STANDARD WORK FROM A LEAN THEORY PERSPECTIVE

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ABSTRACT

This paper presents a proof of concept that standard work procedures as prescribed by lean theory can be implemented within a concrete construction company.

Standard work procedures and knowledge transfer utilizing the "J" programs as prescribed by Training Within Industry and lean theory can and does reduce variability in construction processes. Variability in work processes increases the probability of breakdowns (any deviation from an expected outcome), errors and negative iteration which leads to schedule and cost overruns. Standardizing work methods reduces the probability of breakdowns, thereby improving work flow, providing a basis for learning from what breakdowns do occur, and providing a basis for experimentation with alternative work method designs.

Exploratory research with work standardization in a concrete construction division is presented, including the cultural and organizational issues that were overcome to change the current paradigm.

Two findings from this research are: 1) obtained a better understanding of what standard work procedures are and how they differ from preconceived notions, and 2) development of standard work procedures to create a baseline for continuous improvement. Practitioners can use this research to understand how to analyze processes, improve them and transfer critical knowledge.

KEY WORDS

rework, tfv, training within industry, standard work

INTRODUCTION

The construction industry worldwide is facing reduced budgets and compressed project schedules. To overcome these challenges, many individuals take to fire fighting which is focusing attention on only hot issues leaving no time to develop personnel through appropriate training. This phenomenon is known as the cycle of struggle (Liker and Meier 2007).

A majority of companies have developed training programs for their employees, so why is there such a prominence of ineffective and varied results? The following quote summarizes the current issues with organizational training.

"*Every large company has some type of training program in a large variety of areas….. Yet, go where the actual work is being done and ask people how they learned their jobs and you get a*

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different picture (Liker and Meier 2007)."

Toyota experienced a loss in quality in their Georgetown plant back in 2002 when it was rated twenty-sixth in J.D. Power and Associates quality survey. Top executives at the plant recognized the drop was caused by not following standardized work.

"*By far the biggest headache at Georgetown, is that some hourly assemblers began ignoring standardized work processes -- considered one of the biggest sins inside Toyota plants because of the impact on the consistency and accuracy of manufacturing* (Graupp and Wrona 2006)."

How can an issue that spans many industries be mitigated? The objective of this paper is to conduct exploratory research in the use of Training Within Industry techniques in developing standard work procedures within a concrete construction division of a general contractor. This paper presents consolidated literature on standard work as developed by Training Within Industry, and findings from exploratory research where standard work has been implemented.

PROJECT BACKGROUND

TRANSFORMATION, FLOW, VALUE

The main goals of production are to (1) produce products, (2) reduce costs, time, and materials for the production system, and (3) deliver customer needs based on quality, reliability and flexibility. Therefore, the knowledge and application of this theory should allow practitioners to improve their production capabilities.

Production theory can be looked at from three different viewpoints. The first is the transformation view which focuses on production as a transformation of inputs to outputs. This viewpoint suggests breaking down the entire process into smaller pieces and then optimizing each step independently of each other step (Porter 1985, Wortmann 1992).

The second is the flow view which strives to eliminate waste from the flow of processes (Gilbreth and Gilbreth 1922). The flow view utilizes principles of lead time reduction, variability reduction, and simplification (Koskela et al. 2002).

The third is the value view of production theory which seeks to maximize the best possible value from the customer's point of view (Shewhart 1931). During this time Shewhart invented the Plan, Do, Check, Act (PDCA) cycle to introduce a scientific method into industry. This theory has been used extensively in the quality movement which utilizes requirement analysis and systemized flow down of requirements (Koskela et al. 2002).

These three views must be integrated to develop a production theory utilizing the concepts of transformation, flow and value. The TFV theory of production suggests that modeling, structuring, controlling, and improving production must address all three viewpoints together (Koskela et al. 2002).

It is possible to perform the first two views very well but still fail if the product does not meet the customer needs. For example, a house can be built efficiently with little waste but if the layout does not meet customer expectations, the production system failed and rework is required.

