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The Evolution of Lean Construction Education at US-based Companies

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Abstract

Question: How are US-based companies training their employees and project team members in lean construction / lean project delivery principles and techniques?

Purpose: To identify potential commonalities in practices used by leading US-based organizations/companies to train project team members in lean construction / lean project delivery.

Research Method: Researchers conducted semi-structured interviews with company representatives to determine the specific practices employed in preparing stakeholders for participation in lean projects. We surveyed a cross-section of established construction firms, design firms, and consultants to identify best practices currently in use.

Findings: This study found that while there are some similarities in how trade associations, companies, consultants, and owner organizations are managing lean training, there are substantial variations in the design of training programs and approaches. This indicates that best practices in lean training are still emerging.

Limitations: The sample of organizations contacted was relatively small, only comprising companies known to maintain active lean construction programs. Due to the relative novelty of lean construction, training programs are not a standard requirement across the industry.

Implications: Companies that have successfully implemented lean in project delivery have developed best practices in training within their own organizations/companies, and these practices have been identified in this study. Their lessons learned can provide guidance to other companies that wish to begin implementing lean on their projects.

Value for Practitioners: This paper provides case study examples to organizations wishing to adopt lean practices.

Keywords: Lean construction education, Lean Construction Institute (LCI), Associated General Contractors (AGC), CM-lean certificate, coaching

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Introduction

The purpose of this study was to investigate some of the most active lean construction education programs developed and maintained by US-based, Owner, Architect, Engineering, and Construction (OAEC) stakeholders. The following sections provide case study examples of lean educational initiatives offered within the industry, at the Lean Construction Institute (LCI), and the Associated General Contractors (AGC), as well as strategies used by lean company champions and independent lean consultants.

The underperformance of the construction industry is well documented (Koskela 1992, 2000; Teicholz 2001; Eastman et al. 2008; Forbes and Ahmed 2011, 2020). In particular, a well-known McKinsey Global Institute study identified a growth rate of 1% annually in the construction industry during a defined 20-year period compared with 2.8% for the total world economy and 3.6% for manufacturing (Bughin et al. 2017).

Lean construction emerged as a response to frustration with low construction productivity, errors, delays, cost overruns, and safety. However, a survey from a 2013 report by McGraw Hill revealed that major challenges to implementing lean on a job site include: (1) lack of lean knowledge, (2) lack of sufficient support, (3) perception that lean is too complex, (4) employee resistance, and (5) lack of industry support (McGraw-Hill Construction 2013). Despite these challenges, the OAEC industry has steadily worked on lean implementation, and a decade later, practitioners have noted that the benefits of lean implementation include improved safety, higher customer satisfaction, high-quality construction, reduced schedules, reduced costs, greater profitability, and better risk management (McGraw-Hill Construction 2013).

Methodology

We applied a qualitative case study methodology to identify strategies used by frontrunner OAEC stakeholder companies to impart lean practices to employees and project teams. This involved semi-structured interviews with company representatives to determine the specific practices employed to prepare staff and other stakeholders for participation on lean projects. Fourteen individuals from eight organizations were interviewed as subject matter experts by email and/or conference calls. The selected OAEC organizations are known for leadership in lean construction projects. In order to establish a common frame of reference and to identify possible best practices, the respective organizations were asked the following questions:

- What is the company's mission statement/corporate philosophy?
- How did your company get started with lean? Why?
- How did you personally become involved with lean education?
- How are you training your employees?
- What do they read, if anything?
- What games/simulations do they play, if anything?
- What do you think are the most valuable tools you implement?
- How much time do you devote to training? Is training a "one-shot deal" or recurring?
- To what extent do you train your trade partners, if at all?
- What do you think are the greatest barriers to implementation in your company?

- What do you think are the greatest barriers to implementation in the industry?
- Has lean been incorporated into your company's guiding principles/values? If so, how?

Findings

While the above questions did not apply equally to all respondents, summaries of their responses are included below, as appropriate.

