Aisyah, R. A., & Putra, P. (2024). Towards Sustainable Lean Construction in Indonesian Contractor: Effort & Learning from PTPP (A Government-Controlled Construction & Investment Company)". In D. B. Costa, F. Drevland, & L. Florez-Perez (Eds.), *Proceedings of the 32nd Annual Conference of the International Group for Lean Construction* (IGLC32) (pp. 1159–1169). doi.org/10.24928/2024/0169

TOWARDS SUSTAINABLE LEAN CONSTRUCTION IN INDONESIAN CONTRACTOR: EFFORT & LEARNING FROM PTPP (A GOVERNMENT-CONTROLLED CONSTRUCTION & INVESTMENT COMPANY)

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ABSTRACT

The construction industry must adapt to contemporary challenges; there is a need to change the paradigm of the industry, including in Indonesia. Lean thinking is an example of the evolving paradigm in the construction industry, called lean construction. It emphasises maximising efficiency, minimising waste, and delivering value to the customer through collaborations, optimised workflows, and project performance enhancement. For a construction company such as PT PP (Persero) Tbk (a government-controlled construction & investment company), which have adopted the lean concept in the last five years, there is a need to create an environment that supports lean as quickly as possible. For a company that is relatively new to lean involvement and methodology, education is crucial for raising awareness and understanding of lean construction among the company members. This paper presents an exposition of effort and learning for lean transformation by using Community of Practice as a method to disseminate lean knowledge and experience and share details of the activities about programs as an action learning. The authors will share their experience and learning of making the sustainable change in the company through the lessons learned.

KEYWORDS

Lean Construction, Sustainable, Collaboration, Lean Education, Action Learning, Community of Practice

INTRODUCTION

The construction industry is one of the biggest industries in the world. Like others, the construction industry has been evolving because of many issues such as inefficiencies, productivity, overrun cost, technological advancement, labour, regulation, expectation, environmental impact, etc. For the construction industry to adapt to these challenges, there is a need to change the paradigm of the industry. Lean thinking is an example of the evolving paradigm in the construction industry where the principle was adopted from manufacturing. The Lean Management (LM) system was first brought to bear by the Toyota Motor Corporation in the late 1950s and was named Toyota Production System (Shingo, 1981), while the lean

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construction (LC) terminology emerged in the 1990s initiated by the work of Koskela (Koskela, 1992). It emphasises maximising efficiency, minimising waste, and delivering value to the customer through collaborations, optimised workflows, and project performance enhancement. Different studies have suggested that the implementation of lean construction improves performance, raises the value of money and resources, and reduces waste (Amaro et al., 2019; Shaqour 2022; Bajjou & Chafi, 2018, Tezel et al., 2020, Singh et al., 2018, Erol et al., 2017). Despite the benefits, the slow adaptation of lean concepts in the construction industry created a wide gap and broad interpretation of lean construction (Common et al., 2000). This condition produced some barriers for implementation such as skill-and-knowledge-related, behaviour-related, management-related, financial-related, technical-related, and government-related issues (Sarhan & Fox, 2013; Kanafani, 2015; Nwaki et al., 2021; Albalkhy et al., 2021; Shang & Pheng, 2014; Albalkhy & Sweis, 2021, Ayarkwa et al., 2011; Bashir et al., 2015).