REWORK

Iteration (rework) is wasteful if it can be eliminated without loss of value or causing failure to complete the project (Ballard 1999). Rework is classified as both positive and negative. Positive rework adds value; an example is when designs are reworked and participants in the design process leave with a better understanding of customer requirements.

The definition by Ballard is used in this research to focus on rework that does not add value to the project or customer.

Informal surveys of design teams have revealed estimates as high as 50% of design time spent on needless (negative) iteration (rework) (Ballard 1999). During the construction phase, rework extends project delivery and cost. Previous studies have found the cost of rework in design and construction to range from 2% to 12% of the contract cost (Burati et al. 1992, Josephson and Hammarlund 1999, Love et al. 2000). This is partly due to the variability in the execution of work. In light of these circumstances, how should projects be managed?

TRAINING WITHIN INDUSTRY

Due to a lack of proficient workers in the United States in 1940's and with a world war evident, the United States Government realized that something had to be done to rapidly train workers that were familiar with factory and ship building requirements. Training Within Industry or TWI was born out of this need.

"*The underlying purpose of this activity is to assist defense industries to meet their manpower needs by training within industry each worker to make the fullest use of his best skill up to the maximum of his individual ability (War Production Board 1945)*.

TWI's "J" programs were developed from the *Five Needs Model for Good Supervisors* that was created by TWI during World War II. These five needs must be met before any supervisor can be successful and distinguishes the difference between knowledge and skills. The five needs are (1) knowledge of the work, (2) knowledge of responsibilities, (3) skill in instructing, (4) skill in improving methods, and (5) skill in leading. The first two needs are knowledge based and the last three are skill based. Knowledge as defined by TWI is acquired through class attendance or literature. Skills are acquired through practice and repetition. There is an important difference between the two. For example, if you read a book on how to play golf, will you be able to actually play? Only by practicing and playing golf repetitively can a person acquire the skill and perform it well.

The "J" programs do not address the first two needs which are unique to each organization. However, the last three skills are the basis for "J" programs. Skill in instructing allows a supervisor to develop a well trained workforce which became the Job Instruction program. Skill in improving methods deals with improving the use of resources, manpower and materials leading to the development of the Job Methods program. Skill in leading which improves how a supervisor improves their ability to work with people became the Job Relations program.

In developing the "J" programs, TWI followed the four step scientific method developed by Charles Allen prior to World War I (Graupp and Wrona 2006). This gave the programs a shared common pattern as shown in table 1.

Table 1. "J" Programs Four Step Methods are based on the Scientific Method (Dinero 2005)

Steps	Job Instruction	Job Methods	Job Relations	Scientific Method
1	Prepare the worker	Decompose the job	Get the facts	Observation: Define the problem and its parameters
2	Present the operation	Question every detail	Weigh and decide	Hypothesize: Suggest a possible explanation or solution
3	Try-out performance	Develop the new method	Take action	Testing: Collect information (data) and test hypothesis
4	Follow up	Apply the new method	Check results	Results: Interpret the results of the test to determine if hypothesis is correct
				Conclusion: State a conclusion that others can independently evaluate. (Start process over.)

STANDARD WORK

Standard work is a product of the Job Methods program. It allows a process to be analyzed for its steps, key points and reasons for key points. However, to start standardizing one must classify their process according to task variety and task analyzablity. A framework for classifying work is presented in figure 1. On the x-axis is task variety ranging from low to high. The y-axis is task analyzability ranging from high to low. The lower left quadrant represents routine work which has low task variety and high task analyzability. Examples of routine work are assembly line work, fast food server, bank teller and data entry clerk. The lower right quadrant represents technician work which is high task variety and high task analyzability. Examples of technician work are inspections, material handling, lab data analyst, computer technical support work, and equipment maintenance. The upper left quadrant represents craft work which is low variety, low analyzability. The upper right quadrant represents non-routine work which is high variety, low analyzability. This paper primarily places facility design and construction within the technician and craft work from lower right to upper left, while some portions of project definition may fall under non-routine work.

