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Becoming a learning organization while enhancing performance: the case of LEGO

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Abstract

Purpose – The purpose of this study is to empirically test how problem-solving lean practices, along with leaders as learning facilitators in an action learning approach, can be transferred from a production context to a knowledge work context for the purpose of becoming a learning organization while enhancing performance. This is important to study because many organizations struggle to enhance efficiency in the short term while still trying to be long-term learning oriented (i.e. learning organization development).

Design/methodology/approach – The authors draw on theory on learning interventions to show how lean practices for problem-solving can foster learning and help an organization to become adaptive. This study's subject is a non-production department of 100 employees at the LEGO corporation. The authors applied survey results from a natural experiment lasting 18 months between a pre-measurement survey and a post-measurement survey. The results were compared to a control department of 50 employees who were not exposed to the lean practices intervention. The authors' focus was on the individual level as individuals have different perceptions of lean practices, performance, and learning.

Findings – Using repeated-measures tests, difference-in-difference regressions analyses, and structural equation models, the authors find that a package of contemporary lean practices for problem-solving, along with leaders who function as learning facilitators, significantly improved learning organization dimensions while also enhancing efficiency and quality and that learning organizations positively mediate the relationship between the lean intervention and quality-related performance, while efficiency is directly affected by the lean interventions. Data from LEGO's key performance indicators (KPIs), benefit trackers, on-site observations and more than 40 interviews with managers provided results that were consistent with the survey data. A detailed description of the lean practices implemented is provided to inspire future implementations in non-operations environments and to assist educators.

Research limitations/implications – The authors contribute to the learning literature by showing that a learning-to-learn approach to lean management can serve as an active and deliberate intervention in helping an organization becoming a learning organization as perceived by the individual organizational members. The authors also add to the lean literature by showing how a learning approach to lean, as used by LEGO, can positively affect short-term efficiency and quality and create a foundation for a longer-term competitive advantage (i.e. a learning organization) in a non-production context. By contrast, most of the lean literature streams treat efficiency separately from a learning organization and mainly examine lean in a production context.

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Originality/value – The extant literature shows three research streams on lean, learning, and performance. The authors built on these streams by trying to emphasize both learning and efficiency. Prior research has not empirically tested whether and how the application of problem-solving lean practices combined with leaders as learning facilitators helps to create a comprehensive learning organization while enhancing performance in a non-production context.

Keywords Lean practices, Thinking, LEGO, Learning, Learning organization, Performance, Support department

Paper type Research paper

1. Introduction

Generally, companies seek to reduce or maintain the cost of operations support functions to remain competitive and to increase revenue and value for shareholders. At the same time, companies aspire to build learning environments that improve and sustain performance in the long term by being adaptive (Powell and Coughlan, 2020). However, balancing these outcomes can be challenging (Adler *et al.*, 2009). We therefore seek to study whether and how problem-solving lean practices can help organizations become learning organizations while also improving performance (e.g. efficiency and quality) in a non-production context.

Theoretical developments in the lean literature have begun to explain how lean management and learning is related. One stream of literature characterizes lean as a path to dynamic capabilities, and this stream makes some important initial steps in connecting lean, learning, and performance (Galeazzo *et al.*, 2017; Peng *et al.*, 2008). This stream of literature is closely related to the lean literature that focuses on lean as essential to a becoming learning organization (Found and Bicheno, 2016; Furlan *et al.*, 2019; Saabye *et al.*, 2022). Marsick and Watkins (2003, p. 136) define a learning organization as one that has embedded the capacity to adapt or respond quickly in novel ways while working to remove barriers to learning. In their seminal paper, Furlan *et al.* (2019) relates knowledge codification and articulation to systematic problem-solving on both the organizational and individual level. Their contribution shows the relevance of understanding whether and how lean management, on the individual level, can affect learning and performance. Individuals in an organization may develop their own understandings and interpretations of the level of being a learning organization. Therefore, one cannot assume that workers are simply passively embedded in the workplace (Furlan *et al.*, 2019). This is the stream of literature we seek to both tap into and build upon the avenue set by Furlan *et al.* (2019). We do this by studying how and whether systematic problem-solving and leaders as learning facilitators in an action learning intervention affect the individuals' perceptions of becoming a learning organization. Thereby, we also respond to a call for research Watkins and Kim (2018) on whether an active intervention, such as lean management, can create a learning organization. These researchers acknowledge that individuals interpret differently, and mental models of individual needs to be changed in an active intervention. Thus, studying changes in the individuals' perception of becoming a learning organization is key. Moreover, Watkins and Kim (2018) invite research on the relation between learning organizations (also on the individual level) and enhanced performance in an active intervention that goes beyond the anecdotal level. This is a research gap we are also trying to close by researching whether the lean intervention at LEGO affects performance either directly or in a mediated by becoming a learning organization as perceived by the individuals.

A recent literature review on the combination of lean and learning organizations by Tortorella *et al.* (2020) reveals that rigorous empirical research combining the two streams is scarce. Examinations how lean practices have or can be used to create a learning organization outside the production context is almost non-existent (Malmbrandt and Åhlström, 2013; Tortorella *et al.*, 2020). Tortorella *et al.* (2020) conclude that, when considering service-type organizations, several lean practices seem to conflict with learning. However, Tortorella *et al.*'s (2020) study does not include contemporary problem-solving-focused lean practices, such as A3 thinking, coaching kata, or Gemba walks (see Table 1 for descriptions). Nor does it

Lean practice	Description	References
A3 Thinking	A3 thinking is a collaborative process management and improvement tool developed by Toyota based on the PDCA cycle. It can be used for problem solving, decision making, planning or reporting of a specific issue from the proposal stage to commissioning. An A3 is an indispensable tool due to the structure, focus, collaboration and consensus it brings to problem solving and decision-making. The format and the goals of the A3 are guided by the following set of questions: 1. What is the problem or issue? 2. Who owns the problem? 3. What are the root causes of the problem? 4. What are some possible countermeasures? 5. How will you decide which countermeasures to propose? 6. How will you get agreement from everyone concerned? 7. What is your implementation plan—who, what, when, where, how? 8. How will you know if your countermeasures work? 9. What follow-up issues can you anticipate? What problems may occur during implementation? 10. How will you capture and share the learning?	Shook (2008)
Gemba walks	The Gemba walk is an essential part of the Lean management philosophy. Its initial purpose is to allow managers and leaders to observe the actual work process, engage with employees and customers, gain knowledge about the work process and explore opportunities for continuous improvement	Shook (2008)
Cause-and-effect diagram	Identifies the many possible causes for an effect or problem and sorts ideas into useful categories	Shook (2008)
Demand analysis	Analyzing the amount of failure demand, which is the demand caused by a failure to do something or do something right for the (internal) customer. Customers come back, making further demands, unnecessarily consuming the organization's resources because the service they receive is ineffective. Failure demand stands in contrast to value demand. The latter consists of customer requests that are a normal part of providing a service	Seddon (2005)
Value-stream mapping	Value-stream mapping, also known as "material- and information-flow mapping", is a lean-management method for analyzing the current state and designing a future state for the series of events that take a product or service from the beginning of the specific process until it reaches the customer. A value stream map is a visual tool that displays all critical steps in a specific process and quantifies easily the time and volume taken at each stage	Rother (2010)
Improvement Kata	The Improvement Kata is a model of the human creative process. It's a four-step pattern of establishing target conditions and then working iteratively (scientifically) through obstacles by learning from them and adapting based on what's being learned. 1. Get the direction or challenge: Understand the sense of direction, the larger, likely time-distant vision, and be clear on what that is. 2. Grasp the current condition: Examine where you are now and be able to define the current situation factually and clearly. 3. Establish the next target condition: Determine a good next step goal that will stretch he edges of current knowledge and capabilities, move toward the challenge, and will be accomplished by a certain date. 4. Conduct experiments: Experiment methodically, scientifically to get to next target condition	Rother (2010)
Coaching Kata	The Coaching Kata is a pattern for managers to follow in teaching the Improvement Kata pattern in daily work, so that it becomes part of an organization's culture. The foundation of the Coaching Kata is the "The Five Questions of Coaching Kata". The questions are structured to provide a clear means for the Kata Coach to guide the Kata Learner deliberately and methodically through the improvement process toward the target condition. The Five Questions What is the target condition? What is the current state of the process? What obstacles are you working on now which prevent us from reaching the target? What is your next step? (PDCA cycle)? When we can see the result of this step	Rother (2010)
Visual performance management	VPM is a bundle of practices where visual techniques are used to offer timely information to shop-floor employees about the performance of processes	Rother (2010)

Table 1.
Lean practices and tools at LEGO

focus on implementing lean principles in support departments characterized by highly-skilled knowledge work involving high costs. Thus, there is a lack of empirical evidence on the relationship between lean, learning organizations, and efficiency in environments characterized by complex and novel tasks, such as support departments. Our study addresses this gap by examining whether and how adopting lean practices in a support department supports the development of a learning organization and increases the organization's performance (Browning and Heath, 2009).

We also respond to the call (Lonati *et al.*, 2018) for new research involving experiments in a natural setting that rely on a difference-in-differences design (a quasi-experimental design), as such studies are almost nonexistent in operations management research. Our study fits perfectly with this call, as it involves a natural quasi-longitudinal experiment at LEGO. We also respond to Hadid and Mansouri's (2014) call for rigorous empirical research on the performance effects of lean practices in non-operations contexts.

We contribute to the literature on lean practices and learning organizations by showing how lean practices may be a path for simultaneously developing a learning organization and enhancing performance (efficiency) in non-manufacturing settings. We find that lean practices must be carefully selected to improve both learning and efficiency. Based on our statistical analysis, we show that LEGO has focused on enhancing its problem-solving capabilities through the use of contemporary lean practices, which in turn has furthered LEGO's goal of becoming a learning organization while enhancing efficiency. Hence, LEGO's improvements are based on an implementation that refrains from using lean variability-reduction practices (material flow), such as Heijunka, Kanban cards, and the U-cell layout. This is in line with Tortorella *et al.*'s (2020) findings.

In the next section, we discuss extant theory and develop our hypotheses. We then present the case company (LEGO), provide a detailed description of its lean intervention, and explain our methods. The results are then presented before we discuss the study's limitations and suggestions for future research.

2. Literature background and hypotheses

2.1 Streams of lean literature on performance and learning organizations

Some of the literature on lean theorizes lean as a sociotechnical system (Cua *et al.*, 2001; Furlan *et al.*, 2011; Mckone *et al.*, 1999; Shah and Ward, 2003) – a conceptualization that emerged from codifying the Toyota production system (Ohno, 2013). Here, lean is defined as "an integrated socio-technical system whose main objective is to eliminate waste by concurrently minimizing or reducing supplier, customer, or internal variability" (Shah and Ward, 2007, p. 791). This research stream has been especially focused on eliminating variability to improve efficiency and reduce waste (Treville and Antonakis, 2006; Hopp and Spearman, 2021).

Hines *et al.* (2004) note that a sociotechnical lean approach may also relate to a learning organization. Hence, learning as a goal is central to this stream. This learning-focused stream of the literature focuses on leaders and employees becoming cognitively aware of and effective at finding, framing, and solving problems (Ballé *et al.*, 2019; Shook, 2008). An essential finding of this research stream is that lean can be described as a path to becoming a learning organization (Franken *et al.*, 2021; Tortorella *et al.*, 2020; Liker, 2021; Saabye *et al.*, 2022). Lean organizations are considered to have a learning-to-learn capability that enables them to constantly find, frame, face, and solve problems (Ballé *et al.*, 2019; Powell and Coughlan, 2020; Saabye *et al.*, 2022). As a learning capability, lean is about (action) learning to understand and improve processes and work through ongoing experimentation, reflection, teaching, and empowering workers and managers to innovate for the benefit of customers (Cusumano *et al.*, 2021; Saabye *et al.*, 2022). An important contribution to this literature stream

is Furlan *et al.* (2019), as their research highlights the relevance of articulating knowledge and also codifying systematic problem-solving abilities on the individual level. This lays the foundation for creating a learning organization in which individuals take an active part in the learning process – a foundation that is essential to our hypothesis development below. As Furlan *et al.* (2019) states, the focus must be on changing the individuals' perceptions on learning as these may not be uniform.