LC has been disseminated and taught across the world, including Indonesia. The specific introduction of the LC concept in Indonesia has yet to be officially documented (Abduh et al., 2005). However, we may be able to say that the first major brick of lean construction was the *Kompetisi Konstruksi Ramping (K2R)* event in 2016 (Faculty of Civil and Environmental Engineering, Bandung Institute of Technology 2024). The concept was introduced through a simulation of construction projects. Since LC in Indonesia is relatively young and still in the dawn phase, there is a need to increase contractors' understanding and awareness of lean principles in the construction industry. Studies from other countries implementing LC suggested that barriers vary between countries. For example, the lack of backing from upper management, limited awareness of LC, inadequate training, and a lack of transparency were vital obstacles that significantly impede the acceptance of LC in Jordan (Albalkhy et al., 2021), incomplete or intricate designs, the cyclical nature of the construction industry, limited engagement of contractors and specialists in the design process, insufficient understanding of lean principles, and inadequate communication among all stakeholders represented the top five significant barriers in the UAE (Kanafani, 2015), the major obstacles in China included the absence of a long-term philosophy, a lack of a lean culture within the organisation, and the use of multi-layer subcontracting (Gao & Pheng, 2014), insufficient awareness and comprehension of lean principles, a lack of commitment from top management, and cultural and attitudinal challenges among the workforce were prominent issues in the UK (Sarhan & Fox, 2013), challenges in grasping lean concepts, variability in government policies, unclear project definitions, incomplete designs, absence of standardisation, and a lack of enduring relationships with suppliers were obstacles that impeded the implementation of lean practices in Ghana (Ayarkwa et al., 2011). However, we underline from these studies that people and systems are key factors in determining the success of lean implementation.

This paper aims to present an exposition of effort and learning at an Indonesian contractor, PT PP (Persero) Tbk (called PTPP), that has initiated and adopted LC since 2019. The major effort to achieve the code of conduct of LC at the company was the education of lean principles. The first purpose was to raise awareness of LC amongst company members and to increase their understanding of LC. Another effort was providing in-house training about the Last Planner System (Ballard & Howell, 1994; Lehman & Raiser, 2000) as a tool of lean construction that describes a comprehensive system to address project variability (Maradzano et al., 2019), to optimise the planning, and execution of a construction project (Sarhan & Fox, 2013). The trainers of this training were from the same company. Further effort in implementing LC at PTPP was waste-register method implementation at construction works (Aisyah et al., 2023). This accomplishment was an example of the successful execution of the lean principles at the company. The last effort was to standardise the LC system at the company, although it still needs to be finished. All the above-mentioned efforts were conceptualised under the Community of Practice (CoP) Lean Construction PTPP. CoP is usually used for an event in a

country or larger region. To our knowledge, the notion of CoP at the level of a company is the smallest unit of CoP compared to the usual form of CoP, and it is now well-recognised at the company.

In the next section, we will review the concept of CoP and lean construction education. Sections 3 and 4 will describe the initiation and journey of CoP at PTPP, while Section 5 will explain further challenges towards sustainable lean construction. Ultimately, Section 6 gives the overall conclusion of our work.

LITERATURE REVIEW

LEAN CONSTRUCTION EDUCATION

People and systems are two striking keywords of the identified barriers from different studies on lean construction implementation. Although other factors, such as technical and behavioural issues, are also important, creating awareness and understanding is crucial in preparing for LC. Different studies have suggested that the lack of knowledge hinders people from adopting a new concept (Albalkhy & Sweis, 2021; Gao & Pheng, 2014; Bajjou & Chafi, 2018; Nwaki et al., 2021; Sarhan & Fox, 2013; Moradi & Sormunen, 2023). The problems could be a lack of skill, low level of education, insufficient training, or lack of understanding related to lean (Albalkhy & Weis, 2021). Ultimately, the problems could unconsciously affect the implementation of LC as a system. Due to unawareness, top management could ignore the adoption process, leading to an unsupportive environment. To overcome such barriers, providing training and development investment as part of education was considered a good strategy (Gao & Shang, 2014). The solution could lead to a change in perspective at the top management level and cultural change.

Transferring lean knowledge and skills involves training individuals in the principles of lean thinking. The goal is to provide professionals with sufficient knowledge and skills to improve project delivery, efficiency, and value and reduce waste. Lean education was widely offered at universities worldwide (Tsao et al., 2013). The university-based lean education consisted of theoretical coursework and practical simulations (Rybkowski et al., 2018). The teaching usually contained reading assignments, paper-based reflections, class and online discussions, and simulation exercises to develop students' strong understanding of lean concepts (Tsao et al., 2013; Hamzeh et al., 2016).