Trade Association 1: Lean Construction Institute (LCI)

The Lean Construction Institute (LCI) was founded by Greg Howell and Glenn Ballard in 1997 "as a way to develop and disseminate new knowledge regarding the management of work in projects" (LCI 2017a). LCI offers a variety of educational resources, including organizing the LCI Congress which rotates to different cities on an annual basis. LCI provides educational resources to 31 Communities of Practice throughout the US, and hosts Internet-accessible webinars, lean coffees, and happy hours. It publishes and distributes educational books for purchase, including Seed (2015), Hill et al. (2016), Tommelein and Ballard (2016), and Macomber and Davey (2017). It makes lean simulations available for purchase, including the Make-a-Card-Game (i.e. a variation of the Lego Airplane Game), the Parade of Trades, and Silent Squares (LCI 2017 b, c, & d). LCI also publishes the open-access *Lean Construction Journal* (LCJ). Since 2003, LCJ articles have made peer-reviewed experimental results and case studies from academics and industry-related research partners freely available (LCJ 2017).

According to Executive Director Dan Heinemeier, although LCI has chosen not to develop its own certification program, it partners with the Associated General Contractors organization (AGC), which offers a standardized lean construction course and examination and awards a certificate for successful completion (AGC 2017). LCI's Education Programs Director Kristin Hill stated that the LCI approach to lean Construction education is to enhance awareness through its annual LCI Congress and Design Forum events. Based on recommendations from LCI's Education Committee, several learning modules were rolled out locally (up to 5); they are offered face-to-face and designed to be interactive. The curriculum includes simulations in the "Introduction to lean" class, such as the *Parade of Trades* and the *Make a Card Game*. There is also an exercise that simulates forming a project team and collaboratively learning in a Big Room event. The Target Value Delivery (TVD) module simulates interactions within a project team as they go through a project and seek to lower costs.

LCI's corporate membership includes approximately 35 to 40 owner-member companies, including Procter and Gamble, Intel, and Universal Health Systems (UHS). Four or five representatives sit on the LCI Board. LCI provides incentives to member companies such as having a complimentary (a) "Introduction to Lean" presentation, or (b) attendance of one employee at the Annual Congress. Thus, owners have begun to wield influence in the development of LCI's priorities, which is arguably desirable for increasing construction industry demand for the application of lean principles. According to Heinemeier, one measure of LCI's success is its expansion from fewer than 100 member companies in 2013 to over 200 in 2017, and growth from approximately 800 LCI Congress attendees in 2014 to over 1500 attendees in 2017. Almost two-thirds of Congress participants also attend lean

training courses while there (Dan Heinemeier and Kristin Hill, personal communication, November 7, 2017; Konchar and Mahshum 2017).

Trade Association 2: Associated General Contractors (AGC)

Effective lean implementation requires collaboration by multiple project stakeholders who understand the principles, practices, and spirit of lean construction. Recognizing the enormity of the educational task vis-à-vis the OAEC stakeholder community, former AGC president Chuck Greco engaged Tariq Abdelhamid of Enovio Consulting from 2009 until 2013 under a research contract with Michigan State University to embark on the development of a standardized lean construction education program. Abdelhamid's initial four units, as well as drafts for subsequent units, have since expanded to comprise an interactive 50-minute "Lean 101: Foundations of Lean Construction" web-based introduction and a 35-hour in-seat modular educational program.

Approximately 118 lean construction specialists associated with local AGC chapters throughout the US teach the seven units. The units are taught "in-seat," meaning the sessions are delivered in a bricks-and-mortar (versus on-line) setting. Although each instructor presents the material in a slightly different way, he or she typically structures the course to align with specialized AGC textbooks; they also administer many of the same simulations. For example, lean consultant Colin Milberg is one of the instructors who regularly deliver the course for the Boston area AGC. While he sometimes presents the material as a weeklong block, Milberg prefers to teach on Fridays with "off-weeks" in between. Typically, Milberg consolidates Units 1 & 2 and 3 & 4 into two separate full days, whereas Units 5, 6, and 7 are offered as "standalone" days. During Units 1 & 2, participants encounter the concepts of flow, variation, and bottlenecks and play the Lego™ Airplane Game (Visionary Products 2008) and Parade of Trades (Tommelein et al. 1999). In Units 3 & 4, they are introduced to pull planning and Last Planner® by participating two simulations: the DPR Pull-Planning Game (King 2011; Tsao et al. 2014) and Villego® (Villego 2017). In the remaining units, Milberg introduces the principles of visual management, transparency, supply chain management, cross-docking, A3s, target value design, root cause analysis, the lean triangle, co-location, *kanban*, Choosing by Advantages (CBA; Suhr 1999), PDSA (Plan-Do-Study-Act), etc. Participants play additional simulations including the 5S Numbers Game (Superteams 2016) and the Marshmallow Challenge by Wujec (Wujec 2012; Colin Milberg, personal communication, November 20, 2017).

