International Journal of Business Management and Commerce; Vol. 6 No. 2; November 2021
International Journal of Business Management and Commerce
Published by Center for Contemporary Research

Lean Construction Roadmap

Robert Warcup, Ph.D.
UVU Construction Management
800 W. University Pkwy,
Orem, UT 84058, MS 118, USA.

Many construction companies experienced improved productivity by conscientiously adopting lean construction. My own personal lean successes provide a snapshot of possibilities: 12.7% reduction in direct costs, 40% reduction in schedule durations, high improvements in quality (no statistics available), and visible improvements in morale (no statistics available).

This paper focuses on the 25+ year lean journeys of DPR Construction, the Bolt Company, and Linbeck Construction, ultimately being recognized among the top lean construction firms in the United States. It showcases how and why each company's transformation was so successful. The purpose is to understand how their journeys can assist other companies to become lean in less time without making the same mistakes. This research project followed a qualitative case-study format. It presents a roadmap for any company to accelerate their own lean journey and reap the benefits achieved by greater operational excellence through lean.

The study sought answers around eight major themes:

- Lean Discovery – How and why was the discovery of lean useful?
- People – How did people help or hinder lean?
- Tools – What lean tools were utilized on the journey? (LPS, VSM, 5S, A3, etc.)
- Implementation – What strategies were effective during implementation?
- Training – Who needed training and who did the training?
- Culture –How did culture change with lean adoption?
- Barriers – What barriers needed to be overcome?
- Future of Lean – How does lean move forward at each company?

The study presents each company's lean implementation progression. The Boldt Company will be referred to as "Boldt" hereafter, DPR Construction will be referred to as "DPR" hereafter, and Linbeck Construction will be referred to as "Linbeck" hereafter. Three interviews were conducted at each company for a total of nine. All interviewees are lean influencers and have considerable employment time at each company promoting lean concepts.

Introductory Discussion: Natural Lean Progression

The introductory discussion on the lean progression for Boldt, DPR and Linbeck address the path each company took to become lean as well as the major milestones from their journeys. Table 1 shows the general steps they took in their lean progressions. It is critical to understand that the natural progressions were imperfect early on because each organization was navigating an unknown path at the time. By using this information, companies that have begun or wish to begin to implement lean can identify where they currently lie in the progression and plan next steps for their lean journeys.

Table 1: Implementation Progression

Natural steps to lean	The Boldt Company DPR Construction Linbeck Construction
Lean discovery	• Innovative leaders are continuously searching for improved methods • Lean is discovered and tested on several specific projects with promising results
Learning period	• Consultants are employed to teach and help establish a lean culture • Champions emerge to learn, teach, and implement lean tools bringing further success
Critical turning point	• Executive leadership wholeheartedly commits to lean • Mixed results—acceptable success on several projects, but a lack of success on others, usually due to "a la carte" implementation (picking and choosing only the convenient components of lean tools and strategies)
Culture development	• Dedicated teachers and training programs are established to support and deepen implementation efforts • Refocus of lean efforts, de-emphasizing tools while simultaneously promoting true lean culture
Saturation progress	• Personalization of lean to all employees; lean is developed in all departments; majority of employees implement lean

All three companies initially discovered lean in the mid 1990's and began experimenting with it on their projects. Consultants guided them to experience early success during the learning period. During this time executives at each companies arrived at an important decision. The question was not whether to simply continue forward with lean arbitrarily as they had done to that point. The real question upper management faced was whether to fully commit to lean as the predominant strategy of the organization moving forward. This decision became a critical turning point for each company as they wholeheartedly committed to lean. One emeritus executive at Linbeck exclaimed in an interview, "We had become so convinced that lean was in the best interest of our clients that we decided 'Let's do it!' There's no question that it is superior!" This decision was made based mainly on the early success that lean produced on several major projects. The decision was also founded upon feedback during the learning period as employees and executives alike discovered that lean was the solution to many of the problems that their traditional management strategies could not solve.

Employees naturally respond to the goals and ideas emphasized by executive leadership, whether good or bad. Therefore, when upper management committed to lean and then followed up that commitment with action, much of the company naturally followed. That outward, conscious dedication is extremely critical to any organization. Another executive at Linbeck stated, "It takes leadership at the end of the day—someone to decide this is what we're going to do, and that person has to be in a position to influence it." With any new initiative, dedication must come from upper management because most employees are not in position to impact company culture to such a high degree. Soon after this critical turning point, each company began developing the lean culture by means of lean tools, internal an project lean training events, and even dedicated lean positions. During this period, lean produced noticeable results on most projects, yet only negligible results on others for lack of "buy-in" from some employees.

The final step from Table 1, saturation progress, is the point at which each organization began to deepen the lean culture across all employees in every department, not just construction operations. This step did not occur in an instant. It took time for each organization to recognize the need to personalize lean to every employee at any position within the company. This effort to personalize lean is a theme that helped elevate each company to the "next-generation commitment to lean," as stated by one Linbeck executive. It required many hours of training from everyone in the company. Personalizing lean to each employee's role saturated lean culture company-wide more quickly than did any other action. This topic will surface several times throughout the remainder of this study during the discussion of people, environment, and actions.