The university-based lean education, without question, becomes an ideal notion for learning lean concepts where students can learn and deepen their understanding through theory and practice. However, for a construction company such as PTPP, which have adopted the lean concept in the last five years, there is a need to create an environment that supports lean as quickly as possible. For a company that is relatively new to lean involvement and methodology, the education at the company is typically conducted as training for project teams (Forbes et al., 2018). Forbes et al. took examples and learnt from different companies in the US. For example, JE Dunn introduced the lean concept through the LegoTM Airplane Game, the Parade of Trades, and Silent Squares. In addition to the simulations, it provided training that focuses on introducing lean principles and tools that a project will use. DPR Construction took another path to teach lean thinking, involving Stanford and UC Berkeley to run workshops. Another example from a regional manager of an owner organisation provided hands-on training at the project level and found that the internal construction administration plays a key role in creating a lean culture. The last example was aligned with the finding that transferring and sharing lessons learned within the organisation encourages a successful lean education and culture (González et al., 2014).

Based on the above, there were many forms of lean education at the level of construction companies. The goal was to disseminate and raise awareness of lean thinking within the

company as rapidly as possible. Companies could engage universities or lean consultants to provide education.

COMMUNITY OF PRACTICE IN LEAN CONSTRUCTION

One of many ways to teach and accelerate lean manifestation was through a community of practice (CoP). It is known as a group of people who have the same interests and discuss and explore things for their future goals. They used any methods, especially brainstorming and sharing sessions, through their knowledge and experience (Wenger & Snyder, 2000). CoP was initially developed as a learning theory that promotes self-empowerment and professional development, but as the theory evolved, it became a management tool for improving an organisation's competitiveness (Li et al., 2009). Despite many views, the CoP concept emphasises learning and sharing knowledge and supports formal and informal group interactions.

In the context of lean construction itself, CoP Lean is a group of people interested in LC. The event was usually regional based around the US. An official Community of Practice of Lean Construction was held by the Lean Construction Institute (LCI) (Lean Construction Institute, n.d). Their goal was achieving industry-wide collaboration through communities of practice; whether a skilled practitioner in Lean Design and Construction or just getting started, there was support and a chance to keep learning. LCI nationally supported CoPs after opportunities to connect locally, participate in education courses and workshops, hear from local lean project teams, attend Gemba walks, and more. Since LCI was also present in some European and Asian countries such as the UK, France, Japan, Singapore, and India, the CoP was held chiefly regionally. As the construction industry in Indonesia is growing, such activity is strongly needed to disseminate and teach the lean principle and manifest it in construction in Indonesia.

COMMUNITY OF PRACTICE INITIATION

CoP Lean Construction (CoP LC) is one of the CoPs that exist in the PTPP. The other CoPs are the CoP Green Building, CoP Mechanical & Electrical, CoP Strategic Business Management, CoP Seaport, CoP Power Renewable Energy, CoP Building Information Modelling (BIM), CoP Innovation, and CoP Lean Construction. The CoP LC has three fundamental elements: domain, community, and practice. The domain element is divided based on their operational expertise: building, bridge and road DAM, and Engineering, Procurement and Construction. The community element consists of people who are curious or as simply as they want to know about LC. The last element consists of the method and module used for knowledge sharing of LC. The coordination of all elements is through three divisions of the company: Division of Strategy, Planning and Technology (Stratec), Division of Operation, and Division of Project. These parties determine the operation of CoP LC and improve it. The Division of Stratec is responsible for planning and monitoring corporate LC and innovation implementation, choosing value creation, workshops, socialisation and refreshment as a corporation. The Division of Operation is accountable for monitoring LC of all the projects based on their expertise. The Division of Project is responsible for gaining value creation for the corporation.