After completing all seven modules, students are encouraged to take a four-hour, 150-question multiple-choice test. If successful, they are awarded a certificate. According to AGC's Curriculum Development Director, Warren Kiesel, 600 people earned the credential between the program's inception in October 2015, and November 2017. At the 2017 LCI Congress, all 35-seated courses were completely sold out. It is clear to Kiesel that as soon as AGC offered the lean certificate credential, the program took off, observing that "people want to take the course as fast as they can." He also notes that construction activity in the US is back to pre-downturn levels, but is being accomplished with 13% fewer workers in 2017. He thinks this increased productivity may be related to a heavier emphasis on pre-design activity, BIM, and pre-fabrication. Lean project adoption seems greatest among owner organizations such as hospitals who have to live with the finished facilities. Speculative builders seem less interested; they apply heavy price pressure in the acquisition of design and construction services. Their market may be less sensitive to the

improved functionality and quality that lean projects typically offer (Warren Kiesel, personal communication, November 14, 2017).

Company 1: General Contractor: J.E. Dunn

A number of companies have invested in developing their own lean champions to guide their organization's lean journey. JE Dunn is such a company. Rebecca Snelling joined JE Dunn in 2012 after working as a lean consultant with lean construction pioneers Hal Macomber and John Draper, bringing the company substantial savings on several projects. Snelling said the company decided to engage her on a permanent basis instead of a project-by-project basis. Five years after launching a career with JE Dunn, Snelling has grown her lean division staff to ten employees who are responsible for training the company's project team members in lean. She says JE Dunn is not using the AGC training program at this time, preferring to offer their own tailored form of instruction.

Snelling said she typically introduces lean to employees by facilitating the Lego™ Airplane Game, the Parade of Trades, and Silent Squares. On a typical project, every member of the project team, including trade partners, is provided with a one-day training class that focuses on lean thinking and the specific tools that a project will use. Additionally, all employees (project and non-project) go through a one-day lean training that is focused on lean principles and tools that they can apply to their own work. With regard to support, Snelling's team typically guides a project team in lean facilitation at project inception. Rather than teaching pull planning using the DPR blocks game or Villego® for example, Snelling demonstrates the process to a superintendent or project manager (PM) on an actual project in three ways: firstly, by facilitating a pull plan in front of a superintendent or PM; secondly, by co-facilitating a pull plan with the same superintendent or PM; and thirdly, by observing the superintendent or PM administer a pull plan on his or her own. Snelling then provides feedback in a plus-delta format.

Team members develop a variety of skills which they can then implement on tap; some people are very knowledgeable about lean-integrated project delivery, and others about the Last Planner System (LPS)®. They are dispatched to different project locations; two members help to provide content on procedures for the company. Notification is sent to all project teams of all the latest techniques. In staffing the team, talent is drawn from different sources: some are former project managers or superintendents, while others have prior experience in manufacturing. Snelling guides participants on ways to effectively teach lean to others. She remarks: "These people do not grow on trees." During hiring, she said she looks for rising stars who are both humble and curious (Rebecca Snelling, personal communication, November 7, 2017).

Company 2: General Contractor: DR Construction

DPR Construction has been active in shaping lean thought through the pioneering involvement of Dean Reed and his interaction with Stanford and UC Berkeley during lean construction's formative years. East Coast Leader of Lean and Project Executive, Chris Dierks, is a strong believer in workshops and focuses participants on what it means to have a lean mindset. Projects start with teaching and learning and Chris plans these activities to best match the dynamics of a project by varying the duration and agenda. A project with a smaller overall duration may need only one short workshop, while others may work best with multiple half-day or full-day workshops. There is much emphasis on helping team members bond. DPR's commitment to lean is evidenced by having these activities whether

or not the owner asks for a project to be lean. The curriculum typically includes Silent Squares, the Airplane Game, and the DPR Pull Planning Exercise.

DPR stresses establishing Conditions of Satisfaction (CoS) and defining value; owners' representatives are almost always included, as are the key trade partners. The process is sometimes leveraged by having a knowledgeable trade partner lead portions of the training; different stakeholders specialize in leading walks or presenting the Last Planner System® of production control, for example, while being active participants on projects. "Go and See" projects are considered to be important and special recognition is given to project teams that are succeeding and they create a platform for transferring knowledge to other project teams and individuals.

