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TEACHING LEAN CONSTRUCTION: A SURVEY OF LEAN SKILLS AND QUALIFICATIONS EXPECTED BY CONTRACTORS AND SPECIALTY CONTRACTORS IN 2016

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ABSTRACT

Early studies conducted by researchers and Lean practitioners have reported strategies, methods, and content used to teach Lean Construction. However, none of the publications address the demands from the construction industry. What skills and qualifications are necessary to qualify for a job at companies that implement or are in the process of adopting Lean practices? What topics should be emphasized in the classroom? This study intends to answer these questions. Our main goal is to identify the set of Lean skills and qualifications that are considered important by construction companies. The researchers conducted a survey of job descriptions on the websites of general contractors and subcontractors listed as members of the Lean Construction Institute (LCI). Recent graduates from construction programs usually pursue jobs as project engineers, assistant project managers, project managers, schedulers, and superintendents. For this reason, only descriptions associated with these roles were collected and analyzed. The findings of this research identify major lean competencies required by the construction industry and provide guidelines for development or improvement of lean construction courses offered at universities.

KEYWORDS

Teaching, Lean Construction, Lean skills and qualifications, survey, curriculum

INTRODUCTION

The Lean Construction Institute (LCI) has the goal of "*operat(ing) as a catalyst to transform the industry through Lean project delivery using an operating system centered on a common language, fundamental principles, and basic practices*." In order to

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accomplish this goal, LCI states its vision as: "*Transform the Design and Construction Industry supply chain to provide value and enable other industries through Lean and integrated approaches*" (LCI 2016a). There are many ways in which both statements can be implemented as concrete actions to change the industry, one project at a time, using Lean and integrated approaches. One such way is through the hiring of professionals capable of actually implementing Lean in construction projects based on their experience in previous projects, their continuing education efforts, and/or their involvement with LCI communities of practice (CoPs). Another way is through the teaching of Lean in universities that educate professionals that will join the industry (see Tsao et al. 2012, 2013 for some examples). The study presented in this paper aimed at verifying if LCI member companies are requesting, in at least some of their job openings, skills and knowledge related to Lean Construction. Our initial purpose was to use these findings to provide guidelines for development or improvement of Lean Construction courses offered at universities. However, as the study developed, we noticed a trend that we did not expect at first in terms of what LCI member companies are looking for in terms of Lean-related skills. Therefore, the discussion presented in this paper might be just the beginning of a conversation in terms of how LCI-member companies and academics can help shape up the future of the construction industry one job posting at a time. The study used the published list of LCI corporate member companies as the point of departure for the sample analyzed.

LITERATURE REVIEW

The interest in learning and teaching Lean has been growing amongst universities in the United States and abroad as they respond to an interest of academics, and a growing demand from the industry, and offer courses on Lean-related topics both at the undergraduate and graduate levels. Faculty in these universities tend to use interactive methods in order to encourage critical thinking and discussion about how Lean concepts are used. Tsao et al. (2012, p.1) suggested that an effective approach to teaching Lean Construction should combine: "*readings, lectures, discussions, simulation exercises, team projects and assignments, field trips, and guest speakers to mix theory with action.*" Similarly, Tsao et al. (2013) analyzed the approaches used by seven faculty in seven institutions and verified that the instructors took a very dynamic approach to teaching Lean Construction including similar readings across their curricula and using a variety of methods to convey the message, especially using simulations to engage students and make them experience the benefits of Lean in practice. The use of multiple methods to teach Lean is also appreciated by the students, as documented in student evaluations discussed by Pellicer and Ponz-Tienda (2014) and Nofera et al. (2015).

In a similar fashion, the literature at large on the use of simulations to teach Lean presents multiple instances in which academics have developed and used simulations to convey important Lean tenets, systems, and specific tools. The literature on simulations also documents the diversity in terms of where and how Lean is being taught.

Some of the first documented efforts by construction researchers to teach Lean using dynamic methods can be illustrated by the work developed by Iris Tommelein at

University of California, Berkeley, and documented in the Parade Game simulation (Tommelein et al. 1998) to illustrate the effect of variability in production systems, and Rafael Sacks' LEAPCON simulation to mimic the influence of change orders and pull systems (Esquenazi and Sacks 2006). Later, the Villego simulation was also developed to illustrate use of the Last Planner System™ (LPS) (Warcup and Reeve 2014).

