

Engineering Lean as a Conduit for Collaboration

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Abstract

Engineering Lean methodologies have been successfully employed by industry for decades, increasing resource output and continuous process improvement create a sustainable environment for organic growth. The methods of Lean provide a roadmap that highlights core principals of continuous improvement; recognizing value, journey mapping of those value, maintaining a steady flow, pulling resources when needed, employee empowerment and striving for perfection. Leadership must firmly embrace these practices to ensure commitment throughout an organization and ensure success.

Currently, many profitable companies are using Lean to become efficient global leaders; however, academic resources to prepare our future workforce are scarce for high school (secondary) and relatively few opportunities in college (post-secondary) institutions. These tools are essential to our emerging workforce, yet we are failing to introduce them during crucial learning opportunities to most secondary or post-secondary students. This paper explores how these industry-tested tools can foster career exploration, industry collaboration, and workforce development. The Lean curriculum we are presenting, empowers learners to harness Lean tools for personal growth and to prepare them for real-world opportunities, along with being a conduit for collaboration between academia and industry. Specifically designed to address a currently overlooked opportunity, we created content to be equally accessible to secondary, post-secondary students, educators and those working within industry. Due to the length of each course module measured in time and range of topics covered, the curriculum lends itself to flexibility in content delivery.

Introduction

Originating from Toyota's Production System, Lean emerged post-World War II in Japan as a transformative strategy to heighten manufacturing efficiency. Taiichi Ohno, a pioneer in Lean, introduced methods like just-in-time manufacturing, waste reduction, and empowering employees [1]. These versatile methods extend across industries, emphasizing customer value, process efficiency, and employee empowerment, thus maximizing organizational operations.

In this time of employee shortages and rising costs, Lean serves as a powerful solution, alleviating growth constraints by streamlining processes and potentially reducing the need for excessive automation. *Quality Magazine* reports that embracing Lean manufacturing systems and concepts can significantly improve productivity, reduce work-in-process by up to 90%, increase space utilization by 50%, improve quality by 85%, and cut lead times by up to 90% [2].

Although automation can also improve quality, financial costs need to be considered while keeping profitability factors in mind [3]. So, why haven't these invaluable tools been prioritized for secondary and post-secondary learners? That is a good question. Lean practices encompass practical problem-solving, critical thinking, collaboration, personal life efficiency, career readiness, sustainability, adaptability, life skills, business concepts, troubleshooting, and innovation. Not only are these tools useful in industry applications, but these skills are also vital to prepare students both professionally and personally to be prepared to enter the workforce. The creation of a Lean curriculum and this paper is an effort to address this missing piece in education, to fill in the gap students currently encounter.

Creation of Engineering Lean Curriculum

The Minnesota State Engineering Center of Excellence, in collaboration with Anoka Technical College, through Professional Workforce Training and Organizational Partners, LLC, developed an innovative Train-the-trainer Lean Curriculum. This Lean resource equips educators and industry professionals to apply real-world resources in classrooms and workplace training. The curriculum fosters industry-academic collaboration, bridging the gap between academia and what industries have been using for years, and providing resources for workforce development.

The Train-the-Trainer Lean Curriculum consists of 10 modules, with each module requiring approximately 50 minutes to cover its content thoroughly. Integrated into the curriculum are hands-on activities known as “experiential learning” or “learning by doing activities,” which serve to reinforce the learning outcomes. These activities represent just a fraction of the numerous tools encompassed by the Lean methodology. The selection of these tools underwent a deliberate process, considering factors such as tool/technique complexity and computational demands, with particular consideration for learners who might encounter challenges with numerical calculations.

The Train-the-Trainer modules are structured as follows:

Module 1: “History of Lean”

Learning outcomes: Understand Lean concepts, historical perspectives, and real-life applications.

Module 2: “Spaghetti Diagram & Waste Identification”

Learning outcomes: Create and analyze spaghetti diagrams, distinguish between value add and non-value add, and recognize the 8 wastes.

Module 3: “6S or 5S – Workplace Organization”

Learning outcomes: Recognize the importance of workplace organization, understand 5 or 6S, and break down each S.

Module 4: “Flow – Push vs. Pull”

Learning outcomes: Differentiate between the concepts of push vs. pull, understand one-piece flow, and grasp Kanban systems.

Module 5: “TAKT Time vs Cycle Time”

Learning outcomes: Understand the difference between TAKT vs Cycle, calculate each, and comprehend their utilization.