Journey to Lean: People

The discussion on people influencing lean addresses how employees in various roles effect an organization's lean journey. Individual roles are categorized as executives, champions, early adopters and late adopters.

Several interviewees referred to Lean expert and author Paul Akers (2013) who suggests that 90% of lean is about people, while only 10% is about processes. Although Akers' percentages were not scientifically determined, the qualitative findings of this study confirmed his notions. It is therefore important to understand which employees are the most influential players in a lean transformation. Table 2 provides an overview of the key participants at each company and their role in the transformation. The table highlights two major groups of contributors to successful lean adoption: executives and lean champions. Together, these two roles are crucial to the discovery of lean as well as the process of implementation. This is mainly due to their influence on others inside and outside the organization. Each group's influence will be discussed in detail below.

Table 2: People Influencing Lean

	The Boldt Company	DPR Construction	Linbeck Construction
Discovery of lean by:	• Future lean champion	• Future lean champion	• Company CEO
Executives	• All companies had innovative executives that advanced lean through top-down approaches: financial investments, promoting champions, lean trainings, encouraging or requiring lean on projects • All companies had executives that challenged and empowered employees and removed barriers to lean		
Champions	• Lean champions at all companies were passionate, innovative, driven, and persistent in implementing lean • Lean champions at all companies were responsible in large part for lean success		
Early adopters and early majority adopters	• These employees needed encouragement and top-down persistence to implement lean • Many of these employees enjoyed the challenge of learning and implementing lean		
Late majority and laggards	• These employees were usually seasoned professionals who were resistant to abandon traditional management techniques for lean		

Executives

Executives shared two critical characteristics that allowed them to quickly recognize the power of lean: first, current state awareness; and second, a driving spirit of innovation. Progressive leaders at all three companies recognized the inherent weaknesses of the construction industry and had enough self-awareness to see the weaknesses or needs within their own organizations. Not only did they have vision, but they also possessed the drive and the wisdom to proactively act on that vision rather than give in to traditional industry customs.

Several of the participants mentioned the crisis within the construction industry. This simply refers to problems, or waste, that have crept into the industry over time. Examples include complex contracts, a high potential for litigation, poor communication between parties (fragmentation), inadequate preplanning, and high levels of subcontracted work, which relinquishes control and which often produces language barriers. In essence, the eight wastes illuminate the crisis in the industry.

Several interviewees echoed the sentiments of a Boldt executive, who stated, "The current way of doing things [was] not going to produce the types of results we want[ed] to achieve, so in order to get a different outcome, we [had] to have a different process." A Boldt BIM director and lean trainer stated it slightly differently. He recognized that the industry crisis, or the inherent problems in the industry, produced a "gap between what [the company] wanted to achieve versus what they actually achieve[d]."

He also noted that his company's "current methods [were] not adequate" to achieve better results. The common failures caused by "industry fragmentation" as reported by Johansen and colleagues (2004), exposed a problem which these forward-thinking leaders felt a need to mitigate.

Executives at all three companies greatly valued and supported innovation. Well before their formal introduction to lean, these executives were continually searching for new ways to overcome the industry crises. A Linbeck president and lean champion pointed out that industry problems constantly prompted them to search for a better way to deliver their projects. He further noted that owners and clients were discontent with current results but didn't know how to improve them. At the time of lean discovery, each company was busy implementing several new metrics or approaches to make their projects more productive and efficient. As a result, when future lean champions met with LCI founder-consultants, they quickly recognized the potential for lean to improve company results.

In turn, these executives drove lean culture throughout their organizations by their commitment to it: empowering their workforce, removing obstacles, funding lean initiatives, and endorsing it themselves. Executives were the most important drivers of lean although not all of them were lean experts. This finding coincides with Nesensohn and colleagues (2012), who suggested that executives cannot merely commit to lean; rather, they must constantly drive it throughout the organization for it to take hold.

The executives at the three firms in this study intentionally empowered their best employees by challenging them to learn, develop and apply lean construction strategies and techniques on projects. Several of these employees soon emerged as lean champions and became very influential in the propagation of lean. A Boldt senior director and architect, stated, "Our management is [constantly] challenging us to become lean leaders, and many of us believe it is the future of our industry." Clearly, lean innovation thrived when executives promoted it.

Executives also removed barriers. The most common barrier was funding. Executives at all three companies funded trainings, conference attendance, and lean consultants. As a senior project manager at DPR stated, they "put their money where their mouth [was].… Executives said it with their words, then backed it up with dollars." The second barrier that executives removed was the fear of failure. As one Boldt executive stated, "It's important to make…a safe environment where it's okay for our people to innovate and potentially fail." A DPR project manager said, "It's always about experimentation—trying new things and not being afraid of failure—throwing something against the wall to see if it sticks. If it sticks, great! Celebrate it! If it doesn't stick, that's okay. Tell people why it didn't stick so others don't make the same mistake."