DPR's employee lean training involves simulations including the Lego® Airplane Game, Silent Squares, and the DPR Pull-Planning Game (Visionary Products 2008; LCI 2017d; King 2011; Tsao et al. 2014). Interestingly, although they encourage their employees to take the AGC lean course and occasionally teach local classes, DPR has departed from focusing on tools and has instead turned its attention to an emphasis on leadership, exposing its employees to a nine-week program called "Lean Leadership" where the largest focus is on building teams. Cory Hackler the "West Coast Leader of Lean" and Erika Byse guide 20 to 30 people at a time with two to three courses being offered simultaneously. Students are asked to build individual radar charts to plot personal strengths, as well as areas in which they can improve. They are then encouraged to find someone who scores highly in an area in which they feel they need to improve, in order to learn from that individual. The success of the program is borne out by the fact that 220 people are waiting to take the course. In post-course evaluations, 100% of the attendees have recommended the course to others.

With regard to performance metrics, DPR is studying past projects to determine which ones are the most relevant. Hackler and Byse concur that DPR is intensifying its focus on the "respect for people" part of the definition of lean construction (Erika Byse, Chris Dierks, Cory Hackler, and Dean Reed, personal communication, November 21, 2017).

Company 3: General Contractor: Linbeck Group, LLC

The Linbeck Group based in Texas is one of the earliest general contractors to experiment with lean construction. According to Stewart Trapino, in 1968 Leo Linbeck Jr. responded to a client's urgent request to reduce cost and schedule. He fortuitously uncovered many of the principles that now are associated with the integrated project delivery (IPD) approach: early involvement, collaboration, openness concerning cost, target costing as a method (vs. value engineering), and a commitment to providing the best value" (Stewart Trapino, Email Communication, January 4, 2018). In 1998, Leo Linbeck III formally introduced lean as a management system to the company, having met Greg Howell and Glenn Ballard while completing his MBA at Stanford. The Lean Construction Institute worked with Linbeck to implement the Last Planner System® of Production Control (LPS®) on a project for Rice University—a move which led to LPS® being used on every Linbeck project until 2012. However, because of the perceived complexity of LPS®, Linbeck's management struggled to convince its employees to fully implement it. It was at this time that the company's management developed its "Lean Boards" system as a way to simplify LPS®. The boards were inexpensive and could be packed up in a suitcase at the end of a job. They provided a platform to support pull planning, daily huddles, percent-planned-complete (PPC) tracking, and accountability.

In a 2014 company meeting, Paul Akers encouraged employees to read his book 2-Second Lean (Akers 2014) and use their cell phones to create "before and after" videos recommending opportunities for improvement on site. The company hosts a spoof of the Academy Awards at their annual meeting and presents video winners with small "Bobble head" statues in lieu of the Oscar statuette. The videos are posted on the company website for others to see (https://www.linbeck.com/lean), and new employees are asked to watch the videos so work improvements can be adopted and standardized. Additionally, all Linbeck employees are encouraged to complete the AGC lean education program and demonstrate that they have mastered Lean Boards, make and share at least one lean video, and teach one or more AGC lean units (Stewart Trapino, personal communication, January 4, 2018).

Project manager and company lean champions Sean Sachtelben and David Noonan say lean is deeply embedded in the Linbeck culture. They put great emphasis on combatting the eight wastes of lean (the eighth defined as "unused employee genius") and Sachtelben and Noonan carry a list of the eight wastes on a pocket card as a constant strategic reminder. The two tools they use most often include: (1) pull planning, and (2) lean board tracking. All Linbeck projects are pull-planned and involve posting a master (milestone) schedule, phase schedule, two week-lookahead plan, and weekly work plan. Lean board tracking charts are posted to a white board on casters instead of a job trailer wall so it is made readily available wherever workers are engaged at any point in time.

Sachtelben and Noonan said they stress to employees that lean is simple. For example, as project managers, they move the dumpster and locate portable toilets to areas that are convenient for their workers, reducing the waste of unnecessary movement. They store tools in easy-to-find gang boxes so "$25/hour workers don't repeatedly waste 20 minutes searching for equipment." Since many construction activities are repetitive, small improvements done over and over again lead to substantial savings in time and money. Sachtelben also said Linbeck has a number of project managers who rotate as lean champions. They travel to one another's site locations (e.g. Houston, Dallas, etc.), buy drinks for attendees and exchange "ideas that work" (Sean Sachtelben and David Noonan, personal communication, November 28, 2017).