Module 6: “SIPOC & Process Mapping”

Learning outcomes: Understand and create SIPOC and process maps, interpret flowcharts, and comprehend mapping symbols.

Module 7: “Kaizen Event”

Learning outcomes: Understand the methodology of a Kaizen event, familiarize with the RACI Triangle, and utilize a Kaizen Newspaper.

Module 8: “Cause and Effect Diagram”

Learning outcomes: Define the components of a Cause and Effect Diagram, apply problem-solving techniques, and evaluate and prioritize solutions.

Module 9: “Root Cause Analysis Tools”

Learning outcomes: Utilize Check Sheets and Tick Sheets, connect to Pareto Charts, and analyze and interpret Pareto Charts.

Module 10: “5 Whys”

Learning outcomes: Understand the methodology, purpose, and conduct a 5 Why analysis.

This comprehensive curriculum equips learners with a diverse set of tools and methodologies within the Lean framework, creating a deep understanding of Lean principles and their practical applications.

In our pursuit of continuous improvement, we created a Train-the-Trainer Lean leader curriculum. This specialized program aims to cultivate skills in self-awareness, conflict resolution, effective teamwork, emotional intelligence, embracing diversity, practicing servant leadership, refining communication abilities, and supporting conflict management techniques. The inspiration for this curriculum arose during a meeting with engineers from Caterpillar (CAT) during an industry visit. They highlighted that technical proficiency is not the primary shortfall among recent academic recruits, emphasizing the need for enhanced interpersonal skills. Each of the seven modules is designed for approximately 50 minutes of delivery, incorporating engaging learning activities.

The Train-the-Trainer Lean leader modules are as follows:

Module 1: “Applying Lean Principles in Your Personal Life”

Learning outcomes: Understand and apply key Lean concepts and recognize the benefits.

Module 2: “Emotional Intelligence”

Learning outcomes: Comprehend the components of emotional intelligence and how understanding it can enhance leadership skills.

Module 3: “Understanding and Valuing Differences”

Learning outcomes: Explore personality preferences, types, and how leveraging these can improve team and workforce dynamics.

Module 4: “Servant Leadership”

Learning outcomes: Examine key traits and benefits of servant leadership.

Module 5: “The Art of Communication”

Learning outcomes: Master effective communication, understand the importance of listening, delve into nonverbal communication, and gain tips for better communication.

Module 6: “Team Building”

Learning outcomes: Understand team growth stages, develop skills in building teams, and apply strategies for successful teamwork.

Module 7: “Conflict Management”

Learning outcomes: Explore management strategies, resolution techniques, overcoming resistance to change, and the creation of shared understanding.

This comprehensive curriculum addresses the crucial interpersonal skills identified by industry professionals, providing a platform for individuals to enhance their understanding and contribute effectively to their professional environments. To complement this need for interpersonal skills, in “The Future of Work 2022 Global Report” from Monster.com, identifies in the 2022 survey, employers are having difficulty filling positions due to interpersonal skills gaps, with teamwork and communication being the top two [4].

All of these lessons are designed to be used alongside traditional class curriculum. For example, if you're an educator for a senior mechanical engineering design class, you could use the Team Building module once your project teams are formed to demonstrate how teams can effectively work together. An educator discussing engineering ergonomics would find relevant examples and hands-on techniques using the spaghetti diagram & waste identification modules. In an ethics course, an educator could turn to the history of Lean module, to identify employee empowerment practices, since Lean is a leader in that arena.

Since everything is set up for trainers to teach others, these modules are optimal for a student, or a group of students to present lessons to the rest of the class. This provides an additional opportunity to empower leaders, develop critical thinking and social skills. Further exploration of these topics by students and emerging leaders allows new discussions, exploration and insights about how we understand and use these concepts into the future.

Industry

Upon completing the Lean curriculum training, companies will be able to implement the acquired knowledge to new and existing staff and extend Lean awareness to newly appointed managers. This content can serve as an initial, organized effort in their expedition towards embracing a Lean culture. The initial training adopts a Train-the-Trainer approach, enabling companies to convey these crucial concepts in an academic instruction format which is enhanced by hands-on projects and problem-based activities.

The curriculum promotes partnerships between industries and academia through this Lean common language. One way this collaboration can take shape is through the incorporation of Lean capstone projects, offering students a chance to analyze real-world operational challenges

with a fresh perspective. Another approach for collaboration can involve organizing a Kaizen event within the facility, focusing on improvement to an existing process, allowing students to actively participate, and leverage these new tools.