Another means by which executives influenced their organizations was trusting top performers. These performers quickly developed into skilled practitioners, promoters, and even champions. One DPR project manager stated, "We are where we are because of the executives.… Lean is absolutely a top-down philosophy even though you harness the best of it from the lowest levels." These findings are consistent with Alarcón and Diethelm (2001), who stated that "clear signals and a high degree of commitment from upper management" are necessary to develop a lean culture.

A Boldt BIM director and lean trainer, along with several others, commented on the importance of executive leadership leading by example. He stated, "When lean was successful, it wasn't because management was pushing it. It was because management was walking the walk." It was not necessary for executives to be lean champions or skilled practitioners. However, it was necessary that they participated in trainings and attended book clubs or conferences with their employees. They needed to understand lean thinking well enough to recognize which inputs were needed to then obtain superior outcomes. Without lean theory to guide them, executives will likely grab an old-fashioned instrument from their traditional tool belt that would undoubtedly undermine the new philosophy.

Liker and Meier (2006, p. 25) expressed several thoughts that echo the findings of this study. "The responsibility for living the philosophy falls straight on the shoulders of a particular and easily identifiable group: leadership." They further explain that this group "[has] to live the philosophy every day in a very consistent manner. Leaders have to lead by example…consistently" (p. 25). In a similar tone, Akers (2013) admonished, "As a leader you must be fully engaged with your people in the process, otherwise lean will look like the flavor of the month, just another business tool to be pushed aside when management returns home from the next business conference" (p. 75).

Champions

Almost as important as executive leadership is the role of the lean champion. They were the heart and soul at each of the participating organizations. Champions were highly innovative employees who recognized the value of lean, and who passionately and persistently encouraged others. They were responsible for most of the lean training at their organizations. From Rogers' (2010) diffusion of innovation curve, the researcher concludes that most of an organization's lean champions will emerge from the early adopter group on the curve.

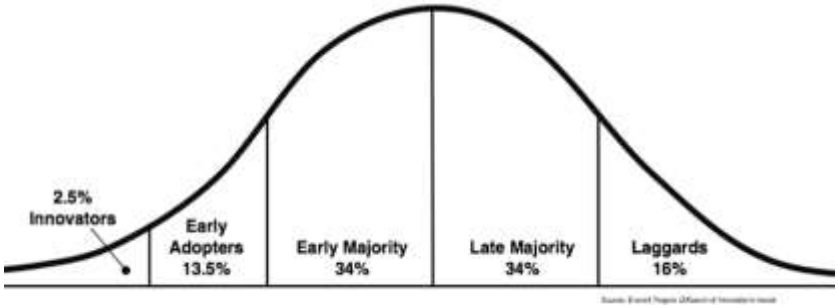

Figure 1: Roger's Diffusion of Innovation Curve

Champions are very influential in the success of lean because they are top performers. They are high-achieving managers who report directly to the CEO so that their influence can be felt both above and below (George, Rowlands, & Kastle, 2006). Based on the findings of this study, champions are inherently driven to succeed, and lean offers a greater potential for practical success than traditional management. Lean cannot succeed without a champion because no other individual has the passion to learn, implement, and drive such a new, unique paradigm shift throughout the organization. True champions rise to the occasion and thrive on the challenge.

Champions and top performers still need continued support and encouragement from leaders at the executive level; they cannot be left alone to figure out and manage the logistics of learning and implementing lean. Champions thrive when the fear of failure is removed and when they are empowered by the executive team. Liker and Meier (2006) likewise explained that when the fear of failure, or blame, is removed by shifting the responsibility for errors from people to the system, they "are free to focus on creating more effective systems and actually solving problems, rather than defending themselves" (p. 186). After experiencing success on several projects, champions typically begin informally training and encouraging other project teams.

Because they are self-motivated, it is quite common for champions to research lean on their own to deepen their knowledge. They are often the first to produce value-stream maps or facilitate pull-planning sessions. They will commonly track Percent Planned Complete (PPC) with consistency on their own projects to compare those results against past research. Champions eagerly share their findings with anyone willing to listen.

Regular Employees: Early Majority, Late Majority, And Laggards

While executives and lean champions are often the early adopters in Rogers' (2010) diffusion of innovation curve, remaining employees complete the curve as early majority adopters, late majority adopters, or laggards. The early majority group includes those who were receptive to lean and willing to try out something new with minimal resistance. They require encouragement, direction, and reinforcement from executives and champions as motivation.

