

# WHY LEAN PROJECTS ARE SAFER

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**Abstract:** Some evidence exists that lean projects are safer, but we don't understand why. Providing an explanation is one of the objectives of the Construction Safety Research Group formed by the Project Production Systems Laboratory (P2SL). In this paper, we describe the research program of the group and its findings in year one of three, including an explanation why lean projects are safer that is grounded in the principle: Respect for people.

**Keywords:** Lean Construction, Human Error, Research, Respect for people, Safety

## 1 INTRODUCTION

There is evidence that projects managed on a Lean basis are safer than those managed with traditional practices—(Thomassen 2003; Saurin et al. 2004; Nahmens and Ikuma 2009; Leino 2010) and we don't know why. Some facts: 20% of all industrial deaths occur on construction projects. A construction worker over a 45-year career has a 75% chance of experiencing a disabling injury and 1 in 200 chance of being fatally injured on the job according to data presented at the American Public Health Association's 139<sup>th</sup> Annual Meeting<sup>4</sup>. According to the U.S. Occupation Safety and Health Administration (OSHA<sup>5</sup>), 4,386 worker fatalities in private industry was reported in 2014 and 899 of those were in construction. The leading causes of worker deaths were reported to be falls, electrocution, and being struck by or caught between objects account for the vast majority (60.6%) of these deaths in 2014. Eliminating these fatal four could save 545 workers' lives in the United States every year. This tragedy happens every year despite safety programs, OSHA inspections and training, stand-downs, posters and project safety officers. This research proposal moves beyond motivation and training to find a different perspective, a new approach that increases productivity and reduces harm.

## 2 CONSTRUCTION SAFETY RESEARCH GROUP

In order to rethink safety management and explore links with lean philosophy and methods, P2SL formed a Construction Safety Research Group in April 2016. Eight

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<sup>4</sup> <http://www.safetyandhealthmagazine.com/articles/construction-workers-experience-higher-rates-of-injury-premature-death-study-2>

<sup>5</sup> <https://www.bls.gov/iif/oshwc/cfoi/cftb0294.pdf> Accessed March 5, 2017

general contracting firms are participating, with one outside the U.S. The fundamental objectives of the group are adopted from Mitropoulos et al., 2005:

- 1) to figure out how best to prevent putting people into hazard, and
- 2) recognizing that there will inevitably be plan failures, to figure out what can be done to prevent injury when people are put into hazard.

After 8 months of reading, observing and discussing, we have found what appears to be a fundamental reason why lean projects are safer: When projects live by the lean principle *Respect for People*, they reduce the frequency with which construction workers are placed in hazardous situations, and they reduce the frequency with which they are harmed when they do find themselves in hazardous situations.

This paper explains how Respect for People improves safety on construction projects, both through planning and preparation, and through intercepting errors before they cause harm. The explanation is plausible and is grounded in academic research: Behaving in accordance with the principle promotes psychological safety, which has been shown to promote learning behaviors in work groups, which in turn promotes improvements in group performance (Edmondson, 1999; Chan et al. 2003; Bossche et al. 2006; Carmeli and Gittell 2009; Mossman 2015).

The sections of the paper after this point are 3) the lean principle *Respect For People*, 4) Preventing Construction Workers From Getting Into Hazardous Situations, 5) Preventing Construction Workers Who Get Into Hazardous Situations From Being Harmed, 6) How Respect For People Improves Safety, 7) Conclusions and 8) References.

### 3 RESPECT FOR PEOPLE AND PSYCHOLOGICAL SAFETY

Respect For People is a fundamental lean principle applicable to all types of organizations and production systems, both project-based and non-project-based (Ohno, 1988; Oppenheim et al. 2011; Cardon and Bribiescas 2015). In Liker's presentation of the principle, it is understood to mean challenging and helping workers and suppliers to improve their capabilities, particularly in problem solving and process improvement (Liker, 2004).

#### 3.1 Psychological Safety

The construct *psychological safety* was developed by Professor Amy Edmondson, who validated the hypothesis that 'learning behaviors mediate between psychological safety and work group outcomes' in Edmondson (1999). Bossche et al. (2006) reported that psychological safety is crucial for the engagement of learning behaviours in teams, which leads to better team performance.