An important part of this learning stream of lean literature depicts lean as a dynamic capability, i.e. a meta-routine that is used to change and improve operational routines (Peng *et al.*, 2008). Anand *et al.* (2009) explain that organizational learning as a dynamic capability can enhance efficiency if the right infrastructure is in place. This infrastructure involves, for example, standardized improvement methods, participation structures, training, and organizational direction (Galeazzo *et al.* (2017). Developing our hypotheses below, we put less emphasis on the technical aspects of lean, as our study is tailored to fit a non-production context. Our intention is to focus on the social practices of lean, such as systematic problem-solving and learning supported by leaders as learning facilitators. Thus, we seek to explore whether building strong learning-to-learn and problem-solving capabilities may increase efficiency as an output, while also changing the perception of the individuals to one of a learning organization. In this pursuit, we involve some of the infrastructure variables from the dynamic capabilities literature stream on lean and acknowledge that efficiency may also be a product of learning, i.e. a mediating relationship.

2.2 Lean adoption challenges within a service context

A contextual challenge for service and knowledge organizations aspiring to adopt lean is acknowledging that the tools and methods developed and codified within a manufacturing context do not necessarily offer the needed complementarity within a service and knowledge context (Modig and Åhlström, 2013; Seddon *et al.*, 2011). Research suggests that implementing lean systems in operations, services, and support environments has not been successful due to a focus on a "tools-only" approach (Hadid and Mansouri, 2014; Hines *et al.*, 2018).

Greater input uncertainties can explain the main difference between service and manufacturing (Bowen and Jones, 1986). Additionally, within a service, the customer becomes the supplier of information necessary to deliver the service; hence, the detailed standardization of the work becomes a hindrance to creating value (Seddon *et al.*, 2011). Moreover, service and knowledge organizations are more intangible than a traditional production context (Seddon *et al.*, 2011). Therefore, many tools and methods are not directly applicable to service organizations (Radnor, 2006). For example, material flow and visual lean practices, e.g. Kanban cards, Heijunka, and U-cells, are not essential in a service or knowledge setting of lean practices. This is in line with Tortorella *et al.* (2020), who finds these technical practices can be counterproductive to becoming a learning organization. Moreover, in a knowledge-context, the rhythm of the work is often slower than in a production context, making it more difficult to learn from standardization, codification, and simplification. In turn, this makes it more difficult to learn (Netland *et al.*, 2021). Thus, we believe that the complete lean practices package, i.e. a strong emphasis on both technical and socio practices, cannot *per se* be directly applied to a non-production context. This hypothesis is supported by Hadid *et al.* (2016, p. 633), who finds that the social and human side of lean implementation within a service context is significantly related to improved operational and financial performance. From a technical perspective, it is only the customer value factor from lean manufacturing that relates to improved outcomes. Service organizations must engage in a learning process of adopting and devising new tools and methods based on lean principles if they are to cope with the extra flexibility required to meet customers' demands (Browning

and Heath, 2009). Hence, for service and knowledge organizations to adopt a lean system, the first step would be to adopt human and learning-oriented practices (Cua *et al.*, 2001).

2.3 Learning-to-learn capability as foundational to lean

Anand *et al.* (2009) present lean as a continuous improvement methodology, and as a dynamic capability if a supportive infrastructure is based on institutionalizing organizational learning that manifests in the form of process improvements. Similarly, learning-to-learn is essentially the core of lean and is what makes it sustainable (Ballé *et al.*, 2017; Liker, 2021; Powell and Coughlan, 2020; Saabye *et al.*, 2022). This perspective builds on the notion that we must rethink lean as a social-technical learning system that enables any production system to become lean (Powell and Coughlan, 2020; Powell and Reke, 2019). Hence, lean is not about codifying or copying the best practices of, for example, the Toyota production system, but truly understanding what underpins this superior system as an education or learning system (Åhlström *et al.*, 2021). Similarly, Edmondson (2012) indicate that modern organizations must develop an execution-as-learning capability instead of execution-as-efficiency. Therefore, developing a dynamic learning-to-learn capability becomes fundamental for any service organization aiming to adopt lean.

A learning-to-learn capability is built on the theoretical foundations of the learning organization, systematic problem-solving (Furlan *et al.*, 2019), leaders as learning facilitators, and action learning (Saabye *et al.*, 2022).

2.4 Lean and learning organization

In the past, some scholars have associated lean with learning organizations (Hines *et al.*, 2004; Hu *et al.*, 2016; Liker, 2021; Liker and Ross, 2017; Tortorella *et al.*, 2020). However, until now, no universal understanding of a learning organization has existed in the lean literature. Moreover, it is not clear whether a learning organization simply refers to the conventional concept of learning – that is, learning to do things faster and thereby marginally reducing costs, also known as the learning curve phenomenon (Arrow, 1962). Yang *et al.* (2004) find that there are at least four understandings of a learning organization: (1) storage of knowledge, where learning is the simple application of this knowledge; (2) an approach where individuals learn at their work; (3) facilitating the learning of a firm's employees; and (4) as a flexible/adaptive entity. To theoretically underpin our study, we adopt Edmondson and Moingeon's (1998, p. 28) definition, which is synthesized based on a comprehensive blend of multiple understandings and reports of a learning organization:

> A process in which an organisation's members actively use data to guide behaviour in such a way as to promote the ongoing adaptation of the organisation. To use data is to seek and attend to task-relevant information, particularly for assessing collective performance and progress against goals. Guiding behavior involves choosing actions based on data-driven observations, including actions designed to test inferences.

We believe this is the best-fitting definition of a learning organization that is trying to implement a learning-to-learn capability based on lean principles outside production. This is because the novelty of tasks and the changing conditions in a non-operations context especially require the ability to be adaptive. Moreover, this definition highlights the importance of initiating, developing, and practicing action learning abilities. To operationalize and measure an organization's ability to be a learning organization, our study applies Marsick and Watkins' (2003) comprehensive and multidimensional learning organization concept, which encapsulates all the above understandings of being a learning organization. Marsick and Watkins' (2003) learning organization framework consists of: (1) creating continuous learning opportunities, where learning is designed into work so that

people can learn on the job; (2) promoting inquiry and dialog by implementing a culture that supports questioning, feedback, and experimentation; (3) encouraging collaboration and team learning; (4) creating systems to capture and share learning across the organization; (5) empowering people toward a collective vision where responsibility is distributed to motivate learning; (6) connecting the organization to its environment by helping people to see how their work affects the entire organization and to scan the environment; and (7) providing strategic leadership for learning by leaders modeling, championing, and supporting learning for business results. Collectively, this compromises a comprehensive view of what a learning organization should be. As noted by Furlan *et al.* (2019) individuals' perceptions of learning and changes may vary as individuals interpret and understand differently. Hence, our focus is on the perceptions of individuals toward lean interventions, just as our definition of a learning organization from Edmondson and Moingeon (1998) focuses on individual members of the organization.

2.5 Lean and systematic problem-solving

Another cornerstone of our learning definition is that "guiding behavior involves choosing actions based on data-driven observations, including actions designed to test inferences" (Edmondson and Moingeon, 1998). From the lean literature, we know that problem-solving is fundamental to any organization aspiring to be lean or to be a learning organization (Ballé *et al.*, 2017; Furlan *et al.*, 2019; Liker, 2021; Spear and Bowen, 1999).

According to the extant literature, there are two distinct approaches through which employees and leaders can handle problems (Furlan *et al.*, 2019; Mohaghegh and Furlan, 2020; Tucker *et al.*, 2002). Ideally, problem owners engage in a learning and discovery process of framing the problem based on facts, analyzing the root causes, identifying and experimenting with a set of possible solutions, and evaluating the results in terms of which ones will likely eradicate the root cause of the problem based on the scientific method. This approach, characterized by Mohaghegh and Furlan (2020) as systematic problem-solving (SPS), is foundational to any lean organization (Ballé *et al.*, 2017; Liker, 2021). Within the lean literature, the scientific method is operationalized as Deming's Plan-Do-Act-Check (PDCA) cycle for continuous improvement (Franken *et al.*, 2021), which forms the foundation for the different SPS methods of, for example, A3 thinking (Shook, 2008), improvement, and coaching kata (Rother, 2010). Furlan *et al.* (2019) explain that SPS can change behaviors and identify opportunities, which, in turn, may drive learning. Moreover, Furlan *et al.* (2019) emphasize that SPS can only be understood by taking individuals', employees, perception into consideration. Therefore, we aim to focus on the individual level, and their perceptions to understand the relations between SPS and learning.

However, problem-solving within organizations is often performed by instituting a preconceived solution that requires minimal cognitive effort. At best, this is a workaround for treating the visible symptoms This "firefighting" approach is characterized by Mohaghegh and Furlan (2020) as intuitive problem-solving.

Although many organizations implement programs to build SPS capabilities as a foundation for lean, many struggle to achieve a satisfactory and sustainable outcome (Bateman, 2005; Netland and Bicheno, 2016). One could suspect that these programs are mostly focused on tools (Netland *et al.*, 2019) and ignore the dimensions of the learning organization, such as integrating SPS into daily work, developing employees' listening and inquiring skills, empowering them to frame the problems to be solved, and instituting systems for sharing knowledge and teamwork (Marsick and Watkins, 2003). Bortolotti *et al.* (2015) emphasize that in lean firms all individuals are expected to detect problems and make improvements. This constitutes another reason to study both becoming a learning organization and firm performance from the perspective of the individuals' perception.

Notably, learning in lean organization should not be driven by just a few key individuals but by all individuals. Therefore, we need to assess whether the mindset of most individuals is changed towards learning in a lean intervention.

2.6 Implementing lean through action learning

In the extant literature, action learning has been proposed as a superior approach to developing a learning organization, developing leaders, developing teams, and solving problems (Marquardt *et al.*, 2018). We can understand action learning as both a theory and a practice for developing an organization's members through a learning cycle of action and reflection while solving relevant problems (Coghlan and Coughlan, 2010). Thereby, we follow the path of Furlan *et al.* (2019) who focus on individuals, members, and their abilities to actively learn. The foundation for action learning is Revans' (2011, pp. 2–3) learning equation of $L = P + Q$, where L represents learning, P represents programmed knowledge, and Q represents questioning insights. Revans (2011, p. 85) emphasizes that "there can be no learning without actions, and no (sober and deliberate) action without learning". In combination with the learning question, this means that, to learn, we need to initiate action for real problems. However, before leaping into action, we must begin by asking insightful questions (Q) to understand and frame the problems we are working on and reflect on the actions we have taken. As we progress with our problem-solving efforts, problem solvers will expand their programmed knowledge (P) of, for example, understanding the context in which they are working and how to apply SPS.

Revans (1971) formed a theory of action and a science praxeology of cyclical and intertwined systems – alpha, beta, and gamma – to complement the action learning equation. System alpha forms the activity of framing the real organizational problem being addressed. This analysis also takes into account the external environment, current organizational performance, and existing management values. When framing problems, owners must distinguish between puzzles and problems. Revans (2011) defines the puzzles as having only one correct answer and being resolved with the assistance of experts; therefore, they should not be approached with action learning. On the other hand, problems have no single or optimal solution and are therefore responsive to action learning (Coughlan and Coghlan, 2010). A cognitive challenge for many organizations is that they presume their problems are puzzles.

