



Building in Learning and Knowledge Reuse

Leveraging innovations from previous development programs accelerates new product, process, and services development.

Part three of a series exploring each of the Lean Product and Process Guiding Principles.

Dear Reader,

Welcome to the third edition of *The Design Brief*, where we explore practical applications of lean product and process development (LPPD) principles and practices. This issue, we examine the benefits of an LPPD approach to learning and knowledge reuse in product and process development. Our contributors share fascinating lessons on several aspects of successful organizational learning and proven methods for effective knowledge reuse.



Our guest contributor is Ken Bertagnolli, vice president of Research, Development, and Engineering at US Synthetic, a ChampionX company. Our Coach's Corner features Senior Coach Katrina Appell, PhD. And our video contains some outstanding stories from the people involved with various development issues:

- Delivering a lifesaving Covid-19 vaccine at Pall Biotech
- Creating engineering standards at Caterpillar
- Closing critical product knowledge gaps at Pella Corporation.

We hope you enjoy the insights distilled in this ebook and wish you good luck in your journey to adopt the lean product and process development guiding principles.

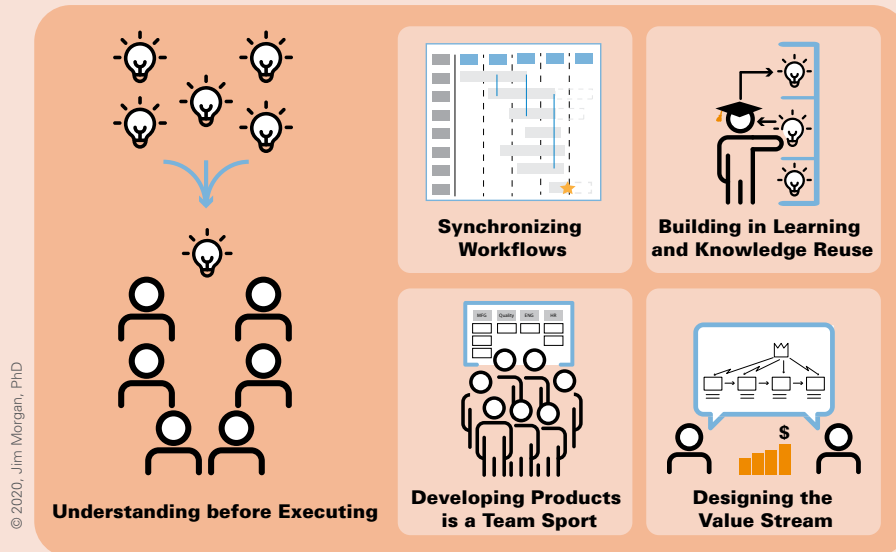
Sincerely,

A handwritten signature in black ink, appearing to read 'Jim Morgan'.

Jim Morgan, PhD
Senior Advisor, LPPD
Lean Enterprise Institute



Putting People First



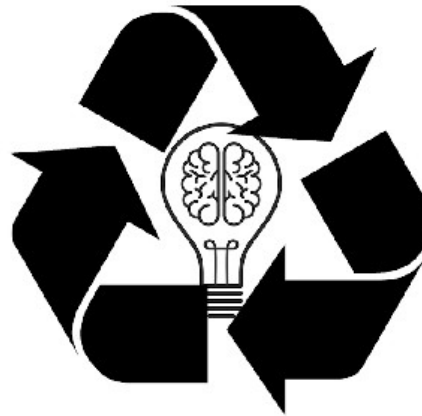
Lean Product and Process Development (LPPD) Guiding Principles

1. **Putting People First:** Organizing your development system and using lean practices to support people to reach their full potential and perform their best sets up your organization to develop great products and services your customers will love.
2. **Understanding before Executing:** Taking the time to understand your customers and their context while exploring and experimenting to develop knowledge helps you discover better solutions that meet your customers' needs.
3. **Developing Products Is a Team Sport:** Leveraging a deliberate process and supporting practices to engage team members across the enterprise from initial ideas to delivery ensures that you maximize value creation.
4. **Synchronizing Workflows:** Organizing and managing the work concurrently to maximize the utility of incomplete yet stable data enables you to achieve flow across the enterprise and reduce time to market.
5. **Building in Learning and Knowledge reuse:** Creating a development system that encourages rapid learning, reuses existing knowledge, and captures new knowledge to make it easier to use in the future helps you build a long-term competitive advantage.
6. **Designing the Value Stream:** Making trade-offs and decisions throughout the development cycle through a lens of what best supports the success of the future delivery value stream will improve its operational performance.