CoP LC in PTPP was established in October 2019 after management declared committing to implementing lean construction in March 20219. This idea came when the company followed the LC Villego competition, called K2R 4.0 (Kompetisi Konstruksi Ramping), held by Institut Teknologi Bandung in 2019. There were many projects representing different sectors, such as building, toll-road, and infrastructure. The CoP LC took a role in uniting the PTPP representatives and won the contest. Based on that, the CoP LC creates big goals for having big impacts on the company as much as possible. CoP Lean PTPP was supported by the Human

Capital Management System in order to build awareness. The group organised gathering events in the first year to share CoP LC's agenda. The group collected advice and remarks to highlight the needs of the projects. CoP Lean PTPP is basically under the Department of Knowledge Management System in the Division of Strategy, Planning and Technology and held by the Division of Creative, Engineering and Technology, which is now known as the Division of Innovation, Lean, BIM and Technology.

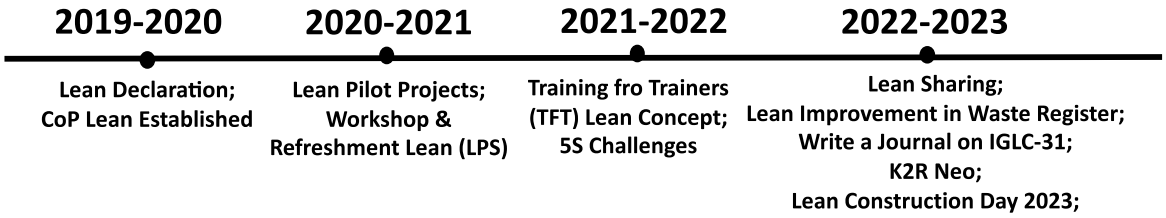

Figure 1 Timeline of CoP Lean Construction PTPP Journey

COP LEAN PTPP JOURNEY

2019 – 2020

As mentioned in Figure 1, CoP LC PTPP was established in October 2019; that year, we focused on all the LC competitions held in Indonesia: Construction Funday GAPENSKI 2019 and Villego Competition (K2R 4.0) 2019. Firstly, we started by doing a site visit project in PLTD Senayan Jakarta to benchmark LC that was implemented first there. This project ran the Last Planner System (LPS) because the project owner was Wartsila, a foreign country. For some project owners, it was usual to do a daily collaboration. This condition was an opportunity for us to know directly how their experience was in it and get some insight through that project.

Because of that experience, we exercised regularly until we won that competition. This initiative project was a milestone in gaining another success story in the next section. In that history, CoP LC did a Sharing Session with the winning team, discussing how strategy, collaboration, and planning affected their win to get some lessons learned that reflect on being implemented in their project. Some lessons learned were how to produce a building that meets the values desired by its users (owners), effective and efficient implementation (time), fit the design (quality), and there was little waste production (cost).

After the competition, we focused on making the modules of The Last Planner System to be implemented in the project. There were so many adjustments from the Villego Competition to the actual project condition, so we learnt to arrange how the methodology was implemented using that basic understanding of LPS through Villego games. On the other side, we initiated the digitalisation of the concept of LPS itself using The PP Planner. It made us collaborate with the Information & Technology (IT) system to apply the project to using LPS as a digital-based project management system.

From the journey of this year, we remark on three key lessons learned that made the CoP LC succeed. First, Last Planner System is crucial in understanding lean construction and its implementation. The members of CoP LC covered the gap of LC understanding in the beginning and LPS was an important first step. Second, collaboration with academic universities becomes vital. The collaboration was done through the competition held by a university, and this event became a milestone in checking the understanding of LC within the company, at least among CoP LC members. Third, the information gathered must be formulated quickly and it was based on experience. By doing such activities, the CoP LC helped the company design lean education and implementation within the company.

2020 – 2021

The work program of CoP LC PTPP continued the year after it was established. We did some correspondence between the CoP LC PTPP committee and the project. The first was to do a workshop on the topic and go back to basics, which was about scheduling and planning. The first workshop was held in April 2020, Workshop Ms Project Integrated with LPS and Workshop Optiwaste (The method for knowing cutting-off reinforcement in the field).