Company 4: Architecture Firm: Boulder Associates

Several architects have begun experimenting with the application of lean construction methods to design thinking. According to Todd Henderson, a principal at Boulder Associates, Romano Nickerson, also a principal, began experimenting with applying the Last Planner® to design. Nickerson was an early advocate of lean who sought to remove waste from his own work. For Henderson, a turning point came when Nickerson shared a graph of staff working hours with his colleagues; three-quarters of the staff were accustomed to working on Saturdays and Sundays. Following application of the Last Planner®, workflows steadied and staff found they were then able to spend weekends away from the office. The method spread laterally at a grass roots level via staff members assigned to multiple projects who then "mentored up" to managers. Company directors recognized the positives in lean thinking and adopted the "Work Plan"—Boulder's lean initiative. Despite the 2009 recession, and a downsizing of nearly one-fourth of their staff, Boulder Associates doubled their profits.

Henderson explained that as an office, they have read and discussed Liker's *The Toyota Way* (2003) about six times. In truth, they are finding it difficult to sustain lean

processes, and do observe themselves backsliding at times. As a design firm, Henderson admits they are discovering that Agile and Scrum, which are heavily practiced by the software design industry, may be a better fit for the "loopy" iterative process of architectural design than the Last Planner® System. The LPS® seems better suited for the more linear processes used by general contractors (Todd Henderson, personal communication, November 11, 2017).

External Lean Coaches / Consultants

Hal Macomber is an example of a lean construction pioneer who has offered a solid foundation for next-generation lean consultants, including the likes of Rebecca Snelling (now at JE Dunn), Colin Milberg (now founder of ASKM Associates), and Cynthia Tsao (now a lean coach, educator, and researcher at Navilean LLC and Building AEC Learning, Inc.). Macomber has made critical contributions in the development of lean practices that have now become mainstream. They include Study Action Teams (SATs), as well as several ideas seminal to lean construction, including Reliable Promises as part of language action theory. He also co-authored with Greg Howell the "Five Big Ideas" for corporate pioneer Sutter Health in the early 2000s as they embarked on a major construction program and took a leap of faith with the then emerging lean methodology. The ideas were embodied in an Integrated Form of Agreement (IFOA) and ultimately in AGC's Consensus Docs. Hal's contributions also include the "Good 5 Why" process. He spent time in Japan in the mid-1980s as part of a program with the Japan Union of Scientists and Engineers (JUSE) that exposed him to total quality and time-based management. Although he since consulted for various technical industries, Macomber ultimately chose to focus on construction, and the 2017 Macomber and Davey book, *The Pocket Sensei*, reflects the Japanese influence.

What is especially interesting about Macomber's recent work however, is that instead of being interested in lean tools, he is most concerned with *kata*—a practice involving personal reflection which leads to continuous improvement. Reflection means an individual observes what he or she is learning, and because of this, continuous improvement becomes automatic, almost involuntary. For example, if a kata-enlightened staff member at Toyota spies a stray paperclip on the floor, s/he will pick it up without being told; if a diploma in an employee's office is misaligned, another employee will straighten it without being asked. Macomber argues that few companies now claiming to be lean actually are because most are missing a type of automatic, "muscle-memory" form of continuous improvement which is key to a true organization-wide lean culture. If his observation is correct, kata may help resolve the difficulty expressed by several companies of maintaining lean within their organizations long-term. In fact, kata may serve as the interstitial glue that holds together the parts of the elephant we call lean (Hal Macomber, personal communication, November 22, 2017).

Owner Organizations

James Pease (now Executive Director of Design and Construction at UCSF) was a Regional Manager with the Sutter Healthcare Organization in Northern California and led a team of 7 Project Managers who manage approximately 100 projects valued at $350 M in the greater Sacramento Area. Sutter is a healthcare provider/insurer with roughly 53,000 employees. Their mission is to enhance the well-being of individuals in the communities served through a not-for-profit commitment to compassion and excellence in healthcare

services. Their vision is to lead the transformation of healthcare to achieve the highest levels of quality, access, and affordability.

Sutter's lean journey started as a need to meet a California Senate Bill that required the replacement of most of their hospitals starting in the late 1990's. Having had limited success with earlier projects, Sutter eagerly sought new approaches to delivering an estimated $7 billion program in the early 2000's and were led by their construction attorney Will Lichtig to seek guidance from Greg Howell and Glenn Ballard. Dave Pixley, the Director of Construction, embraced the idea of lean construction and saw significant success with the first projects that used lean. Subsequently, most projects have been lean based, and designers and contractors on these projects are guided by lean principles. One provider, Herrero Builders, through Paulo Napolitano, created a Lean training program for their partners and clients on an IPD project.