The LPPD Guiding Principles provide a holistic framework for effective and efficient product and service development, enabling you to achieve your development goals.



In this 12-minute video overview, you'll hear practitioners briefly describe how the LPPD Guiding Principles helped them improve their product, process, and services development.



How Building in Learning and Knowledge Reuse Improves Product Development Success



By *Jim Morgan*

People have been writing about “the learning organization” for nearly as long as there have been business books. I started thinking seriously about the topic in the late nineties after reading Peter Senge’s seminal work *The Fifth Discipline*. Since then, it has become increasingly clear to me that the ability to learn and apply that knowledge to improve performance is the foundation of high-performance organizations. It is at the heart of continuous improvement and enables the pursuit of excellence in all facets of our lives.

Not surprisingly, learning and knowledge reuse is just as essential to product and process development. In fact, the failure to learn effectively dooms your organization to painful mediocrity and eventual obsolescence.

Of course, there are many nuances to organizational learning and many good texts to help you. But, as you watch the video embedded on the next page and read this ebook, I encourage you to be mindful of three essential elements.

First, there is no organizational learning without individual learning. Your organization is, after all, a collection of individuals. Consequently, your hiring, retention, and promotion should show that you value people who are

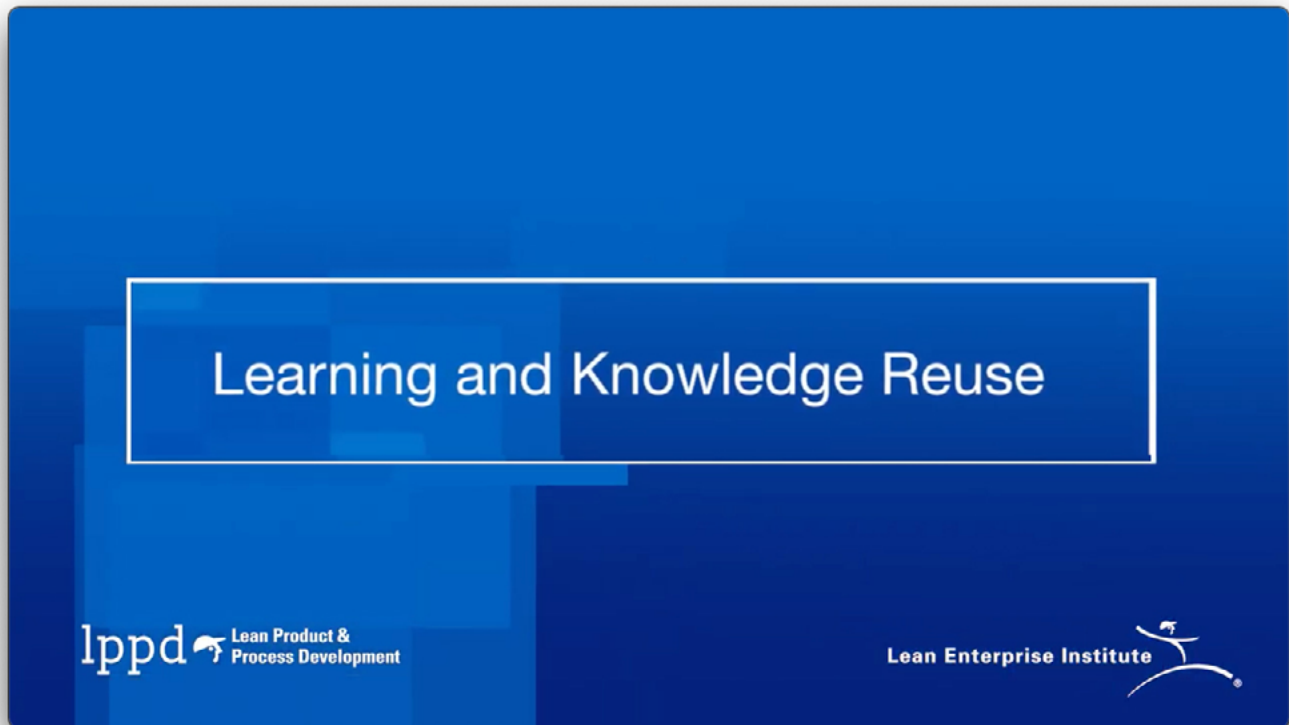
learners. Their experience and demonstrated competence are, of course, critical. Still, they should also be curious, willing to test limits, and humble enough to realize they do not have all the answers. After all, there is no point in learning when you already know everything. These characteristics are especially essential for your leaders to have.