Along the same lines, a group of faculty at Central Washington University (Martin et al. 2014) developed a simulation to teach integrated project delivery (IPD). Graham et al. (2012) integrated the use of Building Information Modeling (BIM) and IPD in an architecture course in Rhode Island (RI). During their course, the instructors conducted the students through an exercise in integrating BIM and IPD from the conceptual stages of a project including working with consultants. Students also had to consider a mandate by the owner to reduce project costs by 20% during the detailed design phase, which pushed them to really understand what the owner valued before making decisions to cut costs.

On the assessment side, in Texas, Rybkowski et al. (2012) developed a method to evaluate how much participants were confident in what they had learned in a workshop they developed to teach Lean-related concepts. The workshop involved multiple simulations and group discussions over three days for a group of practitioners who felt more confident regarding their understanding of Lean after taking this workshop.

Pellicer and Ponz-Tienda (2014) discussed their approach to teaching Lean at the Universitat Politècnica de València in Spain using a multi-faceted approach including lectures, exercises, simulations and a project-based approach to develop the course. Later in the course, they focused on advanced scheduling techniques and LPS, having the students to work on a project with a number of boundaries that had to be solved using Lean tenets. Likewise, Hyatt (2011) developed a course to integrate Lean, BIM, and green principles at Fresno State University in California. He consistently used the LPS throughout the course to teach Lean principles, and found out in the end that students wanted to know more about Lean Construction.

The efforts described take care of some of the challenges identified by Alves et al. (2012) in terms of bridging the gap between Lean Construction practice, research, and implementation. The three main challenges facing Lean Construction academics and practitioners as identified by Alves et al. (2012) were: the different meanings given to Lean, its tools, and principles; the need to have academics and practitioners working collaboratively to better understand and implement major concepts and systems and not only tools, and; the constant need to engage people in meaningful learning experiences when Lean is being taught and disseminated. The work presented in this literature review highlights the efforts developed by academics to support the dissemination of theoretical aspects of Lean, grounded in activities that engage participants and contribute to higher order learning. These activities contribute to higher order learning because students do not only memorize concepts, in fact they see these concepts applied in practice while developing a common understanding of Lean terminology.

However, it is not clear yet if the efforts of academics and the graduates, who have been exposed to these activities and courses, are becoming part of the industry and performing activities that require mastery or even basic knowledge about Lean. To the

authors' knowledge, no study has shed light on this question: is the industry requiring/demanding graduates that are well-versed in Lean Construction concepts, principles, and tools? This paper starts this conversation by looking at LCI corporate members and what they ask in their job descriptions available online.

RESEARCH METHODOLOGY

The data collection stage started by choosing the sample from the Lean Construction Institute (LCI) corporate members list posted at LCI's website (LCI 2016b). The authors first working hypothesis was that: *H1: LCI member companies seek to hire candidates that have knowledge and skills related to Lean Construction principles and tools, and these companies have requirements related to that in their job postings.*

It was decided that the search for job postings would cover a third of the LCI corporate members, and that the sample was going to be randomly selected. The sample was created after including the first member on the LCI list and adding every third member to the list of companies to be studied. In the end, 35 members were identified during the first round of data collection.

In parallel with the definition of the companies to be investigated, it was decided that the study would be focused on five job categories, namely: Project Manager, Assistant Project Manager, Project Engineer, Scheduler, and Superintendent. This is a limitation of this study, which identified these job categories based on the authors' knowledge about job positions usually sought by students graduating from construction engineering and management (CEM) programs. It is important to note that during the search, job titles were limited to the specific category, so any generalization or specification has been excluded. For example, neither a project coordinator nor a senior project manager is considered a project manager, for the purpose of the data collection. However, a construction project engineer is still considered a project engineer, due to the fact that the subjects of this paper are construction related. This is another limitation of this paper as one might say that data from openings for 'senior project manager' could potentially contain more Lean-related content when compared to the more entry-level positions analyzed. However, the analysis presented herein aims to inform about a potential gap in terms of what is being taught in universities and the positions most CEM graduates apply for upon graduation.

