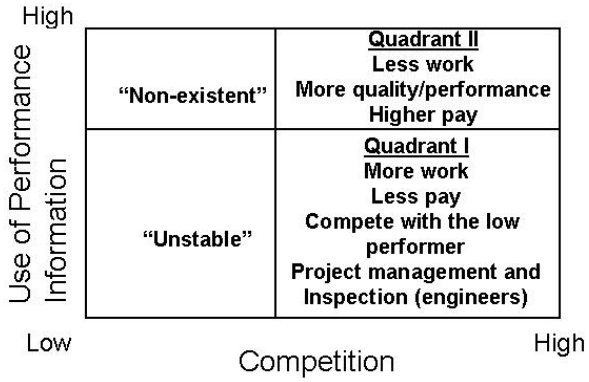

Figure 6: Work/Quality/Pay Issues

Based on Figure 5, the current movement to project management and alternate delivery methods identifies that the construction industry is in Quadrant 1. Figure 6 shows that Quadrant I requires people to work more for less pay. Quadrant I also contains the characteristics of decisions and inspection and construction management (engineering positions), and minimized profit, pay, quality control, and training. These are factors that attract low performing craftspeople. However, this quadrant offers more design/engineering/project management opportunities. Therefore, it may be in the best interest of the design/project management/engineering communities to remain in Quadrant I. To attract a higher quality of craftspeople, to stimulate training, and to give the construction industry the sustainability over time, requires both education of users (users must dictate moving from I to II) and the construction industry to respond to the movement by keeping track of their quality (training), production (selecting quality subcontractors), and contractor's ability to manage their own construction (coordination of construction).

Current industry environment, industry structure analysis, and IMT identify the major causes of the shortage of skilled craftspeople in the construction industry:

1. Low-bid delivery system.
2. Lack of performance information.
3. Emphasis on project management and inspection instead of optimized business and delivery processes and contractor performance.
4.

Solution to Craftperson Shortage in the Construction Industry

The following proposals are given to solve the problem of craftsperson shortage in the construction industry:

1. Educate owners, contractors, and related industry personnel that the competitive low-bid process is an ineffective procurement process that is detrimental to the users and contractors.
2. Promote the use of performance information. Use performance information not to pre-qualify, but to impact the selection of the contractor using information systems, which minimize subjective decision-making.
3. Promote the concept of paying more for proven performance.
4. Change the emphasis from project manager to performing contractor in construction education.
5. Change the paradigm from the owner hiring the project manager to the contractor having their own project manager.

These solutions can only be implemented in construction education. Contractors who have made their living in Quadrant I are running the construction industry. General contractors have leverage in Quadrant I over subcontractors. In both Utah and Hawaii where prototype best value projects have been run, general contractors perceive that their control and leverage is threatened by moving to Quadrant II. In both states, the general contractors have proposed to the state that the performance of the subcontractors can be controlled by the general contractors and therefore making subcontractor performance lines unnecessary. This will result in the general contractors bidding the subcontractors, seeking the lowest price, and using low price as leverage. This is the same low bid system that the user or owners are using to hire the general contractor. The construction industry contains the following obstacles to moving from a low-bid to a performance-based process:

1. Large contractors who leverage price for volume, who currently have a large industry share, will have to compete with smaller contractors who have high performance.
2. No large amounts of performance information or direct process to use the performance information to award contracts.
3. Current process of low-bid (Quadrant I) is advantageous to large, long time contractors.
4. Quadrant I is designer and engineer controlled. Quadrant II is contractor controlled with minimized construction management or inspection role for designers and engineers in the construction phase. If the move was made to a performance based environment, the change from a user's construction management function to a contractor's construction management function would occur automatically. In the process, the management would also improve in efficiency.
5. Quadrant I is governed by minimum standards. These are used as minimum acceptable levels. Standards ensure that contractors and manufacturers meet the minimum or lowest level of acceptability. This gives the owner more risk than if the contractors provided products and services at a higher level of quality and performance. In Quadrant II, the best value is the highest level of performance that the owner can afford. The liability moves to the contractor who now has to ensure that the high level of performance is met. Many contractors used to doing work in the environment of Quadrant I, are hesitant on taking on the risks of performance due to inexperience with performance contracting.

Even in construction education (undergraduate and graduate programs) the task will not be easy. Construction educators are usually long time participants in the industry or engineers. The

industry is the way it is, because of its participants. Construction education programs proliferate the 'status quo' of management (engineer and designer controlled, using specifications with means and methods, and award on price) over craftperson skill. The industry must adopt the proven concepts of Deming's continuous improvement from the manufacturing sector.

Construction undergraduate and graduate education must include the following Deming principles in their curriculum (Deming, 1985):

1. Use of contractor performance information (on-time, on-budget, meeting quality expectation).
2. The study of construction industry structure and the relationship of factors of performance.
3. The study of performance based selection where the selection of contractors is based on performance information.
4. Changing the construction system to get better performance.
5. Increase performance by forming relationship between designers, contractors, and owners based on performance information and not on personal relationships.

A study of construction undergraduate and graduate education programs will find very few courses, which focus on the above. A literature review of the Associated School of Construction journal shows only two documented studies of continuous improvement of a construction environment using performance information when using the following keywords: performance information, best value procurement, performance-based procurement and construction industry structure. There is only one research group doing research on contractor performance information.

Locations of construction programs are usually in civil engineering departments or in architectural schools. The authors propose that Industrial engineering ties would be more beneficial to the construction industry based on the expertise of Industrial engineers to optimize processes, use information systems, and their performance objective orientation of not having bias toward a specific function in the process.

Conclusion

The major reasons for the shortfall of construction skilled craftspeople is the users' low-bid procurement system and the Quadrant I dominated structure of the construction industry which emphasizes management and control by engineers instead of skilled contractors and craftspeople. The analysis proposes that instead of project managers being hired by the owner to regulate the contractor, contractors should regulate themselves resulting in higher performance. Also, instead of using price as the sole determinate, owners should use value (performance and price) as the determinate. The resulting environment of performance will bring high quality constructors and craftspeople, create a demand for more quality craftspeople at a higher pay, and create an environment of higher profit, higher performance, and user satisfaction. The current concept of project management by the owner may not be optimal. Designers and engineers know design. Contractors know construction. Some designers and engineers may know more than poor

performing contractors, but high performance contractors know construction the better. This direction has led to the acceptability of less performing contractors doing more work for less profit and a lessening demand for skilled craftspeople. This has led to a severe shortfall of construction craftspeople. A major change in construction education programs, which change the thinking of the industry, must be accomplished to reverse this trend. This includes education on industry structure and stability, contractor performance and performance information, and performance based procurement.

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