Second, there are two types of knowledge you must account for in your learning strategy: Tacit knowledge, also called “know-how,” is critical for specialized skills, and explicit knowledge such as data and facts. Explicit knowledge is more easily captured and shared. You can embed it in CAD tools or knowledge databases. Tacit knowledge is much more challenging to share, requiring longer relationships between teacher and student — and a great deal of persistence.

Finally, learning should be woven into every aspect of your development system. Learning should be part of the way people do their work. Well-run design reviews, especially at the gemba, are one of my favorite ways to do this because it addresses both types of knowledge. The reviews should be the epitome of rapid learning cycles. Trade-off curves, reflection events, A3 problem-solving, and dynamic standards are a few other methods of building learning into your work, and there are many others.

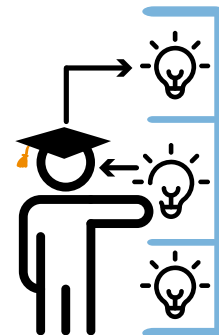
But the tools and methods are available to everyone. The attributes that separate real learning organizations from wannabes are focus, discipline, and perseverance — all characteristics that are in evidence in the organizations in this issue’s video. ■

Building in Learning and Knowledge Reuse



This month's video features excellent examples of building learning and knowledge reuse into the development process from three leading LPPD practitioners:

- Clive Glover, director of strategy, Pall Biotech, tells us how using a fixed and flexible approach to knowledge reuse dramatically reduced the lead time of delivering a lifesaving Covid-19 vaccine.
- Gary Yukon, director of engineering, Earth Moving Division, Caterpillar, shares how active knowledge management and engineering standards build better products and more capable engineers.
- Natalie Reed, project manager, Pella Corporation, describes how they work to close knowledge gaps early in programs to achieve better performing products and product development programs.



**Build in Learning
and Knowledge Reuse**



Coach's Corner

How to Design a Knowledge-Sharing System



By Katrina Appell, PhD

QUESTION: We capture knowledge from projects in lessons-learned documents, but our engineers rarely look at them, forcing us to relearn knowledge for new projects. How can we get our engineers to use the knowledge we already have?

Response: That is a great and common question. You are not alone. Many organizations struggle with effectively using organizational knowledge. Organizations often focus on picking the right practice or tool to capture knowledge, assuming that, once it is captured, others in the organization will use it. Like all lean practices, the effectiveness of knowledge-sharing practices is determined by how well it helps people do their work.

Understanding the Customer of the Knowledge Sharing Practice

If you focus on understanding who needs what knowledge, you can design a knowledge-sharing practice people will use. The customers of your knowledge-sharing system are the development team members. You need to understand what knowledge the team members need and when they need it so knowledge can be shared with or pulled by the people who need it at the right time. It would be best to also understand what doesn't work about your current

knowledge — sharing practices for team members. There are a couple of common reasons why lessons learned documents don't get used:

1. The right knowledge is hard to find. If team members can't find the knowledge they need, they feel like they wasted their time.
2. Creating new knowledge (even if it already exists in the organization) feels more meaningful and enjoyable than searching for knowledge.

Why Knowledge is Hard to Find

Team members — the customers of the knowledge — frequently find it challenging to find captured knowledge because knowledge-sharing practices are often designed around making the process easiest for the people contributing knowledge. In the case of lessons learned, the team completing a project usually creates a document that captures what it feels is essential and then stores it in a shared drive accessible across the organization.

In practice, these documents are rarely — if ever — used, causing the people who write them to put minimal effort into capturing their knowledge, which makes it less likely that other project teams will use the documents — and the

cycle continues.