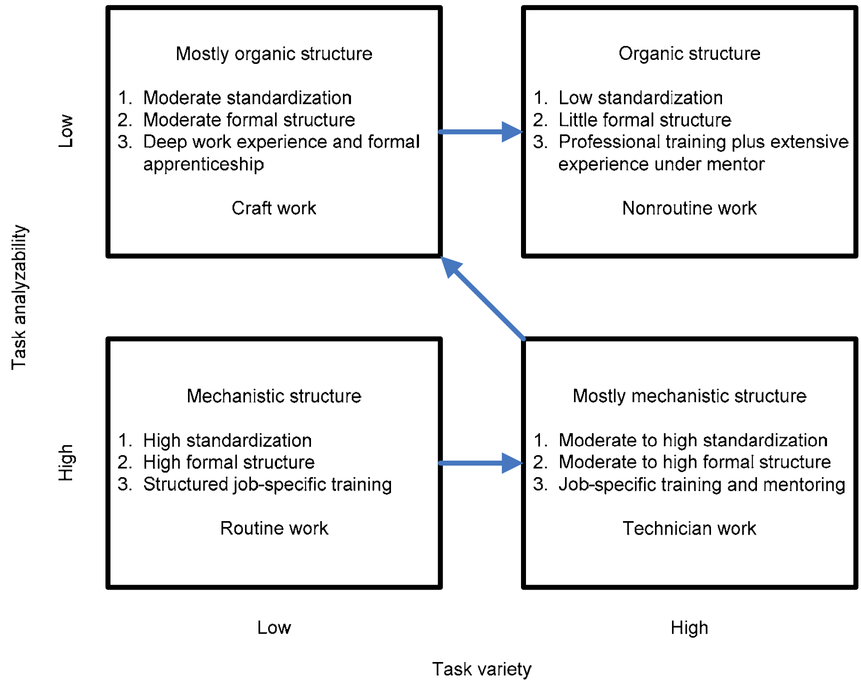

Figure 1. Classifying different jobs by the task requirements (modified from Perrow 1967)

All processes have three types of tasks: (1) routine core, (2) nonroutine core, and (3) ancillary. Routine core tasks are repeatable steps that should be annotated on the job decomposition worksheet. (Note: TWI utilizes the term breakdown instead of decomposition.) A nonroutine task is work that is necessary to support the overall work but can have multiple ways of completion (Liker and Meier 2007). Ancillary tasks are more random in nature and take place on an as needed basis.

Standardized work is not to make all tasks highly repetitive; the intent is to define the best methods and to reduce variation in the work method as much as possible (liker and Meier 2007). Repeatability is not as important for nonroutine work as it is for routine work. Focusing on the entire system is a requirement to ensure that local optimization does not occur.

To avoid over analyzing a system, tasks should be classified according to table 2. Critical work steps are vital to the product and must be performed with a high level of quality and consistency. If the critical steps are not performed well, rework may occur. Critical steps make up between 15 and 20% of the entire work. The bulk of work falls under important. The key is to (1) identify the critical steps, (2) define a best standard method, and (3) then train all personnel to that method (Liker and Meier 2007). Management should focus on the critical tasks and stress that the standard work procedures be followed. Lesser important tasks should operate within a larger defined range as long as it does not negatively affect quality.

Table 2: Decomposition of work tasks by importance (Liker and Meier 2007)

Percentage of total work	Importance	Effect on work
15 - 20%	Critical - work must be highly consistent	Definite effect on results if performed out of range
60%	Important - work must be consistent within a slightly wider range	Probable effect on results if performed out of range
20%	Low importance - work method may be variable	Not likely to effect results regardless of method

Identifying key points and reasons is a major step in developing standardized work procedures. The key points should be stated in positive "how to" language rather than in a negative voice. Five types of key points exist (1) safety, (2) quality, (3) productivity, (4) special technique, and (5) cost control. A description of each category is shown in table 3.