The late majority adopters were those who only adopted lean when upper management was watching, but lacked the motivation to be consistent. Finally, the laggards were those who continually resisted any new initiative. For example, just as a Linbeck general manager and division vice president stated, "Many in construction tend to be strong headed. Change is tough. It requires work and very few want more work. Many will raise their hand that they want to learn lean, but nobody really wants to do the lifting." For this reason, executives must actively drive the lean culture while champions remain passionately persistent. This same Linbeck executive approximated that 40% of all employees will not or cannot make the shift to lean and are unreceptive to big change.

Often, the late majority adopters and laggards were individuals who were highly respected for their successes with their traditional "command-and-control" styles.

But, as the lean culture began to spread, it was common for resistant employees to realize they did not fit into the new culture. Because they had experienced success in their careers using non-lean management strategies, they were hesitant to change. The Boldt Senior Director of Continuous Improvement and Quality stated, "People have made their living firefighting and do not want to change. This doesn't mean that all old people don't want to change. But it does mean that those who don't want to change can be a big roadblock to lean implementation."

Regarding resistant employees, an interesting pattern emerged in the research data. Each interviewee blamed the individual for resisting lean, rather than the process. Each expressed sentiments similar to that of the aforementioned executive who cited "old-timers" and egos as common barriers. The researcher finds this an interesting paradox because lean philosophy states that blaming the individual is never the right approach. Rather than blame people, managers and leaders should re-evaluate the adoption process and consider how it might be improved and personalized to each employee in the company for better results.

Paul Akers suggests that it is absolutely critical to first, make lean fun, and second, make it incredibly simple so that anyone can be successful (2013, pp. 60-64). Paul suggests small, systematic improvements from every employee, every day—whether on a construction site or in the office. Many companies tend to do the opposite; they make lean highly systematic and overly technical. In contrast, fun, simple, personalized lean means that all employees are recognized often for finding ways to remove waste from their daily job responsibilities. The CEO of Linbeck, stated that this philosophy helped his company "evolve into the next generation of lean." This idea is one of the crucial elements to saturating a company by personalizing lean to every employee and their role.

Personalized lean means that all employees at any level should be challenged and empowered to continuously improve the way they work. As mentioned previously, personalized lean was a major milestone that all three companies realized (see Table 2). A Linbeck emeritus executive and architect stated, "You can't make people do things. You need to change their outlook on life. They have to be culturally interested in changing the way they work. People need to come to work not just to work, but to improve the way they work. It's not second nature for people to behave that way. The more people we can get to adopt that principle, lean would be a breeze."

Journey to Lean: Environment

The discussion on environment addresses the influence of company culture on lean implementation. Table 3 provides an overview of the major environmental attributes that promoted or hindered lean at each organization. Culture and organizational structure worked together to shape the manner in which each company established lean.

Table 3 Company Environment

	The Boldt Company	DPR Construction	Linbeck Construction
Company culture	• Highly progressive and innovative	• Highly entrepreneurial, innovative, and diverse	• Highly standardized, yet innovative
Organizational structure	• Traditional hierarchical structure	• Horizontal since the company began • Hierarchy is considered "taboo"	• Initially hierarchical • Departments later removed to become horizontal
Establishing lean	• Lean strongly encouraged by upper management • Lean is required only on specific projects	• Lean strongly encouraged by upper management • Lean is required only on specific projects	• Lean required on *all* projects • Visual management techniques are required on *all* projects
Barriers and failures	• Early failures at all companies were caused by selective implementation • Over-emphasis on tools for all companies became problematic • All three companies experienced resistance from internal employees and external trade contractors • All companies had traditional paradigms (path dependencies) that had to be overcome by deliberate means		

Company Culture, Organizational Structure, and Establishing Lean

The first obvious similarity among Boldt, DPR and Linbeck was a strong culture of innovation. Recall that when each company discovered lean, they had already been searching for innovative solutions to industry problems. Upon discovering and experiencing quick success with lean, executives at each company resolved to become founding members of the Lean Construction Institute (LCI) to further propagate a lean culture and influence innovation throughout their organizations. They also made the decision to hire consultants to teach and train their organizations. Any company accelerating their own lean journey should foster this same spirit of innovation into their culture.

One particular surprise from the interviews occurred as DPR and Linbeck offered up valuable insights about the enabling role of their horizontal organizational structures. Most construction firms have a traditional hierarchy containing several vertical layers: from top leadership down to the common employee. However, two of the three companies in this study were extremely horizontal, while the third operated with a traditional vertical structure. Despite these differences, all three companies reported to one centralized location within their respective organizations.

According to participants at the two horizontal companies, DPR and Linbeck, their organizational structure was a huge enabler to lean. One DPR project manager stated, "We're set up to be as flat as possible.… That empowers people to take on new things." He recognized how the non-traditional, horizontal structure at DPR enhanced innovation and inspired entrepreneurialism. Employees were often encouraged to "[throw] something against the wall to see if it sticks." Linbeck emeritus executive said that he felt so strongly about the barriers that their traditional hierarchical structure presented that he removed departments and created a more horizontal organization. Linbeck's CEO said that this bold move greatly enhanced the company's ability to innovate and perform because, traditionally, "all good ideas stop at middle management."