Some team members become disengaged, feeling like they are wasting their time capturing knowledge that nobody will use. Other team members become disengaged as you ask them to search through poorly organized shared folders, trying to find helpful knowledge. (Often, the documents are filed in folders organized by project, not by essential learning topics.) There is often invaluable knowledge in the files, but finding it is like finding a needle in a haystack. Frequently, people don't even bother looking since the relevant knowledge is hard to find; the search is too frustrating.

Why Knowledge is Recreated Instead of Reused

When it is difficult to reuse knowledge, most people recreate it for their new project. Or worse yet, if there isn't time to create it, people make decisions with insufficient learning, which usually has negative consequences. Most people enjoy creating new knowledge, which is perceived as creating new value, even when the knowledge already exists in the organization.

Just-in-time knowledge creation is fun and often is what is valued and rewarded in organizations. But it is an easy way to fall behind the competition when they effectively reuse knowledge and focus their energy on creating genuinely new knowledge and value for their organization. Still, most team members would prefer not to recreate existing organizational knowledge and wouldn't if it were easy to find.

Designing a System Your Team Will Use

For people to reuse knowledge, it needs to be shared at the right time in the development process in a helpful format that makes the work easier. There isn't an easy knowledge-management tool solution. Instead, you must provide your development teams with the support they need to create new value. You need to build knowledge reuse into your development process.

Creating this process can and should take many forms and should evolve as you capture more knowledge in reusable formats. The easiest place to start is person-to-person sharing, which can include individual mentoring. Such sharing also takes place in obeyas and during design reviews that are part of the development project.

“... deploying such a system frees team members to focus their time and energy toward creating new organizational knowledge.”

Design guides, trade-off curves, and design standards are other ways to share knowledge when it is needed. When structured around how specific part components and the overall product is designed, these documents can be effective for providing knowledge at the time it is required. Design guides work best when used along with mentoring and design reviews and not as a replacement. Trade-off curves, which make knowledge visible and easier to use, is another tool that enables knowledge sharing if their use is built into your development process. Design standards, which includes reusing proven standard components, common platforms, and modularity, enable you to focus your energy and effort on designing the part of the product that adds new value. When 80% of your design is fixed (reused), you can focus your energy on the 20% the customer cares about and differentiates you from the competition.

Designing knowledge-sharing practices that will allow people to get the necessary knowledge at the right time ensures that your team reuses the knowledge your organization has already created. Critically, deploying such a system frees team members to focus their time and energy toward creating new organizational knowledge. Continuously reusing and creating new organizational knowledge sets the foundation to develop new innovative products providing a competitive advantage consistently. ■



Contributor's Corner

Contributor's Corner: Learning With 10X Speed at US Synthetic



By Ken Bertagnolli

Go and find the best chess player you know and challenge them to a game with the following conditions:

1. Your opponent gets to move first.
2. You must give up some of your pieces.

Would you bet \$1,000 that you could win? Would you even be interested in playing?

What if you could move twice for every move your opponent made? Would the advantage of speed make up for your disadvantages?

“At US Synthetic, we experienced the power of speed when we reduced our learning cycle time from 43 days to 4.5 days.”

Rapid Learning Cycles at US Synthetic

I have spent the last 25 years working in R&D at US Synthetic, a manufacturer of synthetic diamond tools for oil and gas drilling, machining, and bearing applications. I vividly recall reading the chess game analogy in *Certain to*

Win by Chet Richards and wondering what we could do to improve speed in product development.

Kaizen

Kaizen is a Japanese term meaning continuous improvement to create more value with less waste. Ideally, it entails the engagement of every employee in the never-ending pursuit of better on the way to perfection. By making incremental improvements, organizations can improve productivity and achieve competitive success.

Kaizen is about questioning the status quo and asks, What is the ideal or should-be condition? Leaders must first envision a target condition to achieve. And to achieve the full potential of kaizen, leaders must unlock the creativity of their workers.

There are two levels of kaizen:

- System or flow kaizen focusing on the overall value stream. This is for management.
- Process kaizen focusing on individual processes. This is for work teams and team leaders.

Value-stream mapping is an excellent tool for identifying an entire value stream and determining where flow and process kaizen are appropriate.

This focus on rapid learning was a powerful insight that shaped my journey with lean product and process development (LPPD).