Building on these successes, Sutter appointed Digby Christian as Director of Lean-Integrated Project Delivery; Christian leads a five-day Lean and IPD training for all project managers and project controllers. Sutter has developed in-house resources for IPD best practices; specific Last Planner® and Target Value Design concepts are usually taught through LCI meetings or conferences. Sutter also often hires consultants to get new project teams started; project teams have been using study action teams on readings such as "4 Phase Project Delivery," *The Toyota Way*, and *Getting the Right Things Done* (Liker 2003, Dennis 2006). They have simulated pull planning with the DPR Block Game and played Parade of Trades, Silent Squares, and Villego®. They devote one day monthly to training for their staff although it is primarily process-driven.

Last Planner® training and education are administered at the start of projects, and include design and construction partners. Trade partners are also picked based on their prior lean experience and abilities. The majority of the training is hands-on at the project level. Christian's training is a one-shot activity for each Project Manager and they are working on a follow-up to that program.

With regard to implementation barriers, projects tend toward chaos and it takes work to keep them organized. When under stress, teams regress to traditional behavior. Keeping focused on training and improving is tough with aggressive deadlines and cost targets. Pease notes that medical departments in the hospital are also embarking on lean initiatives to streamline healthcare operations and lower costs.

Overall, the dedication to Lean from the internal construction administration structure has proven to be successful in creating a lean culture, and in engaging the services of providers who are highly capable. Their efforts also serve as a catalyst for the adoption of lean principles and sustaining high-performance levels in construction projects. Support from the administration, including that of Christian, Pease, and others, can help prevent backsliding from project team members to traditional behaviors (James Pease, personal communication, February, 2018).

Conclusion

This paper describes LC teaching approaches in the OAEC community, including LCI, AGC, design firms, construction organizations, and training consultants.

Results of this study of lean construction leaders in the U.S. provide valuable lessons for the construction industry on ways to improve lean deployment. The findings suggest

that many OAEC stakeholders view lean as providing enough of a competitive advantage to make formal lean training worthwhile.

As reported by the LCI, interest in lean construction and IPD has accelerated in recent years with a growing interest in the training that is offered at LCI conferences. Attendance at the annual LCI Congress has expanded from 800 in 2014 to over 1500 in 2017. Almost two-thirds of the participants attend scheduled training sessions; dedicated "training days" have been extended from one day to two. LCI reports that all of the 35 seated courses that were offered by LCI and AGC were over-subscribed.

Construction professionals appear to be actively seeking the AGC's CM-Lean credential, with 600 certifications earned between its inception on October 2015 and November 2017. The curriculum director of the AGC's seven-unit training program cites the effectiveness of several serious games and simulations such as: the Lego Airplane game, the Parade of Trades, the DPR Pull-Planning game, Villego®, the 5S Numbers game, and the Marshmallow Challenge. The training program mirrors the approach used in academia with reinforcing such foundational concepts as visual management, transparency, supply chain management, cross-docking, A3s and root-cause analysis.

Construction organizations have been adopting the model of internal lean champions as exemplified by DPR Construction, JE Dunn Construction, and Linbeck Construction. Lean deployment is far from uniform and is continuously evolving in this model, from having structured training programs in some cases, to simply promoting waste reduction as part of an internal culture. While lean consulting firms offer training that comprise many of the tools encountered in academic programs, companies such as DPR have begun to emphasize the role of leadership in the lean transformation. Design firms such as Boulder Associates have many successful lean projects to their credit. However, in the spirit of continuous improvement Boulder Associates is gravitating from their "Work Plan" lean initiative to the scrum/agile methodology that may be better suited to the non-linear approaches of facilities design work.

Owner organizations such as Sutter Healthcare attribute the success of their projects to their commitment to lean and active participation and leadership in deploying the lean methodology through their project teams.

Given the wide variety of approaches used by companies in training members of the project team, a number of questions arise: How do individual methods stack up against a cost/benefit analysis? How should lean training be adjusted to match the needs of a specific project? How does "just in time" training compare in effectiveness with routine training? It would be useful to develop an inventory of the tools/techniques used by industry practitioners.

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