System beta encompasses SPS based on the scientific method and multiple cycles of action and reflection. This process involves rigorous engagement in questioning the basis for intervention and the actions taken to solve the problem by, for example, applying the lean practices of A3 thinking (Shook, 2008) and improvement kata (Rother, 2010).

System gamma is the higher-order cognitive process of critically reflecting on the ongoing problem-solving process. It can be defined as upstream and downstream learning (Coghlan and Coughlan, 2010). Upstream learning involves questioning the assumptions that underpin our beliefs, as well as the mental models that we use to frame challenges and solutions. Downstream learning refers to changing one's behavior as a result of the knowledge learned during the upstream learning process. A psychologically safe learning environment, in which one can speak up without fear of punishment or humiliation, is required to engage in upstream and downstream learning (Edmonson, 1999). None of the three systems can function independently; they all require various levels of attention at different periods during the SPS process (Powell and Coughlan, 2020).

2.7 Lean leaders as learning facilitators

Mann (2009) finds that only 20% of lean efforts involve implementing new tools and methods, whereas up to 80% concern changing mindsets and behaviors among leaders. With learning

being at the core of lean, an organization's leaders must adopt the role of learning facilitators (Malouf and Gammelgaard, 2016). As (action) learning facilitators, leaders refrain from providing answers and instructions. Instead, leaders set directions and formulate the (learning) mission for the employees, usually in teams, so that employees may embark on problem-solving expeditions to explore answers (Edmondson, 2012).

Therefore, leadership in lean systems focuses on leaders as coaches (Liker and Ross, 2017; Liker and Convis, 2012; Mann, 2009; Rother, 2010). Senge *et al.* (1994) suggest that a coaching leadership style is required to facilitate learning, whereas Emiliani (2003), Liker and Convis (2012), Alagaraja (2014), Camuffo and Gerli (2018), and Mann (2009) all claim that coaching and performance-challenging leadership are crucial success factors for changing the thinking and mental models of leaders if one is to build a learning organization and improve performance. The goal of coaching is therefore for leaders to activate systems alpha, beta, and gamma by coaching employees and teaching SPS rather than providing all the answers (Poksinska *et al.*, 2013; Rother, 2010). Liker and Ross (2017) described this as "learning by fact-based problem-solving". Hence, in isolation, coaching is not sufficient to change an individual's perception of being part of a learning organization; it needs to be combined with SPS.

The core learning of the group and dyadic coaching process is to practice attentive listening without presuppositions; one must ask humble, open, and reflective questions (Powell and Coughlan, 2020; Rother, 2010; Saabye *et al.*, 2022). Leaders head these sessions as coaches. Hence, coaching is a deliberate way to create room and time for reflection, with leaders as sponsors activating system gamma. Participants recognize and appreciate that learning and synergies occur when they become aware of different worldviews. This enforces several dimensions of being a learning organization, yet to a varying degree as individuals may interpret and make sense of coaching differently given, say, different cognitive barriers (Edmondson and Moingeon, 1998). The coaching session is a social construction (e.g. Furlan *et al.*, 2019) and this enact individuals differently, which is why our focus is on the individuals' perceptions. These sessions provide a learning space for dialog and inquiry, where participants reflect on the experiments being conducted in the organization. This learning space is both mental and psychical, with physical learning often being more challenging to establish in knowledge workers context than in laboring jobs. Moreover, dyadic and group coaching supports knowledge sharing. It allows leaders to communicate the importance of being reflective by challenging presuppositions and the status quo.

Being a learning facilitator also involves fostering collaboration, a psychologically safe learning environment (van Dun and Wilderom, 2016), and team learning, where different views are appreciated in a psychologically safe zone (Edmonson, 1999; Marsick and Watkins, 2003).

2.8 Hypotheses

The purpose and value of developing a learning-to-learn capability that is based on systematic problem-solving and supported by leaders as learning facilitators used in an action learning way, leads us to two major premises. First, the capability of learning-to-learn means the learning organization becomes capable of instituting systems based on lean principles; it becomes adaptive to solving future problems more effectively than before (Saabye *et al.*, 2022). We, therefore, hypothesize that deploying an action learning intervention that helps organizations develop a learning-to-learn capability based on lean principles while still being able to solving urgent problems will increase the level of being a learning organization as perceived by the individuals involved.

H1. An intervention based on a set of problem-solving lean practices in a support department can increase the level of being a learning organization as perceived by the individuals involved.

Second, the capability of learning-to-learn is an enabler of more effective problem resolution, which in turn results in performance improvements (Saabye *et al.*, 2022). We, therefore, hypothesize that deploying our lean learning-to-learn intervention supported by leaders as learning facilitators will also lead to improved performance, given that some of the problems solved may relate to efficiency challenges. We are particularly interested in whether this exists in a non-operational context. We hypothesize that both efficiency and increasing the level of being a learning organization can be changed simultaneously by being ambidextrous. While employees and leaders learn and experiment with new meta-routines and become adaptive, these activities are also goal-oriented with a view to improving efficiency so as to maintain short-term competitiveness. An example of this dual focus is how any A3 experimentation undertaken is not exclusively aimed at learning how to use an A3, as employees and leaders are also expected to improve efficiency (or quality) in the short term. Therefore, companies should not rely heavily on classroom training. Rather, they should employ learning by doing (van Dun and Wilderom, 2021). Leaders and employees should work together on real problems to improve efficiency and quality and to reduce process-time variability (volatility) or failure demand (demand that does not add value for internal customers, e.g. rework). In terms of performance, our focus is also on individual perceptions of performance. Our aim is to assess whether performance in enhanced as a consequence of an individual's interpretation of the lean interventions, not just at the organizational level.

Therefore, we hypothesize:

H2. An intervention using problem-solving lean practices in a support department can enhance performance (e.g. efficiency).

In addition to Hypotheses 1 and 2, we also hypothesize the existence of a partially mediated relationship between the lean intervention (the independent variable, treatment) and performance (the dependent variable) through a learning organization (mediator). Some of the performance effects of a lean intervention may result from building a learning organization (i.e. a mediation relationship) as perceived by the individuals. Some studies have shown that increasing the level of being a learning organization is related to knowledge and financial performance (Kim *et al.*, 2017; Ju *et al.*, 2021). However, these empirical studies have not been conducted in a lean context or by studying a lean intervention. Nor have they focused on individuals as active vehicles of learning and enhancing performance. As they show a positive relationship between a learning organization and performance, we speculate whether this may also be the case in a lean context, with a learning organization mediating the relationship between lean and performance. As Kim *et al.* (2017) note, a primary characteristic of a learning organization is the ability to transform to cope with changes proactively, which in turn leads to enhanced performance. This line of reasoning is also found in the literature on dynamic capabilities and lean (Galeazzo *et al.*, 2017). As reported, bundles of organizational routines (e.g. problem-solving) lead to continuous improvement, which in turn leads to performance improvement (i.e. efficiency). Following Furlan *et al.* (2019), we take the perspective of an individual's perception, as an individual may react and interpret the lean intervention differently. In turn, this may produce different perceptions of the performance outcomes.

Systems thinking is considered the core of a learning organization (Senge, 1990), in which parts of the system interact. Likewise, one could hypothesize that the seven dimensions of a learning organization (Marsick and Watkins, 2003) interact with each other when considered from a systems perspective (Kim *et al.*, 2017). To explore whether the seven dimensions of being a learning organization collectively create performance as a mediator of a lean intervention, we set out to test Hypothesis 3. We do not expect full mediation, as lean is also used directly to increase efficiency in the short term according to Hypothesis 2.

H3. A learning organization partially mediates the relationship between a lean intervention and performance in a support department.

3. Method

3.1 Research design

To quantitatively test our hypotheses, we adopted a longitudinal, natural quasi-experimental design (Shadish *et al.*, 2002) in two departments at LEGO. This approach is recommended for testing the effects of *in situ* changes on performance (DeHoratius and Rabinovich, 2011). According to Lonati *et al.* (2018), experiments are the gold standard for establishing causality. To increase an experiment's practical relevance, they recommend natural experiments within companies using a difference-in-differences approach, which what we applied.

One LEGO department received the lean intervention (treatment department), while the other did not (control department). The use of a control department helped to eliminate counterfactual interference from corporate activities affecting both departments. Measurements were conducted before and after the intervention. Hence, we used an untreated control group design with dependent pre-test and post-test [1] samples (Shadish *et al.*, 2002). In the tables and figures, we use the term "treatment," which is the methodological term used for an intervention in the difference-in-differences literature (Dahl, 2011). In this case, LEGO's lean intervention was the "treatment" in the experiment.

This intervention in a practical setting is a natural experiment, as LEGO decided to implement lean practices in one of its departments. LEGO chose the target department and the timing of the intervention. The choice of department was quite random, as LEGO planned to undertake similar interventions in many of its support departments. The control group was supposed to be "treated" with a similar intervention later on. However, LEGO did not have the resources to implement the intervention in several departments at the same time and wanted to learn along the way. Moreover, LEGO decided which practices from the lean literature were to be used. The researchers decided how to measure and test the dependent variables (i.e. the performance and dimensions of a learning organization). Similar to a quasi-experiment, the lean intervention was well described, giving us control over the independent variables. The control department was selected by the researchers based on similarities with the treatment department, with the aim of reducing variation as much as possible. The task novelty (whether the tasks were changing to "new" tasks) was similar. The tasks themselves were somewhat similar, as both departments supported the operations departments with various types of drawings (either 3D drawings or building instructions for customers). The types of resources recruited were similar, and the structure and compensation plans were similar. In summary, LEGO decided how, when, and where to implement the lean practices, while the researchers determined the research design, measurements, etc.

Our methodological design involved mixing primary data with secondary data. We collected pre-and post-measurements using the same survey instrument in two departments over the course of one and a half years. These measurements were supplemented with a survey taken six months later (after the post-measurement) to ensure the sustainability of the effects. We also performed a "during" measurement six months after the pre-measurement, which was not used actively in the intervention as they were not reported or assessed during the intervention. The only purpose of this "during" measurement was to assess whether the changes in the variables were in the expected direction. Thus, four surveys were conducted in both the treatment (intervention) and control departments. The survey measurements were complemented with direct observations, 40 interviews (conducted before, during, and after the intervention), informal conversations, and observations made by an undercover researcher. We also used several secondary data sources, including internal company reports, actual measurements of KPIs, budget and cost reports, LEGO's benefit tracker,

employee satisfaction surveys, and information posted on the company's intranet. One year after the intervention we had a report-back session with the treatment department to collect their reflections at a distance. We followed Garvin's (1993) recommendations for assessing a learning organization: a survey and interviews to assess the thinking of actors, observations to assess behavior, and an examination of the performance effects.

3.2 Lean intervention in a LEGO support department—independent variable

3.2.1 Background of LEGO. LEGO is a global toy manufacturer with more than 15,000 employees. It is headquartered in Billund, Denmark. The support departments featured in this experiment are also located in Billund.