Our product development process typically involves changing the material properties of the diamond to match the requirements of our customers' applications. Almost every new product we develop must be fabricated and tested in our lab to verify that performance matches our design targets. Our designers were often waiting for parts to be built or lab tests to complete so they could learn if their ideas worked or if they needed to try something else. I wondered what it would be like to wake up in the morning with an idea and have lab results before I went home that evening. The idea of one-day learning cycles became a simple, clear goal that we could use to drive improvement work.

Our first kaizen (improvement) event related to rapid learning focused on the prototype manufacturing step. At the time, highly skilled technicians would beg, borrow, and steal time on the production floor to build prototypes. The kaizen prep revealed that it took an average of 23 days to make prototype parts for testing. Simple tools like spaghetti diagrams and process flow maps showed that a dedicated prototype cell could dramatically reduce cycle time.

“Everyone wants to go ‘faster’ in development, but what does faster mean? Speed should refer to the rate at which we learn.”

— Allen Ward

We cobbled together an assortment of used and unwanted machines from the production floor and built our first cell dedicated to product development. We asked some of the technicians to staff the cell full time so we could experiment with the system and measure the improvement. By the end of the kaizen event, we had reduced the turnaround time from 23 days to four days and demonstrated the value of a full-time staff. Fortunately, our current prototype cell

Plan, Do, Check, Act (PDCA)

An improvement cycle based on the scientific method of proposing a change in a process, implementing the change, measuring the results, and taking appropriate action (see illustration). It also is known as the Deming Cycle or Deming Wheel after W. Edwards Deming, who introduced the concept in Japan in the 1950s.

The PDCA cycle has four stages:

- Plan:** Determine goals for a process and needed changes to achieve them.
- Do:** Implement the changes.
- Check:** Evaluate the results in terms of performance.
- Act:** Standardize and stabilize the change or begin the cycle again, depending on the results.

has the same state-of-the-art machinery as our production floor, and we have been able to further reduce flow time to 1.5 days through years of ongoing PDCA.

The next area we chose to tackle was testing. Our data showed that it took an average of 20 days to complete a test once the parts were built. The kaizen team value stream mapped the testing process and identified numerous sources of waste. Why did we walk nearly five miles back and forth from the testing bay to an office to input data into a computer for each test? Why did we shut the machine down for 40 minutes each day to clean an external component? Why did it take nearly four hours to change over from one test to another? We tackled each of these issues through multiple PDCA cycles and eventually cut testing turnaround time from an average of 20 days to just three.

We have yet to achieve our goal of a one-day turnaround from idea to test, but we came remarkably close, reducing our learning cycle time from 43 days to 4.5. That is nearly ten times the learning rate. Imagine the chess game if you could move 10 times for every move of your opponent! Think about what that means to a development team. They can now learn something new 58 times a year compared to six times a year with the previous system.

Rapid Learning as a Competitive Advantage

Those of us involved in product development often face constraints like the ones in the chess example. Despite our best efforts, we are not always first to market with a new product or innovation. Our competitors may have more money, more people, and more resources working on product development than we do. Finally, the basic rule of all competition is to assume you are not smarter than your competitors (or your customers, for that matter).

Is there a general strategy we can use to overcome these disadvantages and still win? Air Force Colonel John R. Boyd was obsessed with this question. Boyd was a fighter pilot and highly influential military strategist. The F-86 he flew during the Korean War achieved a stunning ten-to-one kill ratio against the MiG-15, a far superior aircraft in many ways. The MiG-15 could make harder turns than the F-86, could accelerate and climb faster, and had better high-altitude performance. So, what happened?

Boyd identified two subtle advantages the F-86 had over the MiG. First, the F-86 had a bubble canopy that gave the pilot a 360-degree field of vision, while the MiG pilot's view was blocked to the rear. Second, the F-86 had full hydraulic control, allowing the pilot to transition from one maneuver to another quicker than the MiG, which did not have hydraulic controls. Boyd hypothesized that the ability to learn and adapt faster in the F-86 was the secret to its success.

“Competitive advantage derives from discovering new principles, or new applications of basic principles, specific to your products and obtainable only from your experience.”

— Allen Ward

Boyd's interest went well beyond the F-86 paradox, however. His direct experience as a fighter pilot and considerable research ranging from the German Blitzkrieg of World War II to the Toyota Production System led Boyd to a breakthrough insight: we can use time as a principal

strategic device.