After that, because we should have a recommendation and suggestion to do next, we often did regular *focus group discussions* over time, both directly and indirectly. Directly, we did *Lean Sharing* each month with multitopic, which was an option for following the issue and problem in the project. This lean sharing was an easy and effective method of sharing knowledge over poor construction. We got some suggestions through the discussion and Question & Answer after the materials were disseminated by the speaker. Besides lean sharing, we continued workshops with different experts to minimise the gap in knowledge and experience of poor construction. Indirectly, we made the group to get instant messages and discussions through WhatsApp. Another thing was the newsletter knowledge (PP WIN), a weekly magazine PTPP, and we ended up with the online meeting/ workshop.

This methodology was used to develop CoP LC PTPP, which was customised with the COVID-19 limitations that we got to reach more closely. Still, we also found out how to make an effective and efficient method that could be accepted by all the projects throughout the Indonesian region from Sabang to Merauke.

From this journey, we highlight that creating a medium for sharing and learning boosts awareness and understanding of lean construction. Sharing and learning must not be limited, and it is better to start with the company members' experience related to lean theory and application.

2021 – 2022

In 2021, CoP LC was trying to explore knowledge widely by benchmarking abroad nationwide. We held Training-for-Trainers (TFT) by Chyntia Tsao (NAVILEAN). This TFT ran for eight months (sixteen meet-ups) from May until September 2021 during the COVID-19 pandemic.

EXHIBIT A - SERVICES

The Company has engaged Consultant for the following service module:

Week	Date	Day	Time (WIB)	Duration (min)	Topic	Material
1	21-May-21	Friday	7 am - 8 am	60	Lean Thinking and Lean Construction Tools	old
2	28-May-21	Friday	7 am - 8 am	60	Lean Thinking and Lean Construction Tools (2)	old
3	4-Jun-21	Friday	7 am - 8 am	60	LPS Success Factors	old
4	11-Jun-21	Friday	7 am - 8 am	60	Milestone Planning: Preparation Pull Planning: Facilitation & Implementation, Takt Planning Fundamentals	old
5	18-Jun-21	Friday	7 am - 8 am	60	Make Ready Planning: How to identify and manage constraint	old
6	25-Jun-21	Friday	7 am - 8 am	60	WWP: Managing Promises Daily Huddle: Fundamentals & Being Agile with exception	old
7	2-Jul-21	Friday	7 am - 8 am	60	Learning: Root cause analysis tools	new material
8	9-Jul-21	Friday	7 am - 8.30 am	90	LPS Simulation on Project + Evaluation part 1	case study
9	16-Jul-21	Friday	7 am - 8.30 am	90	LPS Simulation on Project + Evaluation part 2	case study
10	23-Jul-21	Friday	7 am - 8.30 am	90	LPS Simulation on Project + Evaluation part 3	case study
11	30-Jul-21	Friday	7 am - 8 am	60	LPS and Lean Assessment: Measuring lean maturity on project/company	new material
12	6-Aug-21	Friday	7 am - 8 am	60	LPS and Lean Assessment: Measuring lean maturity on project/company (2)	new material
13	13-Aug-21	Friday	7 am - 8 am	60	Introducing Lean Project Delivery System: IPD Concepts	new material
14	20-Aug-21	Friday	7 am - 8 am	60	Value Stream Mapping part 1 (concept)	old
15	27-Aug-21	Friday	7 am - 8 am	60	Value Stream Mapping part 2 (work session)	old
16	3-Sep-21	Friday	7 am - 8 am	60	Evaluation	work session
17	10-Sep-21	Friday				
				17.50	hours - interaction with PTPP	
				5.00	hours - minimum preparation	
				10.00	hours - maximum preparation	