Despite the positive references to horizontal structure from two of the three companies, the findings illustrate that there is no single correct organizational structure required to be successful with lean. The results may, however, hint that a horizontal structure might be more conducive as newcomers seek to transform their organizations. Such a conclusion must be made by the reader as they take their own company situation into account.

A second interesting finding is that Boldt and DPR differed from Linbeck about whether or not to mandate lean practices. Linbeck was the only organization to require lean on all projects. Participants from the other two companies noted that while requiring lean would indeed improve consistency, they feared that doing so would alienate too many employees. Instead, executives at those companies chose to require lean only on critical projects, such as high-profile jobs with rigorous schedules and extremely tight budgets. The Boldt Company and DPR awarded such projects to lean champions and top lean performers only.

One DPR project manager stated, "Those [lean specialists] who have earned the respect of everyone around them encourage others and influence others to spread the word. That's how leadership supports it. It's contrasted to top-down authoritarian leadership which might mandate it uniformly across the company. But that's not the way we [do] it. Fostering culture is more important. It has to come from within." He called DPR's approach to lean "recommendatory" - an approach that falls somewhere between recommended and mandatory.

Although Boldt and DPR did not require lean on all projects, they acknowledged the potential value of mandatory lean. Below are comments from both companies that illustrate what the benefits might be if their companies chose to require lean on all project.

- "Much of what is asked of project managers is uncomfortable to [project teams], so if there is no support from upper management, this only confirms that it is okay to not use lean." (Champion and executive at The Boldt Company)
- "Until the person gets far enough up on the learning curve that they are able to see now what they couldn't see before, or understand what they couldn't understand before, you almost have to make the use of the tools mandatory so that they begin to see things that they could never see from where they were at initially." (Champion and executive at The Boldt Company)
- "[The] consistency and repeatability [that lean delivers] are important. We need to prove the results over and over." (Champion and executive at The Boldt Company)
- "Requiring consistent lean practices is not part of [our] culture. The consistency would be beneficial, but there has to be a balance… [Ultimately] we realized that [lean] should be used everywhere." (Champion and superintendent at DPR)
- "The top hasn't required lean reports," but if management stopped by and asked each project to "show me your visual controls, show me your PPC … the company would get a quick culture change. It needs to be felt on a personal level. You can say whatever you want, but it's what you check up on that [determines] what you get. Unless you put a metric behind it you won't send the message you are seeking." (Champion and project engineer at DPR)

Based on these comments, the success of Linbeck, who required lean on all projects, and the researcher's own experiences, mandating lean, can be a positive experience for a company when it is instituted correctly and constructively. Liker (2004) agreed; among his tips for transitioning a company to a lean enterprise is his advice to "Make it mandatory." According to Liker, "if a company looks at lean transformation as a nice thing to do in any spare time or as voluntary, it simply won't happen" (p. 304).

Linbeck successfully instituted a lean standardization requirement by coupling it with positive motivational factors. Project reports required lean metrics to be quantified for regular review. Linbeck executives required all employees to read several lean books. Champions and executives would often quiz employees about lean factors, such as the eight wastes, 5S, and so forth. Management made the experience fun for all despite mandating it to lower levels.

Even more enthusiasm for lean resulted when Linbeck began making short lean training videos. Employees were challenged to identify one simple process at work to improve, make positive changes to the process, quantify the results (saved time, money, or resources), then to make a video sharing the results with others on the internet. Executives, construction professionals, and administrative personnel all posted videos.

A CEO at Linbeck stated, "The company began creating videos on "How can I eliminate waste or fix what bugs me as I sit at my desk each day?" We can all create a video.… I created a 2-Second Lean video. Employees saw that it was important."

In fact, Linbeck's CEO considered lean videos as one of the most influential changes the company had made because by doing so, each employee began personalizing lean to their individual roles. Creating videos helped each employee understand, internalize, and apply basic lean principles to their job duties. As CEO, he also credited lean videos with helping the organization "evolve into the next generation of lean within the company." Similar to Linbeck, DPR had already taken steps to expand and personalize lean throughout the organization. They too created lean videos to drive the culture.

Boldt also realized the importance of personalizing lean to each employee. For example, the BIM manager and lean champion stated, "[We] now have the understanding to take the core of lean and the Last Planner to other parts of the company. [We have] internalized the concepts culturally.… The Last Planner is now just a tool in a toolbox that can be applied anywhere." Boldt began utilizing these tools in other departments as well. Whether it was accounts payable, accounting, marketing, or construction, any employee benefits by personalizing lean principles and tools to their job. Boldt's Continuous Improvement Department was created to help employees across the company learn to solve their own problems and improve their own processes.

Barriers and Failures

Despite the different approaches, each company experienced many of the same barriers and failures. Barriers and failures should not always be considered as negative, however. They are simply part of the natural progression of the lean implementation process and should be expected. According to Akers (2013), "The number one way people learn is by making mistakes. If you rob your culture of this experience you will rob yourself of the boundless innovations that could await you" (p. 64).