Steven Spear makes the connection between learning rate and performance clear in *The High Velocity Edge*. The difference between good companies and great companies is their rate of learning. Toyota did not start out making high-quality cars at low cost. In 1965, Toyota's productivity was about half that of GM. However, Toyota was learning how to improve quality and reduce cost at a rate about 3.5 times faster than GM so that by 1990, Toyota's productivity was twice GM's. Toyota and other fast learning organizations have turned their rate of learning into a sustainable competitive advantage.

If we can learn faster than our competition, we are certain to win!

Unintended Consequences

Increasing our learning rate by a factor of 10 created several benefits for US Synthetic. First, we were able to test multiple parts instead of just one. Variation is a fact of life, and the only way to know the size of your measurement variation is to make repeat measurements. Being able to see the variation helped us avoid launching products that would not actually improve performance. Second, we could now use DOE (Design of Experiments) instead of One-Factor-At-A-Time experimentation to truly understand which factors improved performance. It became clear that we had multiple ways of achieving good performance. Some were more complex, costly, and of lower quality than others. The DOE results provided a rational framework for fixing the elements that did not affect performance while leaving the performance elements flexible. The quality of new products improved using this fixed-vs-flexible approach to reduce complexity and variety. Yields of new products have been greater than legacy products for the past four years!

I would like to say that is the end of the story, but the reality is a little more complex. One unintended consequence of reducing turnaround time by a factor of 10 was that it is now faster to test every new idea than to see if the data already exists. We have a gap in our ability to capture and reuse knowledge. However, I know we can close this gap with ongoing kaizen and by drawing on the LPPD community for ideas and inspiration. ■

Faculty Highlight



Katrina Appell, PhD

Senior Lean Coach
Lean Product and Process Development
Lean Enterprise Institute

President
Katrina Appell Consulting

Katrina is passionate about supporting organizations in improvement and transformation with over 15 years of coaching, facilitating, training, and team development experience. Her doctoral research at the University of Michigan focused on effective methods for putting lean product and process development principles and practices into practice. She has coached lean principles and practices at many companies in various industries, including Caterpillar, Michigan Medicine, TechnipFMC, US Synthetic, and Whirlpool. In addition, Katrina codeveloped and is an instructor of LEI's live online course *Designing the Future Remotely: A Lean Product & Process Development Learning Experience*.



John Drogosz, PhD

Senior Lean Coach
Lean Product and Process Development
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Vice President
Liker Lean Advisors

John has over 25 years of experience applying lean principles and practices in manufacturing, product development, and services. He has led lean transformations in numerous companies and industries, including Northrop Grumman, Johnson Controls, Harley-Davidson, Embraer, and Caterpillar. John also teaches classes in Lean Product and Process Development for the College of Engineering at the University of Michigan. He has contributed to several books and articles, including *The Toyota Product Development System (2006)* and *The Toyota Way to Continuous Improvement (2011)*. In addition, John codeveloped and is an instructor of LEI's live online course *Designing the Future Remotely: A Lean Product & Process Development Immersive Learning Experience*.

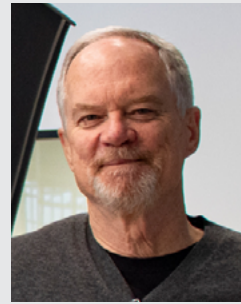


Eric Ethington

Senior Lean Coach & Program Manager
Lean Product and Process Development
Lean Enterprise Institute

President
Lean Shift Consulting

Eric is a recognized expert in process development and problem-solving methodologies, stemming from 27 years of industry experience in frontline through executive-leadership roles at Delphi and Textron and 12 years of consulting practice. His experience in applying lean includes most types of industries and functional areas, including organizations as varied as Medtronic, Michigan Medicine, Coca-Cola Enterprises, and Goodwill. Eric holds a Bachelor of Science in Industrial Engineering from General Motors Institute (now Kettering University) and a Master of Business Administration from the University of Michigan-Flint. Additionally, Eric is the coauthor of the book *The Power of Process, a Story of Innovative Lean Process Development* (2021).