Given the success of lean in LEGO's production facilities (Connell, 2009), LEGO wanted to introduce lean principles into non-production departments. Accordingly, LEGO developed an intervention based on lean practices, chosen with the aim of building the foundation for a learning organization in non-production areas. In 2016, the lean practices intervention was introduced in the treatment department. The purpose of this department was to support the development of new products. Its work mainly consisted of service and administrative tasks, which were distributed across approximately 100 employees. The department's tasks included 3D modeling of LEGO designs for building instructions and games, full responsibility for the master data included in bills of materials, and building models for new projects (e.g. prototypes). All the tasks had internal customers in operations or other support departments. The main task of the control department was to create the building instructions provided inside LEGO's products. The control department was not a subsection of the treatment department. Both departments consisted mainly of knowledge workers, as the work involved in the drawings, instructions, and 3D modeling require highly-skilled workers.

3.2.2 Overview of LEGO's lean practices intervention. Figure 1 depicts an overview of the lean practices intervention in the support department. The intervention was divided into three phases over the course of approximately one and a half years. Table 2 provides a thorough and detailed description of the intervention program, and Table 1 provides an overview of the lean practices employed at LEGO.

The intervention LEGO undertook involved three phases and a preparation stage before the first phase. Before the first phase, the head of the department was engaged as the sponsor by introducing him to the lean practices and involving him in coaching. The first phase involved engaging department leaders in coaching and problem-solving. Through Gemba

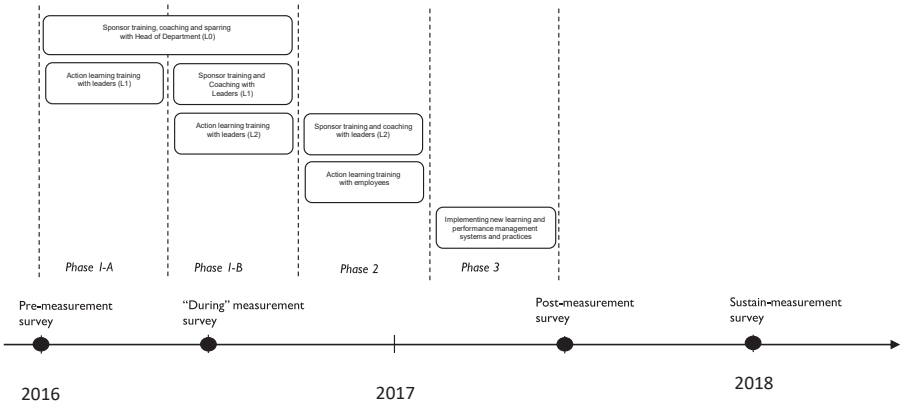

Figure 1. LEGO's implementation and overview of survey measurements

Note(s): L1 = level 1 leaders and L2 = level 2 leaders of the treatment department

Phase	Head line	Description
Before first phase	Sponsoring	The sponsor (head of department) goes through a series of sparring and coaching sessions with the intervention facilitator to ensure that the sponsor adopts a new mental model for creating and leading a learning organization. The sponsor took on this challenge and experienced first-hand the positive effects of Gemba, focusing on the facts, thoroughly understanding the context of the problem, asking questions instead of giving answers, and not jumping to a solution. To help avoid the common pitfalls of biases, assumptions, and logical fallacies, Coaching Kata and the five questions card from Toyota Kata were applied
First phase	Enabling senior leaders in the department to build required problem-solving and learning capabilities among employees	The purpose of the first phase is to change the way the leaders think about what constitutes a problem. They also learn how to solve problems and close performance gaps based on A3 Thinking. An instrumental element of the leadership program was group coaching. Through group coaching, leaders can practice asking good, humble, open, and explorative questions. Another critical learning element is for leaders to practice "Go to Gemba," which is needed to obtain the facts needed to define a problem and grasp the situation. It is followed by experimenting with possible countermeasures and solutions. the leaders were introduced to a range of generic lean tools and practices that support the A3 problem-solving process (Shook, 2008). These tools and practices include the PDCA learning process, Gemba walks, cause-and-effect diagrams, Pareto charts, demand analyses, Improvement Kata, Coaching Kata, and visual performance management. A core belief of the program was that tools cannot solve problems—they can only help visualize problems. Therefore, the problem owners must identify which tools are most useful in a given context
First phase continued	Switching of roles for senior leaders	After senior leaders have been through the program, it is time for the next level of leaders to go through the same learning and development. However, this does not mean that senior leaders are finished with their formal training. Senior leaders became sponsors for their middle managers and attend the "leader of leaders" part of the program. During this program, senior leaders go through a series of individual sessions with the process consultant with the aims of preparing them for the next middle-manager activity and helping them reflect on their own development and the development of their own leaders
Ending phase 1	Extraction session	The leadership program formally ended with an extraction session in which leaders present a problem they have been trying to solve to a group of leaders. They also present their learning and reflections from the program along with their recommendations for improving the program and moving forward with anchoring the new way of working in the organization or unit

Table 2.
Overview of LEGO implementation

(*continued*)

Phase	Head line	Description
Second Phase	Employee Program part one	The employee program lasted for one week for each employee small group, during which the employees work in small groups on a concrete problem that is identified before the program starts. Each morning, the employees took part in short coaching and learning meetings with their leaders. In those meetings, they explored the outcomes and learning from the previous step and then identify the next step. After the meetings, the groups conducted the next experiment, which might, for instance, be gathering facts by interviewing someone involved in the process in question or obtaining data from an IT system for visualization and analysis
Second phase	Employee Program part two	Halfway through the week, the employees attended classroom training about the thinking and methods behind the A3 problem-solving process. This classroom training did not occur at the beginning of the week to ensure that the employees do not become overly focused on trying to use the tools and methods in a specific way at the expense of going to Gemba or challenging their assumptions, which are the fundamental ways of changing their current mental models. Moreover, the employees could better relate to the content of the classroom training if they could connect it to their own experiences from the first few days
Third phase	Establish a new learning- and performance-management system	As a result of the first two phases, leaders and employees gained an understanding of how to measure the actual performance of their systems and processes, and how to conduct learning-focused meetings. This understanding formed the basis for establishing an effective, visual performance-management system and for implementing frequent visual board meetings at different levels of the organization. An overall objective for establishing visual performance-management systems is to make performance gaps and problems visible. Thereafter, the objective is to ensure an ongoing PDCA process in which learning and findings are shared at meetings

Table 2.

walks – group coaching by the head of the department – the department leaders were introduced to several lean practices put in place to solve problems and question presuppositions. This was quite action learning-oriented and involved very little classroom training. In the second phase, employees in the treatment department became involved in group coaching with their superiors. They were also introduced to the process of solving real problems using lean practices, such as PDCA, A3, go-to-Gemba, fact-seeking coaching cards, and systems thinking. In the final phase, phase three, LEGO implemented a visual performance management system to present metrics visually on boards.

The main elements of the lean intervention were selected by a team in the lean department at LEGO. They were also approved prior to implementation by the head of the department in which the intervention took place. Moreover, the program was designed with much involvement by the actors in the intervention department. No external consultant was used in the intervention. The team from the lean department that facilitated this intervention were

mainly focused on helping non-operations departments at LEGO as other teams were more directly focused on operations.

3.3 Data collection

3.3.1 Multi-wave survey. We used surveys to gather the primary data to test our hypotheses. The same questionnaire was used to collect survey data at four points in time: before the intervention, during the intervention, upon completion of the intervention, and after the intervention. The survey was distributed by email to all employees in the treatment and control departments. Figure 1 illustrates the survey timeline and the lean practices intervention phases. To match responses from the same individual across the four rounds of survey measurements, we used email addresses as a unique key.

The treatment department had approximately 100 employees, while the control department had approximately 50 employees. Response rates were high for all eight surveys (four surveys in two departments), ranging from 75% to 90%. As the measurements were collected over one and a half years, some employees moved to other jobs, both internally and externally. However, the total number of such changes was less than five people in each department. We do not believe the size difference between the departments impaired our results significantly as extant empirical research has not established any consistent relation between size and learning (Leal-Rodriguez *et al.*, 2015). The thinking is that smaller-sized entities may foster collaboration and cooperation, requiring less coordination, yet larger-sized entities may have more resources to invest in learning (Real *et al.*, 2012; Leal-Rodriguez *et al.*, 2015).

3.3.1.1 Questionnaire items related to the dependent variables of learning organization dimensions and performance. The survey questionnaire consisted of two main sections: one focused on learning organization effects and the other focused on performance outcomes (see Appendix 1).

The effects of learning organization were measured using a questionnaire developed and validated by Marsick and Watkins (1997, 2003). Marsick and Watkins (2003) described their measurements of learning organizations as capturing an organization's ability to adapt quickly. This is based on the same comprehensive view of learning organizations described by Edmondson and Moingeon (1998). Watkins and O'Neil (2013) and Kim *et al.* (2015) both provide a thorough review of the questionnaire's development, its use in previous studies, and its validity. Additionally, Tortorella *et al.* (2020) validate the Marsick and WAtkins questionnaire in a lean context using explorative factor analysis.

We modified the wording of the first two dimensions ("continuous learning" and "inquiry and dialog") in Marsick and WAtkins's questionnaire to cover each respondent's perspectives and views of their colleagues. This helped capture the effects identified by each individual in the treatment department. Hence, we measured the individuals' perceptions of these dimensions, not the differences between different organizations. Following the approach of Dymock and McCarthy (2006) and Sinclair (2017), we therefore used Marsick and Watkins's (2003) questionnaire to measure individual perceptions. When we later refer to only seven dimensions, the two dimensions covering the colleague's perspective are left out. The seven dimensions used reflect the original learning organization instrument (Marsick and Watkins (2003) from an individual's perspective. These were used in the structural equation models to measure the latent constructs associated with the learning organization. Appendix 1 shows how the questions are linked to each of the learning organization dimensions. We used the same distribution of question items to dimensions as Marsick and Watkins (2003) used. A Likert scale ranging from 1 to 6 (1 = "almost never" and 6 = "almost always") ensured that respondents' answers did not cluster around the mean (Watkins and O'Neil, 2013). In total, the learning organization part of our questionnaire covered 56 items spread relatively evenly over 9 dimensions.

We included multiple questions on performance to cover various facets and to ensure that performance outcomes were not the product of gaming and multitasking. By gaming, we mean where certain tasks and, therefore, their outcomes received more attention and effort at the expense of other types of performance (Prendergast, 2002). Increasing one type of performance should not come at the expense of another lowered performance outcome. In other words, there should not be trade-off. The first three questions about job performance, which were taken from Shields *et al.* (2000), focused on performance in general at the individual level. However, we analyzed each question separately so as to not mix perceptions of job performance relative to standards (expectations) with relative to colleague's, and versus actual performance. The next set of questions was specific to certain types of performance: time per process, time for problem-solving, quality, variability, rework, and value creation (Hadid and Mansouri, 2014; Malmbrandt and Åhlström, 2013). We also measured behavioral types of performance, such as idea generation and time management. It is important to note that the survey measured individuals' perceptions of performance in the same company. This is unlike organizational performance as measured in typical cross-sectional surveys. In total, 12 questions were included that covered performance outcomes.

Staats *et al.* (2011) stress the importance of measuring actual performance changes resulting from lean implementation. Therefore, we followed Wall *et al.*'s (2004) recommendation and combined subjective and objective performance indicators [2] to obtain a reliable representation of performance. Hence, we supplemented the survey indicators with LEGO's own KPIs (i.e. on-time delivery, first-pass yield, actual cost versus budget cost, employee satisfaction) and the benefit trackers of real performance outcomes.

3.3.2 Qualitative data. To supplement the survey results, we conducted 40 longitudinal interviews with the same 8 people over 5 rounds. The aim of the interviews was to verify the reliability of the survey measurements. We selected people at various levels in the control and treatment departments to ensure a representative sample of management employees. We targeted the head of the treatment department, a couple of his immediate subordinates, and their middle management. Thus, we did not include formal interviews with employees who did not have management responsibilities. We targeted some employees with long tenures and some with less tenure, as experience may give different perspectives on change initiatives and learning. The interviewer used a semi-structured interview guide (see Appendix 2) to allow for a comparison between answers. We used different types of questions; some focused on changes in thinking and behavior or performance, and others focused on learning and reflection and examples thereof, while also questioning the understanding of the change initiatives. Each interview lasted 20–40 min.