Figure 2 Module Planning Example

This was followed by the top ten CoP LC participants. During the training, we learnt step-by-step how lean could be implemented; the success story project implemented lean and then discussed many things related to lean construction implementation in PTPP. To know how we understand the result of TFT, in parallel, we gathered by did an online workshop to transfer the knowledge to the project and continue Lean Sharing, which has several topics:

1. Lean Sharing-1: LPS Project Story PLTD Senayan
2. Lean Sharing-2: PP Planner (Implementation LPS by the digital tools)
3. Lean Sharing-3: Book Sharing – "Lean Thinking"
4. Lean Sharing-4: Between BIM & Lean
5. Lean Sharing-5: Value Stream Mapping
6. Lean Sharing-6: Introducing Lean Construction and Its Development
7. Lean Sharing-7: Waste Identification - DOWNTIME
8. Lean Sharing-8: Lean Culture – The Key to Lean Implementation
9. Lean Sharing-9: LPS – Lean Project Execution
10. Lean Sharing-10: Improve Productivity with Lean Project Execution
11. Lean Sharing-11: Lean 5S Implementation
12. Lean Sharing-12: Digital Lean Construction

Lean Sharing invited both an internal and external PTPP speaker to gain knowledge through its lean construction expertise. We rewarded the participants who actively reached out during the Q&A and often follow skinny sharing. Also, the community members got rewards from Knowledge Center (KC) point platforms when they became speakers in lean sharing, contributed to the CoP product output, did sharing through the CoP LC agenda and participated in the Training-For-Training (TFT) workshop. The other event was the 5S Challenge. CoP LC held this competition, and the participants were from different projects. This was a review of what and how the project implements 5S in the project. There was a winner of that competition: Stadion Banten Project, Engineering, Procurement & Construction (EPC) Divisions, and the Depo Makassar Project—three top projects chosen by assessment by internal and external PTPP expertise.

In the third year of CoP LC PTPP, we note that continuous improvement is a key factor that makes lean education successful and sustain at PTPP. This is aligned with approaches taken by the CoP lean, for example, providing a Training-for-Trainers and creating a structured and systematic sharing and learning means within a year. The provided training becomes a tool to yield new agents of lean within the company. The lean education is boosted not only by systematic sharing sessions, but also by providing reward to the company members who contribute to lean construction improvement at the company. Continuous improvement becomes a core value of CoP lean PTPP and it motivates CoP lean to provide novel topics for lean construction sharing sessions and yield an important milestone explained in the next section.

2022 – 2023

In 2022, CoP LC were continuing lean sharing with a new topic to be discussed:

13. Lean Sharing-13: Book Sharing – "The Second Lean"
14. Lean Sharing-14: Construction Waste Register
15. Lean Sharing-15: Integration LPS & CPM
16. Lean Sharing-16: Lean Implementation for Cost Performance

17. Lean Sharing-17: Takt Time Planning for Schedule Project Improvement
18. Lean Sharing-18: Dealing with Construction Waste by Lean Project Execution
19. Lean Sharing-19: Lean Canvas: The Simple Business Model
20. Lean Sharing-20: Lesson Learned K2R Neo 1.0 & Pull Planning Concept

Another learning that we have been through was by following The Lean Construction Conference online. There were so many topics that were related to current conditions, so we were equipped with knowledge and experience from aboard. In 2023, CoP got some highlights of the agenda; one of them was to present our journal of production, planning and control with focusing waste registered. The title of PTPP's journal was Lean Construction Through Waste Register Method: A Case Studies Project in Indonesia. The journal focuses on implementing lean construction for physical construction waste. Furthermore, this article presented Indonesian case studies to illustrate the impact of lean construction on building projects. The study analysed waste management impacts across three periods of time. Lean waste management provided an early warning evaluation in the short term that was used as an indicator so the project could evaluate and follow up as an effort to reduce waste, which in this study showed a reduction of waste from 2.1% to 1.7%. Addressing common waste in the medium-term increased project productivity by 50% and improved cost and duration efficiency. It reduced many possible wastages due to defects, overproduction, non-utilised talent, inventory, transportation, motion, waiting, and extra processing (DOWNTIME). Sustainable waste reduction practices could become a productivity standard in the long term by continuously improving the cycle of writing, categorising, analysing, and writing for each job.