A successful capstone also provides the opportunity for industry to do talent recruitment. An example of this was during my career at General Electric (GE). As a Lean leader, we constantly had workouts to perform. One year we brought in five post-secondary mechanical engineering students to do a Kaizen as part of their capstone. Not only did we have a project that needed to get done, but we also recruited a promising young leader for the GE Leadership program. Over this two-week period, students in this capstone project were exposed to many new experiences they would not normally have gotten in an academic setting. They interacted with workcell owners, acquired skills to effectively communicate change, and created solutions that not only enhanced efficiency but also supported workforce safety. Finally, through observation of team dynamics, we were able to identify a student who would be a perfect fit for the GE Leadership program.

This capstone/Kaizen approach provided several advantages. First, we were able to assess and identify top talent from a pool of potential candidates. Second, this activity provided students with real-world projects, helping them with their practical skills along with enhancing communication techniques. Finally, they served as an additional resource, contributing to projects that our company needed to get done. One important aspect of a successful Kaizen event is the introduction of new members to the team. These newcomers can provide innovative ideas, ignore the existing condition, and can focus on potential improvements. This dynamic engagement not only creates a sense of connection throughout the organization but also allows for combining different skill sets, enriching the problem-solving capabilities of the team.

Furthermore, learners could partake in leadership Gemba Walks, which is a principal concept in Lean management. This process involves company leadership engaging with the work area, looking at processes, interacting with employees, and experiencing current operational situations. This deliberate activity empowers employees to voice their concerns and address issues, an important aspect of a Lean culture. Akio Toyoda, Toyota's CEO, stated, "the gemba is something that no digitization or telework system, no matter how advanced, can ever replace" [5].

By industry expanding these opportunities, they could also create externships/internships for educators seeking to bridge the gap between theory and industry practice. Educators participating in these types of opportunities can grow professionally while gaining insights from current industry practices. This wealth of experience can then be integrated into the classroom, creating dynamic discussions and practical activities from real-world scenarios. From industry's standpoint, this initiative can double as a clever marketing opportunity, showcasing the organization's commitment to youth and education.

Finally, the curriculum and its associated activities can serve as a valuable outreach channel for companies. An operations manager from a major corporation recently approached me, highlighting their limited options for engaging with local schools. Their current engineering outreach content did not cater to academic engineering concepts. However, with the Lean curriculum, this company's technical team can now perform student outreach events demonstrating engineering concepts for continuous improvement.

Learners

The Lean curriculum serves as an introductory gateway for learners to engage in the inner workings of industries. Through these tools, our curriculum reveals the operational metrics valued by companies. This also extends into an awareness of what holds significance for customers, both internal and external.

What sets this curriculum apart is its non-specific career focus, enabling learners to utilize Lean tools and principles across diverse industries of their interest. Lean is about the process of continuous improvement universal to any process or industry. Learners are free to explore potential career paths, with the understanding that Lean and continuous improvement are important within any career field. Lean tools can also support learners through their personal life challenges with resources that can help address current barriers to success.

An important item worth highlighting, is the employability of these acquired skills. These skills present an appealing addition to the toolbox of those entering directly into the workforce, those wanting to enter traditional higher education routes, or undergoing career transitions. The essence of Lean tools centers on process optimization and productivity refinement. The ability to understand and employ these tools are transferrable skills that are valued across many types of industry. In a recent article from Zippia, a job search website, they sorted the top Lean manufacturing manager skills based on the percentage of Lean manufacturing manager resumes. In this article, they found that the most common Lean manufacturing manager's hard skill listed on resumes was Lean manufacturing at 8.8%, with sigma appearing second at 7.4%, and process improvement at 6.8% [6].

As learners contemplate integrating Lean principles into their new company, regardless of its scale, I believe several key considerations should be taken into account:

1. *Leadership Commitment*

Sustained leadership commitment and support are imperative for the success of Lean implementation. It is crucial that leadership consistently demonstrates advocacy for this initiative, marking a shift in organizational culture toward continuous improvement, problem-solving, and waste reduction.

Andrew Grove, former CEO of Intel once said, “A corporation is a living organism; it has to continue to shed its skin. Methods have to change. Focus has to change. Values have to change. The sum total of those changes is transformation.” [7].

2. *Employee Change Management*

Effectively managing change becomes pivotal. Incremental implementation processes are advisable, emphasizing the celebration of early successes. Opting for projects deemed “low-hanging fruit”—those that are swift and uncomplicated—can yield rapid impacts.