In conjunction with the formal interviews, many hours of direct observation provided insight into how the lean activities were implemented. We, the first and second authors, observed internal company teachings and presentations by company representatives of the A3 reports. Moreover, we used the observations of a student appointed as a trainee in the treatment department. As such, we followed Garvin's (1993) recommendation to supplement surveys with direct observations to ensure that the learning organization was actually behaving in learning ways.

The researchers had access to the company's intranet and all 42 A3 reports made during the period, which we used to support our results on the performance outcomes.

4. Results

The results were divided into survey results and results from other data sources. Further, the survey results were divided into three sections of evidence for Hypothesis 1 (i.e. the learning organization); Hypothesis 2 (i.e. performance); and Hypothesis 3 (i.e. mediation model).

4.1 Descriptive statistics and survey validity

Tables 3 and 4 provide an overview of the Pearson correlations, Cronbach's alphas, mean scores, standard deviations, and changes in mean scores between the pre-and post-intervention survey measurements. For all learning organization dimensions, Cronbach's alpha was higher than the suggested threshold of 0.7 (Hair *et al.*, 2014). These values indicate good reliability and internal consistency.

Table 4 indicates that there was a positive change in the mean scores of both performance measures and learning organization constructs from pre-measurement to post-measurement in the treatment department. In the control department, the changes are mixed – some are positive or neutral, while others are negative. The changes support Hypotheses 1 and 2. The changes in the treatment department were greater than the changes in the control department.

To further assess validity, we conducted confirmatory factor analysis (CFA) using SPSS AMOS 23. The results are shown in Table 5. A CFA of the pre-measurement round of the seven dimensions of learning organizations indicates acceptable fit levels for the Chi-square divided by the degrees of freedom (Cmin/DF). This fit statistic is 1.971, which is below the threshold of 2 (Kline, 2011). To assess the overall fit of the model, we assessed the root mean square error of approximation (RMSEA). An RMSEA below the threshold of 0.08 is acceptable; ours was 0.069 (Browne and Cudeck, 1993; Kline, 2011). We found similar results when running the CFA with nine dimensions. CFAs for the post-measurement round yielded similar results, as did the CFA for the differences between the two rounds. In all cases, a one-factor model provided worse-fit statistics with a Cmin/DF of approximately 4.73, and an RMSEA of 0.156. Moreover, all question items loaded significantly on the CFAs. To check for a potential common method variance problem, we applied Harmans's one-factor test (Podsakoff and Organ, 1986), in which we loaded all items covering the learning organization onto one factor using a principal component factor analysis. The test does not raise concerns regarding common method bias, as a one-factor model explains 44.5% of the variance in the data.

4.2 Quantitative data analysis selection

To test Hypotheses 1 and 2, we used the following econometric approach tested in a repeated-measures test and a regression based on a difference-in-differences approach (i.e. the difference between pre-and post-measurement in the treatment and control departments).

In the first formula, the dependent variable is each of the learning organization dimensions (Marsick and Watkins, 2003), or the total average of all the learning organization dimensions.

$$Y_{(\text{Learning organization dimensions})} = \beta_0 + \beta_1\alpha + \beta_2\delta + \beta_3\alpha * \delta + \varepsilon$$

where $\alpha = 1$ if post-measurement, and otherwise $= 0$, meaning 0 is equal to pre-measurement. This is labeled "pre/post" in the subsequent tables, where "1" is equal to the post-measurement.

$\delta 1$ indicates the treatment department, and 0 indicates the control department. This is labeled "treatment" in the subsequent tables.

The interaction between these binary variables represents the effect of the intervention when they take the value of 1 (both post_measurement(α) = 1 and treatment_deparment(δ) = 1).

For each construct of the learning organization, the questionnaire included 6 or 7 questions. In testing Hypotheses 1 and 2, we averaged these 6–7 question items per dimension/construct as recommended by the developers of the questionnaire (Marsick and Watkins, 2003).

	1	2	3	4	5	6	7	8	9
Pre-measurement									
1. Continuous Learning – individual	*0.830*								
2. Inquiry and Dialog – individual	0.633**	*0.779*							
3. Continuous Learning – colleagues	0.755**	0.554**	*0.891*						
4. Inquiry and Dialog – colleagues	0.582**	0.567**	0.724**	*0.909*					
5. Collaboration and Team Learning	0.656**	0.574**	0.744**	0.817**	*0.891*				
6. Systems to Capture Learning	0.606**	0.582**	0.585**	0.613**	0.628**	*0.849*			
7. Empower People	0.711**	0.577**	0.678**	0.674**	0.763**	0.803**	*0.898*		
8. Connect the Organization	0.626**	0.557**	0.620**	0.601**	0.715**	0.655**	0.748**	*0.847*	
9. Provide Strategic Leadership for Learning	0.686**	0.513**	0.596**	0.636**	0.689**	0.679**	0.790**	0.749**	*0.921*
Post-measurement									
1. Continuous Learning – individual	*0.848*								
2. Inquiry and Dialog – individual	0.647**	*0.815*							
3. Continuous Learning – colleagues	0.736**	0.631**	*0.866*						
4. Inquiry and Dialog – colleagues	0.647**	0.616**	0.714**	*0.879*					
5. Collaboration and Team Learning	0.714**	0.630**	0.768**	0.846**	*0.916*				
6. Systems to Capture Learning	0.635**	0.561**	0.693**	0.676**	0.745**	*0.887*			
7. Empower People	0.780**	0.623**	0.747**	0.769**	0.830**	0.749**	*0.927*		
8. Connect the Organization	0.668**	0.583**	0.671**	0.660**	0.772**	0.620**	0.811**	*0.892*	
9. Provide Strategic Leadership for Learning	0.721**	0.625**	0.661**	0.763**	0.772**	0.631**	0.801**	0.725**	*0.937*

Note(s): Cronbach's alpha is reported on the diagonal. $N = 154$ for both panels; **Correlation is significant at the 0.00 level (2-tailed); ** correlation is significant at a 0.00 level

Table 3.
Pearson correlations of organizational learning dimensions (each dimension is average of 6 or 7 questions in survey)

Table 4.
Mean scores and std. deviations

Variable	Pre-measure total ($N = 154$)	Post-measure total ($N = 154$)	Pre-measure treatment group ($N = 106$)	Pre-measure non-treatment group ($N = 48$)	Post-measure treatment group ($N = 104$)	Post-measure non-treatment group ($N = 48$)	Change % in treatment group	Change % in non-treatment group
Learning organization								
Learning org - 7 dimensions average	4.32 (0.676)	4.57 (0.632)	4.23 (0.722)	4.52 (0.515)	4.58 (0.684)	4.56 (0.503)	8.27%	0.88%
Learning org - 9 dimensions average	4.30 (0.670)	4.55 (0.612)	4.20 (0.714)	4.49 (0.513)	4.55 (0.658)	4.55 (0.502)	8.33%	1.34%
Separate learning organization dimensions below								
1. Continuous Learning – individual	4.40 (0.757)	4.56 (0.677)	4.30 (0.812)	4.64 (0.560)	4.57 (0.732)	4.54 (0.540)	6.28%	−2.16%
2. Inquiry and Dialog – individual	4.85 (0.614)	5.03 (0.578)	4.72 (0.634)	5.11 (0.472)	4.99 (0.616)	5.12 (0.477)	5.72%	0.20%
3. Continuous Learning – colleagues	4.20 (0.801)	4.43 (0.626)	4.11 (0.815)	4.39 (0.742)	4.44 (0.634)	4.41 (0.613)	8.03%	0.46%
4. Inquiry and Dialog – colleagues	4.23 (0.829)	4.50 (0.664)	4.11 (0.829)	4.48 (0.778)	4.46 (0.685)	4.60 (0.613)	8.52%	2.68%
5. Collaboration and Team Learning	4.24 (0.788)	4.51 (0.691)	4.16 (0.827)	4.44 (0.659)	4.48 (0.735)	4.58 (0.582)	7.69%	3.15%
6. Systems to Capture Learning	4.06 (0.822)	4.35 (0.730)	3.99 (0.848)	4.21 (0.746)	4.41 (0.770)	4.23 (0.624)	10.53%	0.48%
7. Empower People	4.15 (0.826)	4.47 (0.771)	4.08 (0.900)	4.31 (0.758)	4.50 (0.815)	4.41 (0.668)	10.29%	2.32%
8. Connect the Organization	4.36 (0.755)	450 (0.800)	4.30 (0.776)	4.48 (0.701)	4.55 (0.818)	4.40 (0.759)	5.81%	−1.79%
9. Provide Strategic Leadership for Learning	4.17 (0.976)	4.59 (0.873)	4.04 (1.049)	4.43 (0.730)	4.57 (0.953)	4.63 (0.667)	13.12%	4.51%
Performance								
My performance relative to colleagues last 3 months	5.02 (0.976)	5.17 (0.941)	4.96 (0.967)	5.16 (0.993)	5.22 (0.945)	5.04 (0.928)	5.88%	−2.33%
Time per process has been reduced the last 3 months	4.42 (1.078)	4.41 (1.007)	4.38 (1.032)	4.51 (1.179)	4.54 (0.940)	4.13 (1.101)	3.65%	−8.43%
Variability of time and quality per process has been reduced the last 3 months	4.36 (0.989)	4.51 (0.921)	4.33 (0.970)	4.43 (1.039)	4.62 (0.884)	4.28 (0.968)	6.70%	−3.39%
I have reduced re-work the last 3 months	4.92 (1.200)	5.01 (0.888)	4.85 (1.103)	5.08 (1.391)	5.10 (0.938)	4.83 (0.746)	5.15%	−4.92%

(*continued*)

Table 4.