Furthermore, from each company only one job offer was included for each individual job category. This job was prioritized based on location, and the state of California was chosen as the main location. The reason for this choice was that it is commonly believed that California is one of the leading states in Lean Construction implementation in projects of different types and sizes. The authors' second working hypothesis was that job openings in California would tend to have requests for knowledge related to Lean implementation or mastery of its tools and techniques. The authors considered that the Project Production Systems Laboratory (P2SL), a leader in Lean Construction research, is located in Berkeley, CA and works closely with the local Northern California LCI Community of Practice (CoP). Additionally, there are two other LCI CoPs in the state, Los Angeles and San Diego. Thus, this second working hypothesis assumed that: *H2* –

job openings in California have a higher chance of requesting candidates with specific Lean-related skills and/or background. If no jobs were available in California, then jobs located at the company headquarters geographic area were investigated. After that, the position was randomly chosen from those available. Finally, while this paper only considers "full-time" job postings on the firm's official website, it is important to note that there might be other job offers posted elsewhere.

INITIAL ANALYSIS OF THE SAMPLE

Only 20 of the 35 LCI member companies analyzed had job offers that matched the job categories defined for the search. This required the addition of other members not initially considered in the first sampling effort. Additional companies were randomly chosen from the LCI members list and added into the sample to make the number of companies with valid entries to at least match the original sample of 35 companies.

The final sample covered 52 firms, 38 of which had some sort of job description that could be used in the analysis. The sample included 98 job descriptions, coming from these companies, and this was the number of entries analyzed. Moreover, the final sample included: 33 Project Managers, 8 Assistant Project Managers, 29 Project Engineers, 18 Superintendents, and 10 Schedulers. Data were collected during one month between February and March, 2016.

RESULTS AND DISCUSSION

The authors searched the final sample of 98 job descriptions to find Lean specific terminology. Only 8 companies included Lean terminology and/or related Lean practices in their job descriptions. Lean practices or tools were not well covered despite the fact that LCI Corporate member companies formed our sample. All other job descriptions focused their content on traditional project management skills and tools that are usually taught in CEM programs (e.g. Critical Path Method and knowledge of software such as Primavera and MS Project).

Nine job descriptions (9.2% of our sample) expected job candidates to have some Lean skills or qualifications. The positions were as follows: three project managers, two project engineers, two schedulers, one assistant project manager, and one superintendent. These jobs were located in: California (3), Minnesota (1), New York (1), Ohio (1), Washington (1), Wisconsin (1), and one not specified (company located in California).

A comprehensive analysis of these jobs indicates that companies expect people to know what Lean is in broad terms, but no specific skills or qualifications were listed except for two positions. Below is a list of broad statements with specific Lean-related terminology found in our sample:

"Collaborate with project teams to implement continuous improvement and lean strategies throughout the project delivery process".

"Mastery of Lean scheduling tools and techniques".

"Able to motivate and lead teams through Lean planning exercises".

"Schedule in Design/Build or IPD environment".

"4-D: Integrating schedule with BIM models".

"Provide intentional leadership for project team in areas of LEAN construction, project site safety and career development".

"Apply and implement Company's Lean project delivery system".

"Effective LEAN planning & scheduling".

"Ability to implement leading-edge technologies such as BIM and LEAN to benefit the project"

Only two jobs out of the 98 analyzed (from two companies out of 52 analyzed) presented detailed descriptions related to Lean skills/qualifications and responsibilities. They are as follows:

"Develop and maintain 3-week look ahead schedule using Lean tools. Coordinate and assist with scheduling of assigned subcontractors and self –performed work using Last Planner (Weekly Work Plan, Constraint Log and Plan Percent Complete) and Pull Planning (Collaboration+Communication+Commitment)".

"Help the Lean Production Leader to provide control, metrics and reporting for: Team Leaders, Supervisors, Trade Partners, Customers and other team members; help develop team members to be Last Planner System experts; motivate and drive the team to a zero-waste culture through detailed standard process and job instruction creation. Plan, develop, coordinate, and manage preconstruction and construction project activities in support of the project team while encouraging a collaborative environment and an integrated project culture."

"Develop scope of work for preconstruction services; Facilitate Lean training and integration of Trade contractor team members; Assist with all tasks that support the development of reliable estimating in the Target Value Design process including, qualifications, scope evaluation for the selection of trade partners; constructability reviews".

"Be or possess the ability to become knowledgeable in Lean principles and processes and support the implementation of these principles and processes on the project. Plan and lead pull planning sessions in support of the last Planner process. Become knowledgeable of the Standard Process and its' practice. Understand, lead and facilitate Last Planner processes in order to integrate Lean production principles and processes into the construction project. Be able to lead a Task Force effectively to maintain project milestones and resolve constraints. Understand the process of working in a VDC model and has some experience working hands on in a VDC model".