3. *Communication*

Communication is paramount. Establishing pertinent metrics and key performance indicators (KPIs) to gauge the success of Lean initiatives is essential. Regular performance assessments and

data-driven identification of areas for improvement contribute to effective communication. A Kaizen newsletter, detailing ongoing activities, can enhance transparency.

4. *Employee Involvement*

A cornerstone of Lean is the empowerment of employees. Involving personnel at all organizational levels is critical. Their insights are valuable for pinpointing improvement opportunities and facilitating changes. Fostering a culture where employees feel empowered to propose and engage in continuous improvement is essential.

5. *Training and Education*

Providing comprehensive training on Lean principles and methodologies is paramount. Ensuring that employees possess the requisite skills and knowledge to comprehend and contribute to Lean initiatives is essential. Learners can leverage some of this curriculum, or alternatively, seek education from various educational institutions and industry professional groups.

The initial step involves determining the company's vision for its model line. This serves as a critical template for cascading changes throughout the entire organization. Functioning as a training ground, this line continually evolves through regular Kaizen events, becoming the focal point for implementing the numerous Lean tools and techniques employed across the organization. A current state value stream map will also be important in the initial stages. Notably, challenges arise for companies characterized by high "product diversity" or "product variety." Effectively addressing these situations may involve focusing on machine or assembly processes conducive to the vision of "quick changeover" or "SMED" (single-minute exchange of die), an additional Lean topic not presently covered in the curriculum.

In looking toward the future of this programming, virtual reality emerges as a valuable tool for training and career exploration. With this Lean knowledge, learners can gain a better understanding of their desired career/work exploration by employing these Lean tools to evaluate processes and responsibilities integral to those roles in a virtual setting. Imagine a virtual reality nursing station, for example. Learners can actively observe and assess how they might use the Lean methodology to increase safety, efficiency, teamwork and encourage employee empowerment to provide an overall improved experience for the nurses, staff, and patients, as well.

Educators

For educators, the Lean curriculum offers a straightforward concept that demands minimal computation, much to the delight of some learners. The modules come equipped with project-based and problem-based activities, which align with the learning outcomes and practices of the curriculum. The blend of content and activity engagement is designed to make learning enjoyable for students while facilitating practical application.

In line with this, the Engineering Center of Excellence provides professional development for educators who participate in the training. This activity not only recognizes the integrity of the curriculum but also fosters necessary ongoing professional advancement. Most importantly, our Lean curriculum serves as a bridge for effective communication between academia and industry,

reducing the historical divide in interaction. This curriculum acts as a catalyst for enhanced collaboration, benefiting the educational journey and the preparation of a well-equipped workforce and future leaders.

Another advantage to the industry of student engagement is talent recruitment. At the Capstone/Kaizen event mentioned earlier, we invited five post-secondary mechanical engineering students to GE, successfully engaged students with industry and gave them a real-world experience. By doing a Kaizen in this fashion, we were able to evaluate for top talent. We provided real-world projects along with increasing communication techniques and providing an additional resource for project completion. This fosters a mutually beneficial relationship between academia and industry by providing a relevant pathway to students looking for experience and future employment and for industry to connect directly to the skilled workforce they need to be successful.

Conclusion

In conclusion, our Lean curriculum provides a multitude of diverse benefits. Lean equips learners to embrace continuous improvement in their personal lives and their future careers, while serving as a bridge or a conduit between academia and industry. The curriculum can facilitate industry collaborations, by providing companies with fresh insights and opportunities for learners and educators to get hands-on experiences. Ultimately, this curriculum fosters a mindset of innovation and continuous enhancement, preparing industry, educators, workforce and future learners for real-world challenges and the successes that can be achieved.

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Biography

JASON BRUNS is the director of the Minnesota State Engineering Center of Excellence. He received his BS from the University of Minnesota, Institute of Technology in Mechanical Engineering, and a Master of Business Administration from Minnesota State University Mankato. He spent 23+ years in the industry successfully serving in engineering, operations Lean leader and manufacturing leadership roles at various companies including General Electric. Throughout his professional tenure, he played an integral role in obtaining two national patents as a co-founder and one international patent as a co-founder. Mr. Bruns now directs the center's activities as it pertains to enhancing engineering education, engaging industry, and inspiring students. He enjoys spending time with his wife and his four daughters, along with their youth social events.