Variable	Pre-measure total ($N = 154$)	Post-measure total ($N = 154$)	Pre-measure treatment group ($N = 106$)	Pre-measure non-treatment group ($N = 48$)	Post-measure treatment group ($N = 104$)	Post-measure non-treatment group ($N = 48$)	Change % in treatment group	Change % in non-treatment group
My ability to manage my time effectively has increased the last 3 months	4.84 (1.196)	5.02 (1.101)	4.84 (1.171)	4.83 (1.263)	5.14 (1.046)	4.77 (1.186)	6.20%	−1.24%
My performance relative to my performance standards (expectations) has increased the last 3 months	5.16 (1.070)	5.45 (0.945)	5.10 (1.072)	5.29 (1.063)	5.44 (0.956)	5.46 (0.929)	6.67%	3.21%
My performance has increased the last 3 months	5.22 (1.074)	5.52 (0.878)	5.18 (1.063)	5.31 (1.105)	5.56 (0.893)	5.42 (0.843)	7.34%	2.07%
Quality of my work has improved the last 3 months	5.09 (1.047)	5.20 (0.874)	5.08 (0.960)	5.09 (1.231)	5.26 (0.906)	5.07 (0.796)	3.54%	−0.39%
The value you have participated in delivering to your internal customers has increased the last 3 months	5.05 (0.973)	5.14 (0.912)	5.07 (0.957)	5.03 (1.016)	5.17 (0.944)	5.09 (0.845)	1.97%	1.19%
The amount of ideas I generate has increased the last 3 months	4.70 (1.129)	5.07 (1.132)	4.77 (1.167)	4.55 (1.038)	5.18 (1.179)	4.85 (0.998)	8.60%	6.59%
Time spend to solve a problem has decreased the last 3 months	4.55 (1.100)	4.62 (1.088)	4.53 (1.095)	4.60 (1.122)	4.68 (1.086)	4.50 (1.096)	3.31%	−2.17%
The level of my teams' performance has increased the last 3 months	4.74 (0.950)	5.00 (1.007)	4.78 (0.924)	4.66 (1.010)	5.12 (1.057)	4.75 (0.844)	7.11%	1.93%

Note(s): Standard deviations are reported in parentheses

Constructs and items	Std. Loadings	*t*-value (all significant at $p < 0.01$)
1. Continuous Learning – individual		
ITEM 1	0.614	a
ITEM 2	0.713	6.655
ITEM 3	0.419	4.330
ITEM 4	0.618	5.968
ITEM 5	0.723	6.746
ITEM 6	0.644	6.186
ITEM 7	0.698	6.566
2. Inquiry and Dialog – individual		
ITEM 8	0.574	a
ITEM 9	0.718	5.987
ITEM 10	0.627	5.498
ITEM 11	0.632	5.525
ITEM 12	0.617	5.437
ITEM 13	0.576	5.182
3. Collaboration and Team Learning		
ITEM 27	0.792	a
ITEM 28	0.651	7.872
ITEM 29	0.741	9.194
ITEM 30	0.756	9.403
ITEM 31	0.805	10.197
ITEM 32	0.789	9.918
4. Systems to Capture Learning		
ITEM 33	0.552	a
ITEM 34	0.691	5.967
ITEM 35	0.713	6.077
ITEM 36	0.761	6.307
ITEM 37	0.827	6.580
ITEM 38	0.668	5.839
5. Empower People		
ITEM 39	0.842	a
ITEM 40	0.819	11.829
ITEM 41	0.775	10.820
ITEM 42	0.783	10.909
ITEM 43	0.714	9.539
ITEM 44	0.704	9.356
6. Connect the Organization		
ITEM 45	0.714	a
ITEM 46	0.693	7.600
ITEM 47	0.736	8.053
ITEM 48	0.718	7.841
ITEM 49	0.544	5.944
ITEM 50	0.720	7.890
7. Provide Strategic Leadership for Learning		
ITEM 51	0.849	a
ITEM 52	0.684	9.130
ITEM 53	0.816	11.822
ITEM 54	0.898	14.125
ITEM 55	0.929	15.058
ITEM 56	0.806	11.566

Note(s): "a" indicates a loading fixed to 1; See ITEM text in Appendix 1 from Questionnaire

Table 5.
Confirmatory factor analysis of dimensions of learning organization – principal component

The second (and similar) formula uses the dependent variable as each of the performance variables (e.g. efficiency) to test Hypothesis 1.

$$Y_{(\text{Performance})} = \beta_0 + \beta_1\alpha + \beta_2\delta + \beta_3\alpha * \delta + \varepsilon$$

These formulas ensured that we controlled for time-invariant factors, as we are interested in isolating the effect of the change (i.e. the intervention). This is similar to a fixed-effects model (Dahl, 2011).

To test Hypothesis 3, we used a different statistical approach than the one used to test Hypotheses 1 and 2 – instead turning to a structural equation model (SEM). SEMs are more appropriate for testing mediation effects. However, we did not apply a traditional cross-sectional approach (Nielsen *et al.*, 2018) as our methodological design provided a pre-and post-measurement. Specifically, our SEM approach included 7 items for the learning organization variable and 12 items for performance. For each item, we considered the difference between the post-measurement and the pre-measurement observation. In this way, we derived a measure for the relative change in learning organization and performance that occurred over the observed time interval.

The independent variable of our SEM test is the treatment (i.e. a binary measurement: treatment or not), while the mediator variable is the learning organization, and the final dependent variables are the performance measures. We also included a direct effect from the treatment variable to the performance variables to account for non-mediated relationships.

Following the recent approach of Kim *et al.* (2017), the seven dimensions constituting a learning organization were modeled as second-order variables, meaning each dimension was a first-order latent variable in the SEM model, and each was measured using five or six questions, as found in Appendix 1 and Table 8. The second-order factor model accounted for multilateral covariances and the interactions of the first-order variables (Rindskopf and Rose, 1988). Thus, it also captured the super-additive effects of the coexistence of first-order variables (Kristensen, 2021; Nielsen *et al.*, 2018; Tanriverdi and Venkatranam, 2005). We believe that the dimensions of learning organization interactions depend on each other, so a second-order construct was required to statistically model these interactions and dependencies (i.e. the covariances) when relating these to performance.

4.3 Survey-based results for Hypothesis 1 – learning organization effects

The repeated-measures test in Table 6 presents evidence in support of Hypothesis 1. All interaction terms (pre-/post-measurement × intervention, the interaction) are significant except for team learning. The team learning variable value was not significant, even though the direction of change was as expected. This is not significant because the control group had the highest increase in this regard. In other words, in a simple event study without a control department, we found a significant positive change in team learning in the treatment department, but this does not allow us to attribute a significant effect on team learning from the intervention. When measuring the effect on team learning (repeated-measures test) between the pre-measurement and the sustained measurement taken six months after the post-measurement, we found a significant positive effect [3]. This may suggest that the intervention enables to sustain team learning over time and to focus on continuous rather than short-term event-led improvement. From Table 4, we know that all changes in the treatment department were positive, as expected. The results were significant, with a medium effect size, as indicated by the partial eta squared (Cohen, 1988). Thus, the survey test results support Hypothesis 1 in all measured dimensions. Notably, all dimensions of the learning organization were positively affected by the intervention. This stands in sharp contrast to Tortorella *et al.*'s (2020) results regarding lean services and their learning organization survey.

Dependent variable	Independent variables	Significance	Partial eta squared	*F*
Learning org - 7 dimensions average	Pre/post	*0.000 (0.263)*	0.093 (0.008)	15.625 (1.265)
	Pre/post x treatment	*0.002 (0.000)*	0.059 (0.089)	9.482 (14.885)
Learning org - 9 dimensions average	Pre/post	*0.000 (0.249)*	0.095 (0.009)	15.993 (1.339)
	Pre/post x treatment	*0.003 (0.000)*	0.056 (0.081)	9.054 (13.406)
Separate learning org dimensions below				
1. Continuous Learning – individual	Pre/post	0.158 (0.689)	0.013 (0.001)	2.013 (0.161)
	Pre/post x treatment	*0.003 (0.000)*	0.057 (0.121)	9.240 (20.887)
2. Inquiry and Dialog – individual	Pre/post	*0.007 (0.530)*	0.046 (0.003)	7.398 (0.397)
	Pre/post x treatment	*0.010 (0.017)*	0.043 (0.037)	6.757 (5.827)
3. Continuous Learning – colleagues	Pre/post	*0.013 (0.728)*	0.040 (0.001)	6.261 (0.122)
	Pre/post x treatment	*0.026 (0.000)*	0.032 (0.074)	5.026 (12.215)
4. Inquiry and Dialog – colleagues	Pre/post	*0.000 (0.092)*	0.087 (0.019)	14.503 (2.868)
	Pre/post x treatment	*0.058 (0.145)*	0.023 (0.014)	3.655 (2.144)
5. Collaboration and Team Learning	Pre/post	*0.000 (0.551)*	0.084 (0.002)	13.859 (0.357)
	Pre/post x treatment	0.154 (0.065)	0.013 (0.022)	2.056 (3.465)
6. Systems to Capture Learning	Pre/post	*0.002 (0.098)*	0.059 (0.018)	9.561 (2.766)
	Pre/post x treatment	*0.006 (0.000)*	0.049 (0.103)	7.828 (17.485)
7. Empower People	Pre/post	*0.001 (0.281)*	0.076 (0.008)	12.492 (1.171)
	Pre/post x treatment	*0.035 (0.001)*	0.029 (0.067)	4.530 (10.858)
8. Connect the Organization	Pre/post	0.198 (0.982)	0.011 (0.000)	1.675 (0.000)
	Pre/post x treatment	*0.017 (0.054)*	0.037 (0.024)	5.856 (3.759)
9. Provide Strategic Leadership for Learning	Pre/post	*0.000 (0.029)*	0.155 (0.031)	27.907 (4.850)
	Pre/post x treatment	*0.020 (0.012)*	0.035 (0.041)	5.522 (6.515)

Note(s): Multiple test of within-subject effects used, they yield similar results (Sphericity-assumed; Greenhouse–Geiser; Huynh–Feldt; Lower-bound); Significant results marked with italic. As robustness check results from pre-measurement compared to "sustain" measurement are reported in brackets

Table 6.
Repeated measures ANOVA test of within-subject effects/ constrasts – Learning Organization behavioral effects – $N = 154$

To increase the reliability of the test results, we carried out a series of additional robustness tests. For all dimensions and the averages of those dimensions, the intervention group experienced a significant positive effect from pre-to post-measurement, not accounting for the control group. All of these OLS regression results are found in Appendix 3 under the model with no control group. Hence, changes in the control group are not the only changes that create significant test results. We also tested the hypothesis using a difference-in-differences OLS regression approach, which yielded similar results to the repeated-measures test in Table 6 (see Appendix 3). The interaction term (multiplication) between the pre/post variable and the treatment in the difference-in-difference OLS regressions was significantly positive in each of the tests in Appendix 3. This indicates that the effect on a learning organization is produced only in the post-period and only in the treatment department, providing further evidence to support Hypothesis 1.

To ensure that the assumptions of the repeated-measures ANOVA test used to produce Tables 6 and 7 were not violated, residuals were controlled, and we checked for compliance with the normality assumption using normal probability plots. Moreover, we checked homoscedasticity via a scatterplot of the residuals. The additional robustness checks using difference-in-differences OLS regressions have variance inflation factors of approximately two in all cases, which does not indicate multicollinearity. Little's (1988) MCAR test shows that values are missing at random, which means that the expectation-maximizing method (Hair *et al.*, 2014) is an acceptable way to impute and replace missing values.

We also measured the effect six months after the pre-measurement (labeled "during measurement"). The learning organization dimensions all improved for the treatment department, but not by enough to be statistically significant. However, these improvements indicate that the learning organization dimensions steadily improved.

Dependent variable	Independent variables	Significance	Partial eta squared	*F*
My performance relative to colleagues last 3 months	Pre/post	0.441	0.004	0.598
	Pre/post x treatment	*0.047*	0.026	4,005
Time per process has been reduced the last 3 months	Pre/post	0.282	0.008	1,164
	Pre/post x treatment	*0.010*	0.043	6,811
Variability of time and quality per process has been reduced the last 3 months	Pre/post	0.470	0.003	0.524
	Pre/post x treatment	*0.019*	0.035	5,592
I have reduced re-work the last 3 months	Pre/post	0.982	0.000	0.000
	Pre/post x treatment	*0.015*	0.038	6,078
My ability to manage my time effectively has increased the last 3 months	Pre/post	0.229	0.010	1,460
	Pre/post x treatment	*0.061*	0.023	3,556
My performance relative to my performance standards (expectations) has increased the last 3 months	Pre/post	*0.003*	0.056	8,958
	Pre/post x treatment	0.352	0.006	0.872
My performance has increased the last 3 months	Pre/post	*0.017*	0.037	5,867
	Pre/post x treatment	0.164	0.013	1–967
Quality of my work has improved the last 3 months	Pre/post	0.371	0.005	0.805
	Pre/post x treatment	0.283	0.008	1,162
The value you have participated in delivering to your internal customers has increased the last 3 months	Pre/post	0.350	0.006	0.877
	Pre/post x treatment	0.823	0.000	0.050
The amount of ideas I generate has increased the last 3 months	Pre/post	0.000	0.076	12–508
	Pre/post x treatment	0.608	0.002	0.265
Time spend to solve a problem has decreased the last 3 months	Pre/post	0.816	0.000	0.055
	Pre/post x treatment	0.197	0.011	1,679
The level of my teams' performance has increased the last 3 months	Pre/post	*0.009*	0.045	7,089
	Pre/post x treatment	0.137	0.015	2,237

Note(s): Multiple test of within-subject effects used, they yield similar results (Sphericity-assumed; Greenhouse-Geiser; Huynh-Feldt; Lower-bound), significant results marked with italic

Table 7.
Repeated measures ANOVA test of within-subject effects – performance effects – $N = 154$

For the "sustain measurement" conducted six months after the post-measurement, the statistical conclusions remained the same as for the repeated-measures test in Table 6 (pre- and post-measurement repeated-measures ANOVA with control department). This is with the exception of the fourth dimension. The results comparing the pre and sustain-measurement are reported in Table 6 in brackets next to the pre- and post-measurement results. Thus, the effects were sustained six months after the intervention.