Each of the barriers and failures experienced in this study seemed to be intertwined. The major factors discovered at each company were (a) selective lean, (b) an overemphasis on lean tools, (c) internal employee resistance, and (d) path dependencies (cultural paradigms unique to each organization).

Selective lean refers to an inconsistent application of lean tools: picking and choosing elements of a tool but neglecting the whole of it. For instance, project managers may choose to add a few simple elements of the pull-planning process but neglect to carry out other important measures, such as PPC, the 6-week look-ahead, and formalized learning components. In such a case, pull-planning benefits are minimized because there is no weekly scoring incentive for trades to commit to the plan. If PPC is not tracked regularly, it is portrayed as unimportant to the project team. The same is true for the other neglected elements of the system when they are removed or ignored.

Each company experienced a lack of positive results when employees were haphazard in the implementation process—selective lean. In contrast, when companies were deliberate in following lean concepts and tools with exactness, their projects offered a much greater level of success. This does not mean that the system itself is overly-rigid or inflexible. It simply means that greater success is realized when the tool is maximized. The system itself can and should be adapted to fit the needs of each individual project.

When employees perceived a failure in a lean tool such as the Last Planner System (LPS), they often blamed the tool itself. However, as previously noted, it was actually poor or inconsistent utilization of the tool that caused the failures. A DPR lean instructor/superintendent shared that bad weather, out of sequence work, and other delays were recognized using the LPS. "The system showed us what we were doing ineffectively. The system worked as it should." He explained that proper use of tools exposed problems—it did not create them. This result is fundamental to lean philosophy. Only when problems are uncovered can they then be corrected. Otherwise, they remain unresolved—only to contribute additional waste into the system or process.

The second common barrier to implementation was an overemphasis on lean tools. Nearly every interviewee expressed this sentiment. Tool use can be a challenging issue because lean is a philosophy that assists practitioners in solving problems, and lean tools are simply a highly developed strategy or problem-solving approach. When practitioners implement a tool without understanding the underlying lean concepts, they accept the tool as lean rather than thinking in a lean fashion (Fearne & Fowler, 2006). Liker and Meier (2006) added, "We often see organizations place the tool before the understanding" (p. 82).

This lack of understanding can cause poor outcomes because decisions are often based on lingering traditional management ideas rather than lean principles. So, while lean tools are in use, decisions based on old management paradigms counteract any positive results. But which comes first: the tool or thinking lean? In reality, lean theory and the use of lean tools need to grow together.

For this reason, the researcher considers the overemphasis on tools as an expected growing pain. Employees cannot fully understand the philosophy without training. But training alone will not suffice. Until lean is actually implemented through tools, employees will not fully grasp the concepts. Even then, it takes years of practicing lean to fully internalize it. Tools are merely a method of training and implementation. Just as one Boldt executive stated, "You have to follow the tools for a particular period of time to be able to see the benefits of what you are able to [achieve] with…that system." It takes time for the learning to take root. Therefore, tools are necessary to the learning process.

Every interviewee suggested that theory alone is insufficient for grasping new concepts. Training must include a hands-on element to be effective. So, when employees stated that lean tools were overemphasized, it was because they pushed lean tools onto project teams that did not have a complete understanding of the concepts. When requiring lean practices (utilizing a tool in its entirety, not selective tool use) in a spirit of fun and simplicity, employees are free to grow and improve the utilization of the tool as they increase in their understanding of that tool. In other words, true understanding grows in parallel with the application of the associated tool.

Employee resistance to lean was the third barrier or failure common to all three companies. This topic was considered previously and will not receive further attention here. Lean tends to move people out of their comfort zones. The traditional command-and-control approach may seem easier than having to collaborate with others and intensely preplan. Therefore, it is easy to fall back into old habits. According to the participants, acceptance seems to be more challenging for long-time, seasoned professionals. One subtle finding worth noting was the sentiment by Linbeck division vice president about hiring college graduates who are not burdened with traditional training. They are more easily adaptable to new methods even though their college training may not support progressive strategies such as lean.

Finally, the fourth and final barrier or failure to lean implementation common to all three companies was the issue of path dependency. Path dependency is defined as a company's past events and decisions, which continue to influence present decisions by locking the organization into paths from which it cannot break away (David, 2001). It should be noted that path dependencies were less of a barrier for the three organizations in this study because each of them had consciously and deliberately promoted lean to overcome traditional industry problems. However, two examples that were evident to the researcher were technology and unwilling leaders.

At some point in their histories, each company felt like technology would be more effective when coupled with lean. However, two out of the three have since abandoned their lean tool software endeavors because lean was found to be more effective on its own without the technology they had developed.