Jim Morgan, PhD

Senior Advisor
Lean Enterprise Institute

Jim is recognized globally for his expertise in product and process development. Jim's know-how comes from a unique combination of industry experience as a senior executive and rigorous scholarship. His most recent industry role was as chief operating officer for Rivian, an electric vehicle manufacturer, during a critical transition period. Before that, he was global director of Body and SBU Engineering and Tooling Operations during Ford's historic, product-led revitalization under then CEO Alan Mulally. Before joining Ford, Jim served as vice president of operations at TDM, a tier-one global automotive supplier during a period of rapid growth. He holds a PhD in engineering from the University of Michigan. In addition to his more than thirty years of industry experience, Jim has authored or coauthored two books — *The Toyota Product Development System* (2006) and *Designing the Future* (2018) — three book chapters, and numerous articles.

LEI's Co-Learning Partner Program is for leaders looking to transform their enterprise and contribute to the lean thinking and practice body of knowledge. You and your team will closely partner with LEI Coaches in a journey of discovery that will take your organization to the next level.

Become a Co-Learning Partner

Partner with the Lean Enterprise Institute (LEI) to accelerate your lean journey and jointly conduct experiments on the best way to advance your lean transformation. As one of a select group of companies, you'll work closely with LEI thought leaders, such as John Shook, Jim Morgan, and other top-flight LEI Coaches and subject-matter experts.

Within the partnership, LEI Coaches will guide you as you design and evaluate the experiments that will help you discover the best lean approach to address a business problem or achieve breakthrough performance. We don't come in with a cookie-cutter solution. Instead, LEI Coaches bring their decades of lean thinking, practice, and coaching to bear on the business issues you need to address and guide you through discovering — for your organization and in the specific situation — how to resolve it.

By offering targeted, immersive experiences that demonstrate the value of addressing all five dimensions of the Lean Transformation Framework, LEI Coaches ensure you and your team gain an in-depth understanding through crucial guided practice.

Join a Learning Group

LEI's most advanced partners — those who have reached the highest levels of lean thinking and practice — are invited to participate in an LEI facilitated learning group. Open only to those who have and are willing to share advanced lean thinking and practices, this learning opportunity allows organizations and their teams to learn from one another. While participants in the learning groups collectively direct the learning, LEI Coaches facilitate the meetings three to four times per year and share related learning materials.

The meetings are held on-site at a learning group company or in virtual gatherings. The learning groups are organized around a specific LT&P discipline, industry, business function, and the like.

The longest-running Learning Group is focused on Lean Product and Process Development (LPPD), bringing together partner companies interested in transforming their product, process, and service development systems. Much of this Learning Group's learning was captured in Jim Morgan's and Jeff Liker's *Designing the Future*, which LEI co-published with McGraw Hill in 2019. Who knows, maybe your lean transformation story will become part of an upcoming book published by LEI.

Companies we've partnered with



Herman Miller





About The Lean Enterprise Institute

The Lean Enterprise Institute, Inc., was founded in 1997 by management expert James P. Womack, PhD, as a nonprofit research, education, publishing, and conferencing company. As part of its mission to advance lean thinking around the world, LEI supports the Lean Global Network (leanglobal.org), the Lean Education Academic Network (teachinglean.org), and the Healthcare Value Network (healthcarevalueleaders.org).

Continue Your Learning

The Lean Enterprise Institute (LEI) offers a wide range of learning resources, all with the practical knowledge you need to sustain a lean transformation:

Learning Materials

Our plain-language books, workbooks, leadership guides, and training materials reflect the essence of lean thinking — doing. They draw on years of research and real-world experiences from lean transformations in manufacturing and service organizations to provide tools that you can put to work immediately.

Education

Faculty members with extensive implementation experience teach you actual applications with the case studies, worksheets, formulas, and methodologies you need for implementation. Select from courses that address technical topics, culture change, coaching, senior management's roles, and much more.

Events

Every March, the Lean Summit explores the latest lean concepts and case studies, presented by executives and implementers. Other events focus on an issue or industry, such as starting a lean transformation or implementing lean in healthcare. Check lean.org for details and to get first notice of these limited-attendance events.

lean.org

A quick and secure sign-up delivers these online learning resources:

- Thought-leading content delivered monthly to your inbox.
- First notice about LEI events, webinars, and new learning materials.