4.4 Survey-based results for Hypothesis 2 – performance effects

Table 7 presents statistical results in support of Hypothesis 2 (i.e. lean implementation has a positive effect on performance) using a repeated-measures ANOVA test. All interaction terms (pre-/post-measurement × intervention) were significant, as shown in Table 7. From Table 4, we know that all changes in the treatment department were positive, as expected. The statistical results were significant, with medium effect size, as indicated by the partial eta squared (Cohen, 1988). Thus, the results support Hypothesis 2 in several performance dimensions.

Table 7 only reports the performance items for which we found a significant effect; none of the other performance items were negatively affected. The complete list of performance items can be found in Appendix 1. There was no sign of shirking on these other performance dimensions to increase the performance items reported in Table 7. As such, we found no evidence of a multitasking effect. Time efficiency was increased, and rework was reduced in the treatment department. This is congruent with the focus of many of the internal A3 projects carried out in the treatment department. These were guided by a strategic focus on increasing the number of activities without increasing the use of resources.

To ensure that the performance effect kept increasing or did not slide back, we also tested the performance effect changes between the pre-measurement and the sustain measurement in a repeated-measures ANOVA, including the control department. The same performance items also increased significantly in this test, except for "My performance relative to colleagues in the past three months", in which the effect from pre-measurement to the sustain measurement was no longer significant [4]. However, the "Level of my performance has increased in the past three months" variable increased significantly, with a p-value of 0.05. Notably, the performance effects were measured on a change scale, that is as an increase over the past three months, meaning that performance increased from pre-measurement to post-measurement. Almost all variables increased somewhat more from the post-measurement to the sustained measurement. The only exception was performance "relative to colleagues".

4.5 Survey-based results for Hypothesis 3 – mediation model

We use an SEM approach to test Hypothesis 3, as this contains a mediation relation. The test results from our SEM are presented in Table 8, which supports the same pattern found in the test results for Hypotheses 1 and 2 in the previous sections. The SEM statistics in Table 8 first confirm that the treatment variable (lean intervention, 0/1) is positively, marginally significant at a 0.88 p-level, related to the second-order construct representing the learning organization. Moreover, it confirms that the seven dimensions (i.e. first-order variables) all significantly positively represent the second-order construct, which reflects our theoretical notion that these dimensions are interdependent (see the panel at the bottom of Table 8). However, the test results from the SEM approach also reveal a couple of additional findings. Table 8 shows that the learning organization second-order variable positively affected the four performance variables. The performance items – variability of time and quality, quality, rework, and general team performance – all improved during the last three months due to the increased level of the learning organization variable (second-order), as shown in the second panel of Table 8. To ensure that the SEM tests showed mediation relations, we tested the indirect effects

Structural equation model – hypothesis 3	Std. loadings	*T*-value (*p*-value)	Std. indirect effect (*p*-value)
Learning organization (second order)			
Lean treatment	0.178	*1.703* (0.088*)*	
My performance relative to colleagues last 3 months			
Learning organization (second order)	0.034	0.321 (0.748)	
Lean treatment	0.088	0.873 (0.383)	0.000 (0.860)
Time per process has been reduced the last 3 months			
Learning organization (second order)	0.127	1.191 (0.234)	
Lean treatment	0.171	*1.717* (0.086*)*	0.023 (0.227)
Variability of time and quality per process has been reduced the last 3 months			
Learning organization (second order)	0.196	*1.804* (0.071*)*	
Lean treatment	0.164	*1.655* (0.098*)*	*0.040 (0.003)*
I have reduced re-work the last 3 months			
Learning organization (second order)	0.243	*2.198* (0.028**)*	
Lean treatment	0.091	0.932 (0.351)	*0.049 (0.003)*
My ability to manage my time effectively has increased the last 3 months			
Learning organization (second order)	0.124	1.159 (0.246)	
Lean treatment	0.137	1.368 (0.171)	0.020 (0.280)
My performance relative to my performance standards (expectations) has increased the last 3 months			
Learning organization (second order)	0.102	0.960 (0.337)	
Lean treatment	0.028	0.281(0.779)	0.014 (0.391)
My performance has increased the last 3 months			
Learning organization (second order)	0.136	1.258 (0.208)	
Lean treatment	0.085	0.845 (0.398)	0.020 (0.381)
Quality of my work has improved the last 3 months			
Learning organization (second order)	0.232	*2.112* (0.035*)*	
Lean treatment	0.069	0.700 (0.484)	*0.046 (0.004)*
The value you have participated in delivering to your internal customers has increased the last 3 months			
Learning organization (second order)	0.140	1.304 (0.192)	
Lean treatment	0.027	0.272 (0.785)	0.024 (0.099)
The amount of ideas I generate has increased the last 3 months	0.061	0.609 (0.543)	0.016 (0.290)
Learning organization (second order)	0.094	0.878 (0.380)	
Lean treatment	0.099	0.983 (0.326)	0.009 (0.671)
Time spend to solve a problem has decreased the last 3 months			
Learning organization (second order)	0.060	0.568 (0.570)	
Lean treatment			
The level of my teams' performance has increased the last 3 months			
Learning organization (second order)	0.291	*2.585** (0.010**)*	
Lean treatment	0.086	0.891 (0.373)	*0.059 (0.026)*
Learning organization (second order) - loadings of reflective dependent variables below			
1. Continuous Learning – individual	0.861	*3.872****	

(*continued*)

Table 8.
Structural equation model of Hypothesis 3: Treatment → Learning organization → Performance

Table 8.

Structural equation model – hypothesis 3	Std. loadings	*T*-value (*p*-value)	Std. indirect effect (*p*-value)
2. Inquiry and Dialogue – individual	0.726	*3.810****	
3. Collaboration and Team Learning	0.751	*4.308****	
4. Systems to Capture Learning	0.833	*4.389****	
5. Empower People	0.920	*5.050****	
6. Connect the Organization	0.869	Fixed to 1	
7. Provide Strategic Leadership for Learning	0.778	*4.621****	

Note(s): For alle variables it is the difference between pre- and post-measurement (subtraction) representing the change; First-order loading of learning organization construct not shown. * indicates (italic) significance at a *p*-level of < 0.10 and *** at 0.000 level; Italicized labels indicates dependent variables and non-italicized are indepedent variables; Fit indices of model: RMSEA 0.073; CMIN/DF 1.817 - $N = 154$

of the lean intervention on the learning organization regarding the four abovementioned performance items. These were all statistically significant in the bootstrapped test, which confirmed the mediation relationship. The *p*-values of the indirect effects are also found in Table 8. Thus, the SEM test results indicate that the quality-related performance variables were mediated by the department becoming more of a learning organization. That is, the treatment variable positively impacts the learning organization, which in turn increases these performance variables. Therefore, this test confirms Hypothesis 3.

The general team performance item was not significantly affected in the direct effects tested in Hypothesis 2's repeated-measures test. Therefore, we find that overall team performance is associated with lean intervention by increasing the learning organization level.

Efficiency performance in terms of time per process was far from significantly affected by the learning organization variable, which indicates that there is not a mediation relationship between the lean intervention and efficiency based on becoming a learning organization. Instead, there is a direct relationship between the treatment variable, lean intervention, and improvements in the time per process, i.e. efficiency. Hence, in terms of efficiency, there is no mediation through the learning organization from the lean intervention. This was also reaffirmed by the indirect effects test, which was non-significant (bootstrapped *p*-value = 0.227). Moreover, this treatment variable also had a marginal significant direct effect on the reduced variability of the time per process, which was also affected by the learning organization variable, indicating a partial mediation relationship.

4.6 Financial and non-financial performance effects – non-survey data

To validate our evidence in support of Hypotheses 2 and 3, we also assessed data from LEGO's benefit tracker and its KPIs, including budget evaluations, and LEGO's A3 reports. We used the student worker to code patterns across the A3 reports. In coding these patterns, the student focused on the performance effects, being the reduction in time consumed, on-time delivery, quality and other performance effects, such as working environment. This coding aligned with LEGO's formal KPIs.

The head of the treatment department provided actual and budgeted financial figures for the department. Prior to the lean practices intervention, the department's costs and the number of deliveries (output) rose by almost the same pace, approximately 2–3% per year. In 2017 (after the intervention), budgeted and actual costs fell by 13% (no layoffs, only internal transfers, voluntary retirements, and voluntary changes to new jobs). At the same time, the number of required deliveries continued to grow by 2–3% per year. Thus, the costs no longer

followed the activity (number of deliveries) linearly as it had in the prior period. This indicates an improvement compared to previous performance, as the activity increased and the costs decreased at the same time. The department head attributed the increase in productivity to the lean intervention. The changes are somewhat larger than those found in the survey results in Table 4 in terms of percentage change.

The internal KPIs for on-time-delivery and first-pass yield followed a similar pattern. Delivery on time increased from 56% in 2016 to 94% in 2018 for the treatment department. At the same time, the treatment department experienced an eight-point improvement in employee satisfaction in 2017. Some employees rated their immediate leaders 20 points higher than in the previous year. During the same period, there was no major change in these indicators in the control department.

We assessed the content and purpose of 42 A3 reports written between early 2016 and mid-2017. More than 50% of the reports focused on time consumption, while 25% focused on quality and on-time-delivery. These foci prove that the A3 work was aligned with LEGO's performance indicators. The remaining 25% focused on other performance indicators, such as the work environment.

LEGO also collected the costs and benefits of the 42 A3 reports in a "benefits tracker". The accumulated results indicated that the average payback time was approximately seven and a half months when comparing the benefits measured only as a reduction in time consumption to the time consumption used to analyze and implement the lean practices. The benefits in the following years were even higher, as the intervention time consumption was avoided (lean practices introduction). However, the benefit tracker does not include benefits from other initiatives not systematized in specific A3 reports, such as coaching cards.

To validate LEGO's internal benefit tracker, we randomly selected six A3 reports to be audited for the time consumed and compared those findings to the expected reduction in time consumption. The time savings were around 1,150 h per year, while it took approximately 750 h to complete these 6 A3 reports. Thus, the payback time was approximately nine months. In the first year after the intervention, increased productivity helped the department avoid hiring three new employees. Moreover, eight employees were relocated to other departments, while department activities increased 2–3%. Thus, both employees and LEGO as a whole benefited from the company's growth, which made internal transfers possible.

In summary, the non-survey data from quantifying the A3 reports, the KPI's, budget evaluations, and resources employed support the positive performance effects stated in Hypotheses 2 and 3.