Edmondson's video, titled Psychological Safety<sup>6</sup>, starts with a story about a nurse on night duty in a hospital. She is taking medication to a patient, but becomes concerned when she sees the dosage, which is very much higher than normal. She thinks to herself "Maybe I should call the doctor and ask if this is the correct dosage." Then she remembers how that doctor reacted when she questioned one of his decisions before, and begins to talk herself out of calling—"Well, this patient is undergoing an experimental treatment. Perhaps the dosage is appropriate after all." She doesn't make the call.

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<sup>6</sup> <https://www.youtube.com/watch?v=LhoLuui9gX8>

The doctor's behaviour discourages subordinates on the medical team from speaking up; in this case, speaking up about the possibility of an error. It seems apparent that she and others on the medical team would also be reluctant to share ideas about better ways of working.

We propose that behaving in accordance with the lean principle of Respect For People promotes psychological safety and hence work group performance, including construction safety, through the impact of individual and team learning behaviors. We further propose that learning behaviors reduce injuries and occupational illnesses by reducing the frequency and extent of differences between work situations as planned and those situations actually encountered during execution. And lastly we propose that learning behaviors reduce injuries and occupational illnesses by increasing work groups' abilities to 'catch' errors before they cause harm.

We provide arguments for these proposals in the following sections.

## 4 PREVENTING CONSTRUCTION WORKERS FROM GETTING INTO HAZARDOUS SITUATIONS

There appear to be two basic ways to 'engineer out' hazards, through design of the product to be constructed and design/execution of the construction process:

1. Prevention through Design (Gambatese et al. 2005; Manuele 2007; Toole and Carpenter 2011).
2. Task Planning<sup>7</sup> (Mitropoulos and Cupido 2005)

### 4.1 Prevention through Design

Prevention through Design is an initiative of the United States' National Institute for Occupational Safety and Health (NIOSH), defined as: "PtD encompasses all of the efforts to anticipate and design out hazards to workers in facilities, work methods and operations, processes, equipment, tools, products, new technologies, and the organization of work. The focus of PtD is on workers who execute the designs or have to work with the products of the design. The initiative has been developed to support designing out hazards, the most reliable and effective type of prevention. PtD aims to eliminate hazards and control risks to workers to an acceptable level "at the source" or as early as possible in the life cycle of items or workplaces."<sup>8</sup>

### 4.2 Task Planning<sup>9</sup>

The planning of construction tasks starts in the design phase, following the lean principle to design both product and process simultaneously. Product design leads, but only in the role of first person to speak in a discussion. The 'level of detail' criterion in process planning is fitness for purpose; i.e., sufficient that the constructors are confident they can build the product design safely and to quality requirements.

Refinement and further elaboration of process design occurs nearer in time to execution; first in planning for each construction phase (pull planning), then just before

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<sup>7</sup> For lack of space, we omit the common safety management methods such as enforcing rules, use of visual warnings and correcting unsafe conditions.

<sup>8</sup> <https://www.cdc.gov/niosh/topics/ptd/> accessed 12/27/2016

<sup>9</sup> This section is derived from Ballard and Tommelein 2016.

execution, the responsible foreman and crew agree individual roles and adjust the plan for context (weather; concurrent work; access and egress routes for workers, materials, equipment; the skill sets of workers assigned to the task, etc.). The key elements of effective task planning are these:

- Product and process design are done together
- The people directly involved in doing the construction work are the ultimate process designers
- Processes and operations are designed for quality, safety, time and cost; not separately for each.

## 5 PREVENTING INJURY WHEN CONSTRUCTION WORKERS DO GET INTO HAZARDOUS SITUATIONS

Safety theorists such as Rasmussen (1997) and Perrow (2011) argue that workers will find themselves in hazardous situations despite all attempts at prevention. The challenge then is how to get them out of such situations without harm to themselves or others. The commercial aviation industry, among others, has developed methods for ‘catching’ and defusing errors before they cause harm (Leiden et al. 2001). In her research on medical teams, Edmondson (1999) found that team members who feel psychologically safe voice more concerns about the safety of patients or colleagues, and yet commit fewer medication and other errors than medical teams who don’t feel psychologically safe with one another and with their supervisors.