While lean is not anti-technology, it is very manual and very visual. This is one reason why it is effective. The hands-on, collaborative approach to pull-planning, for example, allows the group to regulate each other and hold their peers accountable for their actions. It provides a near-perfect environment for social marketing to guide the team. The manual and visual approach symbolically commits each team member to the project and to the rest of the group. In contrast, technology removes the manual influence, and subsequently, the level of commitment also. Medical, economic and political circumstance have since interrupted this line of thinking. Many companies were urged to use software to facilitate project teamwork over the past 1.5 years, including lean software programs.

Even though all three companies made the transition from a traditional mindset to a lean mindset, they each still struggle on occasion with traditional leaders making traditional decisions. The influence of these traditionalists slows the progression of lean. Those new to lean must realize that opposition is to be expected. It is for this reason that executives and the champions are so heavily emphasized. They must be persistent and passionate despite the expected resistance. They set the tone for the rest of the organization to follow.

Journey to Lean: Actions

The discussion on actions identifies the activities that a company should take to successfully implement lean. Actions refer to implementation efforts such as hiring consultants, funding training events, and investing in appropriate software.

Table 4 illustrates that the majority of actions by each company were similar in nature. Because each of the three companies viewed lean as an investment, it was easier for them to see the return on that investment. Viewing lean as merely a cost limits one's perspective because it can be difficult for everyone in the organization to see past the bottom line during the initial implementation phases.

Table 4: Company Action

	The Boldt Company DPR Construction	Linbeck Construction
Consultants	• All companies utilized consultants for 5+ years • Consultants helped maintain consistency and accuracy of implementations	
Investments	• All companies were LCI founding members • All companies paid for consultants and company training events • All companies funded conference participation for their employees • All companies funded software implementations related to lean construction	
Company trainings	• All companies relied upon internal lean champions to develop formal and informal training programs • All companies ultimately hired or promoted dedicated trainers to spread the culture of lean	
Trade contractor trainings	• Boldt and DPR committed to train trade contractors on select projects	• Linbeck trains trade contractors on all projects

Consultants and Specific Investments

Each of the three companies sought out LCI founders for consulting purposes for more than five years initially. The founder-consultants were still developing the Last Planner and other lean tools at the time. Their major roles were to keep the employees motivated, keep them on track, and teach them the new lean concepts. Boldt, DPR and Linbeck interviewees all agreed that the consultants were absolutely necessary to the establish a lean culture. The use of consultants also introduces a greater level of commitment to the organization. Any organization today that is either beginning their journey or has only been traveling that path for a short while should consider utilizing lean consultants. Their influence will enhance the speed of adoption and deepen the understanding of employees. Ultimately, the lean culture became engrained enough within each of the three companies that they outgrew the consultants.

While consultants were one of the first investments made by all three companies, the second investment by the executives was to become a founding member of the newly established LCI organization. This gave them access to the experts on an as-needed basis as well as a training resource for future employees. Other lean investments included conference and training attendance held by LCI and other lean associations. It didn't take long for the champions at these organizations to prepare and deliver elaborate presentations for a growing LCI membership body. Today, the champions at The Boldt Company, DPR and Linbeck are still leading the industry by presenting new findings and sharing new implementation approaches to LCI members.

Company Trainings

The third area of discussion from Table 4 is company trainings. Interviews showed that none of the participating companies had formal lean training during their initial adoption period other than those from the consultants. Most training included project teams informally sharing results and best practices with others. Because results were so positive early on and because each company had committed to lean construction as its operating system, formalized training became an obvious need.

Formal training at each organization today includes established lean instruction modules delivered in a classroom setting that company employees take throughout their careers. The very best trainings also include a hands-on element with learners carrying out lean ideas and concepts on their own projects or implementing it in their own office roles. These trainings were part of a standard curriculum that all superintendents, project managers, and project engineers were encouraged to take part in.

Each of the companies still administers informal training as needed today. Tools such as value-stream mapping and the Last Planner System were taught by champions and consultants to project teams. Sometimes these trainings were held on projects by initiating pull-planning sessions with the project team. Other times they were taught theoretically in a classroom setting using simulations as a learning method. Online trainings were also made available. All these programs were developed to help establish the culture of lean, to teach problem solving, and to learn to properly apply lean tools. Complementary approaches such as book clubs also encouraged questions and discussions from learners.

After several years, champions realized that the formalized training was becoming less effective. Trainers were not always effective teachers and learners were not always enthusiastic about learning. A superior practitioner is not necessarily a great trainer. Champions quickly learned that it was important not to lecture about lean during training events. The best teachers were able to persuade even resistant learners to discover lean by asking the right questions. They acted more as mentors than teachers. These individuals inherently knew how to ask the right questions and let learners struggle just enough to pique their interest in finding their own solutions with the new skills they had learned. They guided the conversation so that learners could figure it out on their own rather than spoon-feeding learners all the answers. A seasoned teacher and trainer at DPR stated, “People don’t want to be talked at. Successful trainers bring others along by asking the right questions. When they [begin to catch on], the students become the ones asking questions.”