"Must be able to identify a breakdown and pull the Andon cord if required".

Analysis of this limited data set suggests that knowledge of the Last Planner System™, and one of its components, the Pull Planning technique, are the common abilities demanded by companies at the moment. The scheduling process seems to be the focus of attention, even though there were a couple of references to preconstruction services and

the Lean Project Delivery System™, which is a trademarked term by the LCI. Another observation that can be drawn from these job descriptions is that companies are looking at ways to integrate Lean and BIM. One of the most generic descriptions about this included language such as "*ability to implement leading-edge technologies such as BIM and LEAN to benefit the project*."

Two companies listed that candidates should be able to train, motivate, and lead teams through Lean planning exercises. There is no comment on what these exercises are, but this is the type of skill that only professionals or college students who were exposed to Lean training offered by industry organizations (e.g. LCI, AGC) or undergraduate/graduate courses would be able to have. Given that 4-8 years of experience was necessary for these positions, this requirement certainly limits the access of entry level or less experienced college students to jobs requiring Lean-related background and skills.

Twenty-one positions expected candidates to have experience using Primavera and MS Project, even though there are several commercial software packages available to support Lean construction implementation. Regarding Lean tools and software, only one job mentions knowledge of "Our Plan".

The authors also searched the sample for the following terms: collaboration, collaborative scheduling, commitment, ethics, and trust. Our results were:

"Collaboration" – 8 jobs, 5 companies

"Collaborative Scheduling" - No jobs

"Commitment" – 15 jobs, 11 companies

"Ethics" – 4 jobs, 2 companies

"Trust" – 8 jobs, 7 companies

Even though collaboration, trust, and commitment are words often mentioned when relational contracts and Lean implementation are discussed (Lichtig 2005, Darrington et al. 2009), they did not appear frequently on the data set analyzed. The authors speculate that some of these terms might be considered as implicit aspects related to the job of forming teams and building projects. However, if some of these terms are indicated in the job descriptions, they can actually take a more prominent role in terms of what candidates should be expected to deliver when hired and also become a trait that will be evaluated in candidates' job performance analyses.

CONCLUSIONS

This study intended to identify skills and knowledge demanded by LCI corporate members. The original idea was to find out what the industry needs were in order to inform and guide academics in the process of developing or improving their Lean construction courses. Our findings indicate that there is a lack of "pull" from the market regarding Lean skills and knowledge, especially for entry-level professionals. This conclusion was somewhat unexpected, as the sample provided no content or feedback that can be used by academics in their course preparation. The sample suggests that knowledge of the Last Planner System™ is a must have attribute. However, why do we

need to develop an entire course on Lean Construction including simulations and multiple forms of teaching if all students need to know is to how to schedule a project following the Last Planner System™ directives? Perhaps future research should try and discover the reasons why LCI firms are not explicitly listing Lean skills in their job postings. Are they training their own experienced employees and/or new hires? Until there is a clear demand from the marketplace, also materialized in these job postings, construction schools might not have much incentive to introduce Lean Construction courses in their undergraduate curriculum. Also, students are usually motivated to learn skills that are valued by companies, and faculty are typically hearing the demands from advisory board member companies to improve course offerings. It is our opinion that if this situation remains the same, Lean might not advance as a discipline in CEM programs in the near future.

The authors tested two working hypotheses in this study:

H1: LCI member companies seek to hire candidates that have knowledge and skills related to Lean Construction principles and tools, and these companies have requirements related to that in their job postings. This hypothesis was not confirmed. Only 9.2 % of all job descriptions demanded Lean skills and two companies provided detailed descriptions including Lean skills and practices.

H2 – job openings in California have a higher chance of requesting candidates with specific Lean-related skills and/or background. This hypothesis was not confirmed either. Only three jobs in the entire sample required Lean skills in California.

This study proposed more questions than answers to the issues related to Lean teaching and how that relates to skills valued by the market. This topic deserves further investigation and attention from the LCI whose goal is to serve as the catalyst to transform the construction industry.

The study has limitations in that the sample was defined based on the assumption that jobs in California would have more Lean related requirements, given that the Lean Construction movement started more strongly in California before spreading out in the United States and abroad. Additionally, the sample was based on job postings of LCI corporate members during one month in 2016. Additional research can be done using data from other members from the LCI (e.g., owners, sponsors, law firms, associations).

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