### 5.1 Stopping the Line

Sidney Dekker argues that the systems within which work is performed are not inherently safe, and that work as found never exactly matches with work as planned (Dekker 2014); a way of saying that ‘designing out’ hazards cannot be fully achieved. Whether this is or is not always the case, the possibility of a difference makes it necessary that direct workers have the authority to ‘stop the line’ when they detect such mismatches between plan and actual (Howell et al. 2002). This may happen before execution begins, as when a foreman or craftworker examines the work location and finds an unexpected obstacle or hazard. It may also happen during execution, as the progress of the work reveals or produces a hazard.

It is becoming more common that construction projects have a stated policy that anyone can stop the line when they have a concern for safety. Some distribute Safety Training Observation Programme (STOP) cards (DuPont 2017) and promise no retribution for using them, including protection from retaliation by supervisors.

## 6 HOW RESPECT FOR PEOPLE IMPROVES SAFETY

We propose that behaving in accordance with the lean principle Respect for People improves safety by creating the feeling of psychological safety needed for learning behaviors within construction crews and project teams that result in these outcomes:

- design of products that are safer to construct
- reduced frequency and extent of differences between construction work as found and work as planned

- higher frequency of direct workers stopping the line when they have a concern for the safety of themselves or others

Appealing again to the work of Edmondson, here is what she lists as “learning behaviors” (Edmondson, 1999):

- Asking for help
- Talking about errors
- Seeking feedback
- Sharing information
- Experimenting

The causal relationship between these behaviors of team members and outcomes is perhaps sufficiently apparent, but a bit more explanation may be helpful. Consider the team of designers and constructors working together to create a design for a product that meets the needs of its users within the constraints of the buyer, and that also is safe to construct. Experience has shown that success requires that the team ‘ask for help’, ‘talk about errors’, ‘seek feedback’, etc. They must work together as a team; which is very different from the old-fashioned idea that constructors could assure “design constructability” by acting as inspectors of product designs already produced.

As for reducing the difference between work as found and work as planned, a project team and construction crews functioning as learning organizations is vital. The activities of learning organizations are visible in pull planning, in speaking up when there is a possibility that a constraint cannot be removed in time for task execution, in foreman and crew putting the finishing touches on a plan for the day, and in crew members working together to figure out how to move forward with task execution safely, even if that involves stopping the line.

## 7 CONCLUSIONS

Arguments have been offered for the claim that Lean projects are safer because they follow the lean principle *Respect For People*, which creates the feeling of psychological safety within the project team, which in turn is a precondition for individual and team learning behaviors such as experimenting, requesting feedback, talking about errors, and asking questions. These learning behaviors have been shown in academic studies to result in improved team performance. The specific mechanisms proposed for improving safety are better planning and increased agility in recognizing and reacting to plan inadequacy. Better planning results in reduced frequency and extent with which work as found during execution differs from work as planned. Agility in reacting to plan inadequacy is evident in the frequency with which errors are identified and ‘defused’ prior to causing harm, and in the success of countermeasures preventing reoccurrence.

### 7.1 Limitations and Future Research

A number of hypotheses have been proposed and arguments provided for them, but the hypotheses need to be tested and the causal mechanisms in the chain from ‘Respect For People’ to ‘reduced harm’ need to be further elaborated in future research.

Of special importance is the role supervisors play in creating or impeding psychological safety. Rother (2014) and Mann (2014) connect Standard Leader Work with activating the principle *Respect For People*. Empirical research is needed to



understand how the role of construction industry supervisors at every level, from foreman to project manager to company executives, is understood and what is being done to develop the knowledge and skills they need to carry out their roles. If Rother and Mann are correct, supervisory behaviour is the link between lean principles and the economic, environmental and social outcomes that come from continuous learning and continuous improvement.

The more general issue that needs further research is the relationship between safety and the lean philosophy of organizational management. Lean has most often been associated with economic benefits, with less research done on the environmental and social elements in sustainability. Do current formulations of the lean ideal adequately capture these relatively neglected benefits? The same question applies to current formulations of lean principles, which are intended to serve as guides to pursuit of the ideal. We hope to have made a contribution to the inquiry into these questions, but do not pretend to have settled them.

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