We presented our journal in Lille, France, for the first time and only for Indonesia as a presenter. The goals were reaching out insights through the lean construction international conference, establishing strategic partnerships with practitioners and academics in the international scope, improving PTPP's branding in the implementation of lean construction and getting insight into lessons learned on project site visits on an international scale to increase lean construction awareness for the futures. After IGLC's 2023 in June-July 2023, we moved into the Indonesian competition of lean construction (K2R Neo) event on 1 October, 2023. As mentioned before, this agenda was held by academic institutions and followed by Indonesian construction practitioners and academicians. CoP prepared seriously until we won two champions at once. The goal following this event as an innovative collaboration platform was to gain a deep understanding and competency in the lean construction concepts of the LPS**.**

The other agenda by CoP LC presents Lean Construction Day 2023 (LCD 2023). PTPP's Lean Construction Day 2023 was one of the agendas for increasing the competency of project participants in the form of sharing sessions, talk shows, workshops, and other similar activities regarding the implementation of lean construction, which were carried out by PTPP through its CoP LC. A similar agenda was previously carried out in 2022 and was then carried out again on 3 November, 2023. The purpose of LCD 2023 was to: 1. Accelerate the increase in corporate knowledge in implementing lean construction; 2. Refreshment of knowledge and experience of implementing lean construction from the perspective of regulators (Ministry of Public Works & Housing - PUPR), academics (Dr. Gao Shang) and practitioners (PTPP) and 3. Creating value-added in the form of positive branding to stakeholders that PTPP was concerned with implementing lean construction and PUPR Ministerial Regulation No. 9 of 2021: Guidelines for Implementing Sustainable Construction.

FURTHER CHALLENGES TOWARDS SUSTAINABLE LEAN CONSTRUCTION

Lean implementations (in construction and beyond) because of barriers hindering successful implementation, including respect for people who are not specific to construction. These

challenges involved an excessive focus on continuous improvement and a lack of complete understanding or underestimation of the importance of respect for people to the sustained success of lean principles (Korb, 2016). Beyond those initial barriers, a further challenge towards sustainable lean construction was creating the same perception of future constructions. People, which is one of the critical aspects, can be developed through CoP at the company and have the same vision to disseminate lean principles as a community. In the CoP Lean PTPP, the majority of CoP members were young people who tended to have the courage to make a better change through continuous improvement actions. After people, the big challenge towards LC implementation was the systems, which we identified to three points. The first point was that the company needed agents of lean. These people had roles to continue, evaluate, and improvise LC implementation. The second point was that LC implementation standards and legal were mandatory for every project in PTPP. The last point was the involvement of the top management, which could influence the adoption and implementation of LC at the company.

CONCLUDING REMARKS

This work describes the effort and learning of lean construction education at the PTPP, which started adopting lean thinking in 2019. In particular, lean education at the company was conducted through a community of practice, which became a place to learn and share theories, experiences, practices, and tools related to lean construction. CoP lean at PTPP, in the last four years, has disseminated learning throughout the company members, including top management level and company experts. Lean sharing has become the most frequent activity for raising awareness and understanding of the concept. It was then made into a more significant event, Lean Construction Day, which disseminated lean construction to broader participants and involved universities. At the project level, team members also received hands-on training about the Last Planner System using Villego. CoP was an excellent strategy to raise people's awareness and understanding. The company must have agents of lean to ensure that the learning process continues throughout the time and did not depend on the company member's position. However, some challenges remained regarding the system for developing sustainable lean construction at the PTPP. Top management support was the most important because of their influence and authority in establishing standards and legal lean construction implementation at the company.

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