EXPLORATORY RESEARCH

The researcher conducted a preliminary experiment where leadership in a concrete division created the job decomposition sheets and then transferred that knowledge using the job instruction program for two junior personnel that work within the division.

The first step in conducting this experiment was to prepare the organization. This required a series of training sessions where lean theory was introduced. Once this was complete, group leadership was taught Last Planner. Once complete the researcher went into the background of standard work and its place in lean theory and Training Within Industry. Theoretical education was presented first and then how to apply the methodologies in construction were next. The group understood improvements could be made to their organization and were interested in new techniques since they experienced quality issues in the past.

Implementing these methodologies is a difficult task because personalities within the organization resist change and hold construction work in a different light. A field superintendent studying implementation of the "J" programs says:

"*In my 30 years of construction experience, I never looked at work this way.*"

Karl Goeking, personal communication, 6 Nov 07.

Table 3. Types of key points (modified from Liker and Meier 2007)

Category	Description
Safety	Primarily related to injury avoidance or repetitive stress injuries
Quality	Provide specific instructions on how to perform a task without making mistakes that cause defects
Productivity	Techniques to ensure job is performed within the correct amount of time
Special technique	Aspects of a job that require special finesse
Cost control	Methods that are necessary to maintain the standard cost of products

The leadership of the concrete division consisted of the division leader, production control manager and a field superintendent. This group has over 100 years of experience and had all worked in concrete construction prior to their current assignments. The company culture is similar to many other organizations where the emphasis is on day to day operations.

The experiment consisted of how to design a work method for legend plan detail reading. Many junior field personnel are not knowledgeable on how to read plans and understand the intent of the design drawings.

"*I didn't really know much about plans to begin with. It was good, I actually learned a lot. When I look at plans I get confused really easy...*"

Timothy Goeking, personal communication, 14 Dec 2007

While senior field personnel have learned through the years how to interpret construction plans. One responsibility of senior personnel is to identify requests for information (RFI's) from the drawings to clarify designer intent. There is a lack of proper training in this critical requirement and is the focus of the experiment. This information would then be used to transfer the knowledge to two individuals that were junior to the organization but were interested in advancing their careers within the company.

The first part is to establish the important steps, key points and reasons for each of the steps for legend plan detail reading. The goal is to understand what senior leadership looked at in developing and using design drawings in the management of a construction project. This skill is important in building to prescribed plans but also in identifying requests for information and clarification of design intent.

In conducting the experiment, the researcher's role was as a facilitator to educate the division leadership on how to follow the "J" program's methodology. He kept the team focused on identifying on the important steps that needed to be trained and helped them from trying to train too much information. During the actual training the researcher took notes of how the training followed the Job Instruction methodology, provided feedback to leadership after the experiment and interviewed each of the trainees. These experiments attempt to keep the variables of workers and design drawings the same, the variable that is changed is the approach to critical processes in which the important steps are made explicit and there is an attempt to transfer that knowledge to the field workers for implementation.

Figure 2 shows the job decomposition sheet that was created during the experiment. It follows the job methods program by first describing the name of the process to be trained. The important steps are listed using short verb/noun constructs. The key points are then listed next to each important step and finally the reasons for those key points.