For this reason, all three companies determined that dedicated positions were necessary to focus on the professional development of their employees. All three companies hired at least one individual to teach and manage all trainings within their organization. This corroborates Alarcón and Diethelm’s (2001) research, which suggested that a “special organization” within the company is necessary and that clear “definition of functions, responsibilities, and levels of authority” is important to a successful lean implementation.

Not all training positions were completely dedicated lean positions. However, all three companies promoted or hired champions to advance lean along with other professional development competencies. Several of the titles of these dedicated positions include VP of process and innovation, director of continuous improvement, VP of learning and people development, senior director of continuous improvement and quality, and lean/virtual building coordinator. Dedicated professional development positions indeed allowed these three companies to progress beyond what normal “dual-role” employees could do. Beyond simply teaching, these individuals are also responsible for further research and development of lean principles and for finding lean solutions to problems occurring in other departments.

Trade Contractor Trainings

Champions and executives also learned that internal training was insufficient because the majority of the trade contractors who were hired on a project were not lean. Lean concepts are often initially perceived as counterintuitive, and because lean is less effective when project teams are made of trade contractors from traditional cultures, newcomers should expect to not only implement lean, but also to share it actively. As the CEO at Linbeck stated, “We cannot be lean if our subs aren’t lean!” This can be both energizing and frustrating. Training trade contractors is exciting when projects begin to flow and foremen are making reliable promises and offering up cost-saving ideas for the project. The problem is that “once it ‘begins to click’ the project is over, so we have to start all over again on the next job”.

Once a company has gained internal momentum with lean, training trade contractors to do the same is one of the most important actions they could undertake to improve project performance. On certain projects, subcontractor participation with lean was written into the contract with all subcontractors. This included LPS contributions such as pull-planning sessions, look-ahead meetings, weekly work plans, daily huddles, etc. Project teams determined beforehand what they wanted the project culture to be, then made it happen by contracts and by their daily actions and conversations with all project stakeholders.

Trainings for each company grew to include coaching and participation with clients, owners, architects, and engineers as well as trade contractors. At times, this became costly and time consuming, but it ultimately payed off considering the level of lean excellence for all three companies today. The old adage, “The teacher learns more than the student” is indeed true. The mandatory use of visual lean displays on all projects by Linbeck became an exceptional training tool.

Every trade contractor was required to contribute to regular weekly lean meetings. It was discovered that employees experience a great deal of pride and become more eager to learn as they teach others on the project. Furthermore, teaching lean to others increases individual commitment to the system.

Confirming the findings in this study regarding training, Liker and Meier (2006) shared the importance of establishing a "lean learning enterprise." In the construction industry, all project participants: trade contractors, suppliers, designers, owners, etc. They suggested study groups for the critical suppliers and trade contractors where they learn together by doing. As much as possible, Like and Meier recommend keeping classroom instruction to a minimum as the best learning occurs on the job when trade contractors, suppliers and designers take ownership of their work (p. 289).

Conclusion

Saturating lean into a company's culture can be both rewarding and frustrating. The journeys of The Boldt Company, DPR Construction, and Linbeck Construction can be utilized by any company desiring to transform their own organization. The roadmap begins with people influencing lean, company environment and company actions. The journeys of all three companies showcase how others can progress with lean as the predominant operational strategy of the company.

References

Akers, P. (2013). 2 second lean: How to grow people and build a fun lean culture. Retrieved from http://www.fastcap.com/

Alarcón, L. F., & Diethelm, S. (2001, August). Organizing to introduce lean practices in construction companies. Paper presented at the ninth annual conference of the International Group for Lean Construction (IGLC-9), Singapore.

David, P. A. (2001). Path dependence, its critics and the quest for "historical economics." Evolution & Path Dependence in Economic Ideas: Past & Present, 15, 40.

Fearne, A., & Fowler, N. (2006). Efficiency versus effectiveness in construction supply chains: The dangers of "lean" thinking in isolation. Supply Chain Management: An International Journal, 11, 283-287.

George, M. L., Rowlands, D., & Kastle, B. (2006). What is lean six sigma. Columbus, OH: McGraw-Hill.

Johansen, E., Porter, G., & Greenwood, D. (2004, August). Implementing lean: UK culture and systems change. Presentation at the 12th annual conference of the International Group for Lean Construction, Helsingor, Denmark.

Liker, J. K. (2004). The Toyota way. Madison, WI: CWL Publishing.

Liker, J. K., & Meier, D. (2006). The Toyota way fieldbook: A practical guide for implementing Toyota's 4Ps. Boston, MA: McGraw-Hill.

Nesensohn, C., Demir, S. T., & Bryde, D. J. (2012, July). Developing a "True North" best practice lean company with navigational compass. Paper presented at the International Group for Lean Construction (IGLC) annual conference, San Diego, CA.

Rogers, E. M. (2010). Diffusion of innovations. New York, NY: Simon and Schuster.