Operation: Legend Reading

Tools & Materials

	Quality, Cost, Productivity, Special Technique, Safety	
IMPORTANT STEPS	KEY POINTS	REASONS
A logical segment of the operation when something happens to advance the work	Anything in a step that might -- 1. Make or break the job 2. Injure the worker 3. Make the work easier to do, i.e., "knack, " "trick," special timing, bit of special information	Reasons for the key points
Review Legend	1. Confirm meaning of abbreviations.	To understand intent of drawings
	2. Comprehension of abbreviations (typical/nontypical)	If you don't understand what your are reading it won't help you
	3. Generate questions	Sometimes other types throughout
	4. Check if only one legend (are there more legends/ID)	
	5. Read general notes for legend items	Gives you overview of the job - some things generic
2. Tab most used dwgs	1. Tab legend/civil/structural/landscape/electrical	Save time looking for most used sheets
	2. ID overview/foundation plan	
3. Apply legend in situation	1. Apply to civil/structural/landscape	Need to do all drawings - look for conflicts
4. Highlight the scope of work	1. ID obvious concrete work application	To foresee upcoming issues, keep the flow
5. Understand cuts/sections	Which area specifically does detail pertain too?	May apply incorrect detail to section

Figure 2. Job decomposition sheet for legend plan detail reading

A preliminary finding is the act of creating a job decomposition sheet, as for any process, is a learning curve. The team experienced difficulty in narrowing down exactly what needed to be included in the training. In many instances, the team developing the JBS tried to list too many items. The team had to continually refocus its efforts on a simple process and how it is accomplished. By reading the JBS alone it would be impossible to learn the operation which supports the 'show alone or tell alone' concept of Graupp and Wrona. To successfully transfer knowledge according to Training Within Industry it is imperative to follow the Job Instruction program which follows the four step method presented above. The operation must be presented three times, the first time being the important steps only. The next is to add in the key points and finally a third repetition is conducted implementing the reasons for each of the important steps. Then in trying out the performance, the operator must also conduct the process three times. First the operation alone, the second repeating back the key points and finally a third time with the reasons. By utilizing this three and three method of job instruction, the operator has a higher likelihood of learning the correct operation.

This initial training session had many benefits, but the trainer had difficulty following the prescribed Job Instruction methodology. However, this is a paradigm shift from what they are used to doing in training sessions. This process took a lot more upfront work to establish the baseline process steps. Figure 2, captures only the critical steps that were determined by the leadership team. This job decomposition structure took approximately four hours to complete. However, the time to complete fell dramatically as the team understood the difference between critical and important steps. The next job decomposition structure for bolt templates was completed in two hours.

This experiment provided valuable training to the operators:

"*Yeah, like all the abbreviations, I had no idea where to find any of the abbreviations. I didn't know what they mean, didn't know anything about that…now I know to refer back to that page with all the breakdowns. And how everything has its own meaning*"

Timothy Goeking, personal communication 14 Dec 07

One major challenge to implementing these processes is finding the time to break down the processes and conduct training sessions. The concrete division is very similar to other organizations that are still under the pressure of firefighting everyday crisis items. This comes in the forms of unexpected weather and construction changes, however, this will give the experiment more validity because it occurs under typical conditions of any facility design and construction project. The experiments are not shielded from outside influences, therefore, if successful, they can be implemented into other design and construction organizations.

SUMMARY

Standard work is a foundation of lean implementation. The process for standardizing work was developed to support the war effort in the United States back in the 1940's. Two Training Within Industry "J" programs are aimed at standard work. The Job Methods program establishes the ability to break down a process into its critical steps and forms the baseline for knowledge transfer using the Job Instruction program.

Utilizing the theory presented in this paper, exploratory research in implementing the two programs into a concrete construction division was conducted. The use of the Job Methods program in concert with Job Instruction for knowledge transfer will be used to standardize work for critical items identified in the Last Planner production system.

This research shows that the concept of standard work utilizing the Job Methods program and transferring that knowledge using the Job Instruction program is feasible in the design and construction of facilities. Preliminary findings show that implementing TWI techniques takes time and a learning curve must be overcome. However, management became more efficient on subsequent job decomposition efforts. Future experiments will utilize Last Planner to identify critical work items, incorporate a job decomposition sheet and then transfer knowledge to field personnel. First run studies will be used to test standardized methods and knowledge transfer developed using the "J" programs. This will reduce the variability of critical processes, improving reliability of workflow.

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