4.7 Qualitative results from observations, interviews, and informal discussions

We taped all interviews and listened to them by categorizing the quotes and meanings based on the seven dimensions of a learning organization (Marsick and Watkins, 2003). More specifically, we performed a theoretical thematic analysis (Braun and Clarke, 2006), acknowledging that our study was driven by our theoretical framework of developing a learning organization (multiple dimensions) and performance. One of the researchers coded the interviews, and the results and patterns were discussed with the other authors and with a student worker to ensure consistency and to make sense of the interviews.

In many of the interviews and observations, employees expressed a common theme:

> Previously, we put out fires without understanding what caused them. Now we locate the root causes of the fires and then work to prevent them.

This points to improved learning behavior in the treatment department.

Interviewed about the supportive learning environment, the head of the treatment department stated,

> We now have a learning organization in which we thank employees who share their mistakes because they have learned something. Failures are now a good thing, as they increase learning.

This perspective was also evident in a conversation we observed between a new employee and the head of the department.

After the lean intervention, new learning processes became part of the daily work in the treatment department, as explained by a senior manager:

> We use our new way of thinking—finding the facts, and identifying root causes by going to the internal customers and stakeholders and asking questions.

This statement also indicates that the go-to-Gemba/fact-seeking approach was functionally combined with individual and group coaching between employees and across hierarchical levels. Another manager echoed this sentiment:

> We no longer only raise our concerns when we see a problem. Instead, we analyze the problem and provide possible solutions upfront.

When we reported back to the managers a year after the final phase, they shared some reflections with us. A couple of the managers still found the notion of "going slow to go fast" in the lean and learning approach somewhat counterintuitive and difficult to understand why it was working. It was sometimes difficult for the managers to understand why they should not just apply a solution to a problem without going through participatory processes with group coaching and dwelling on understanding the problems in detail before searching for solutions. The managers acknowledged that going slow – i.e. fostering participation, taking longer to understand the problems, etc. – to go fast was beneficial and the right way to address issues. However, it was also difficult for them to adjust their mindset to this notion, and therefore they had to remind themselves occasionally that this was the mindset they should use. This was especially the case when deadlines were tight. Yet, the managers reminded each other, and the employees also reminded them to work using reflection, participation, and questions instead of providing solutions. When new employees and managers were onboarded, this needed to be emphasized. Employees needed to collectively remind each other not to slip into old ways of working, that being managers providing the solutions.

The lean intervention had an impact on leadership that reinforced learning. One senior manager said,

> We have changed not only the way we lead but also the way we view the world. We have integrated it into everything we do.

One middle manager was about to leave the treatment department during the implementation. S/he felt devalued when he/she was no longer the primary source of solutions and had to take on an inquiring and coaching role instead. Hence, staff initially felt that their usual way of doing things was not appreciated by their department heads. One of the managers also felt that the new lean approach was initially a straitjacket as they saw the new approach as something they had to do. Yet, after reflecting, he/she has now accepted the new role, understands its purpose, and believes that the new approach is flexible and enables learning. However, this was not without friction during the change.

Despite this friction, we generally observed that the leaders began to ask more questions instead of providing answers, which empowered employees to solve problems and work together across departments. The same senior manager said,

> I used to just ask a few questions before coming to a conclusion. Now, I ask questions to have the employees make the conclusions. This enables me to see how they understand a problem.

This behavioral change made it safer for leaders and employees to challenge each other, ask for help, experiment, and listen to new ideas from colleagues and other teams, which fostered a sense of belonging within the treatment department. Additionally, one year after the study, we presented the results to the head of the treatment department and one of the middle managers, who fully agreed with them.

4.7.1 Learning to be a learning organization and efficiency – an example. One aim of the lean intervention was to enable the treatment department to cope with increased pressure (i.e. complexity and task novelty) not only from the point of view of product development, marketing, and manufacturing but also from LEGO's top management. This pressure primarily arose from external changes related to double-digit sales growth, expansion of the product assortment, a demand for reduced time to market, and the digitalization of products, sales channels, and marketing materials. These changes led to a significant increase in the number of tasks, as well as increased task complexity and novelty, without a proportional increase in resources. To cope with these pressures, the lean intervention focused on developing the organization's ability to adapt while continually improving performance.

We witnessed an example of how the lean intervention enabled the department to adapt to ongoing changes. Recall that the department was responsible for creating 3D digital models of the designs for marketing materials, building instructions, and games. The department experienced a significant increase in the number of overdue tasks. LEGO's own data showed that the department reduced the number of overdue tasks from 214 to 4 in only 5 weeks as a result of the lean intervention, despite the middle manager's initial statement that doing so was impossible.

Prior to the lean intervention, incoming tasks from the product development department were registered in the task management system and assigned to individual employees by a coordinator. Every week, managers and employees worked together to identify ways to handle overdue tasks. Given the many overdue tasks, the employees were continually confronted by irritated colleagues from the product development department.

After the lean intervention, leaders and employees achieved significant improvement by adopting a proactive approach to handling incoming tasks. This occurred by developing an A3 report and problem-solving regarding not delivering on time and with the right quality. Thus, as a solution, instead of waiting for tasks to come into the task management IT system, middle managers and employees began to proactively contact their colleagues in the product development department. They asked about the kinds of tasks they could expect in the next two weeks and about potential operational challenges. By forecasting two weeks ahead, they were able to better plan deliveries. Moreover, when they were in contact with their colleagues from product development, they also tried to identify potential new challenges with forthcoming deliveries and would react to these by applying the A3 problem-solving process even before the potential problem caused an overdue delivery.

The department established a pull system to handle incoming tasks. This system enables employees to pull a new task from the task management system instead of being assigned a task by the coordinator. This ensured better utilization of the department's resources and process flows.

5. Discussion, conclusions, future research, and limitations

Generally, in this study, our overall purpose was to study whether problem-solving lean practices combined with leaders acting as learning facilitators could be transferred to an operations support department (an administrative and knowledge worker environment). We asked would this change an individual's perception of being part of a learning organization while also enhancing the performance (efficiency and quality. Studying a lean intervention at LEGO to answer these questions, we believe we arrived at three main findings.

The first gap in the literature our findings starts closing concerns changing individuals' perceptions of the organization as a learning organization. Thereby, we contribute to the literature on learning organizations and lean, in which learning organizations have been characterized as an undelivered promise (Elkjaer, 2001; Garvin *et al.*, 2008). The results of our study show that some lean practices can be used to enhance all dimensions of a learning organization (Marsick and Watkins, 2003). Thereby, active interventions can be used to improve a firm's or a department's status as a learning organization as perceived by the individuals in the organizations. It is notable that all seven dimensions of learning organization were positively affected, yet the prior literature on lean services arrived at very different results (Tortorella *et al.*, 2020). We attribute this to the unique combination of LEGO's meta-routines for problem-solving, and its support for leaders as learning facilitators. This finding is particularly relevant because Tortorella *et al.* (2020) empirically found that lean implementation, with a more traditional focus and somewhat missing the socio practices used at LEGO, would not lead to becoming a learning organization in a non-production context. We, however, find that a learning organization can be supported in a non-production context if the focus is on socio-technical practices similar to those used by LEGO. In this, we place emphasis more on the socio side of the practices than the technical ones, particularly when viewing this in the context of Shah and Ward's (2007) 10 factors that constitute lean [5].

Notably, LEGO's intervention included contemporary lean practices focused on meta-routines for SPS and leaders as learning facilitators. The company does not use variability-reducing practices, such as Heijunka, Kanban cards, or U-cells, and theoretically focuses less on perceiving lean through the lenses of theory of even swift flow and Factory Physics theory (Treville and Antonakis, 2006). Implementing practices that emphasize learning allows for more contextual ambidexterity, as the department's employees were able to improve multiple performance measures while simultaneously enhancing their learning abilities, measured in terms of learning organization dimensions. Thus, our study shows that a socio-technical lean implementation in a non-production context may produce a learning organization, quality performance, and increased efficiency, even though LEGO's implementation places less emphasis on lean technical tools. LEGO places more emphasis on socio practices, such as leaders becoming learning facilitators (e.g. through various types of coaching) in combination with SPS. This approach seems to be suited to a non-production context where things are less tangible. Here, the customer is part of the value creation process and may demand change with constant adjustments to the deliveries to internal customers.

The second contribution to the literature relates to understanding how to push the potential trade-off between short-term performance concerns and acquiring learning-to-learn capability. The goal of learning-to-learn may come at a cost, as management needs to allocate time to becoming a learning organization. The availability of this "spare" time can increase learning and is particularly relevant in a low-volume environment (Browning and Heath, 2009), such as the support department we studied. In this department, changes in demand and being adaptive were important for sustaining competitiveness. This allocation of time may potentially reduce short-term capacity utilization and may, therefore, reduce efficiency. Hence, companies may try to balance this time to ensure that efficiency is not completely sacrificed in the pursuit of becoming a learning organization. LEGO wanted to become more of a learning organization while also increasing short-term efficiency and quality. Theoretically, this is an attempt to push the trade-off curve to a higher level (Adler *et al.*, 1999) between the time set aside for learning and the time spent being "efficient". LEGO managed to do as much of their process to become a learning organization being focused on solving real problem – also those related to improving efficiency. An intervention in a support department where both the employees and the leaders have to simultaneously run daily activities and implement lean practices, is less likely to fail, as shown in our case. LEGO managed to increase performance while also learning to learn as they focused on lean action

learning (e.g. not learning lean in a classroom and with great involvement in solving real problems by both leaders and non-leaders through group and dyadic coaching combined with fact-based systematic problem-solving practices, such as kata, A3, coaching cards, and go-to-Gemba). Moreover, LEGO did not rely on external consultants to do the lean intervention. Instead, it relied on employees to both increase performance and learning, which accords with Secchi and Camuffo's (2019) recommendations in situations where there is no great sense of urgency (i.e. large short-term performance gaps).

A third contribution of this paper relates to the literature on whether the performance effects of a lean intervention directly affect performance or whether it is mediated by changing the learning organization perception of the individuals. We find that efficiency is directly affected by lean implementation, while quality-related performance is mediated by the learning organization. In our context of a support department with internal customers with changing/increasing demands for delivery quality, we suspect that meeting these needs requires a full and comprehensive learning organization (i.e. a system) to affect quality and adapt to changing demands. At LEGO, efficiency is more internally controlled and is, therefore, easy to directly affect – at least in the short term. As such, we supplement the findings of Staats *et al.* (2011), who find that lean in a knowledge context can increase efficiency without a significant emphasis on the learning approach. Our results suggest that focusing on the socio practices that support learning may also enhance efficiency. We believe this is a contribution to finding the balance between the socio and technical practices of lean when used in a non-production context, as it seems like learning is improved, but not at the expense of completely losing the complementarity effects of socio and technical practices on performance.

Practitioners may be inspired by LEGO's choices of lean practices in their pursuit of becoming a learning organization and improving efficiency. They may wish to focus on meta-routines for problem-solving in a non-production setting and on supporting leadership to facilitate learning. In essence, practitioners could follow the implementation plan depicted in Figure 1 and Table 2 covering the three phases as this provides guidance on how to start and progress the implementation. Moreover, practitioners should focus their implementations on using dyadic and group coaching by and with leaders, A3's, coaching cards. They should also prioritize solving real problems as opposed to classroom training, conducting experiments using a PDCA approach, Gemba walks or challenge assumptions to change mental models, and visualizing performance gaps. LEGO's implementation succeeded in creating more of a learning organization while enhancing performance. This may be interesting for practitioners given that, in some previous cases, introducing lean production has led to a short-term decline in efficiency, as in Lockheed Martin's F22 case (Browning and Heath, 2009), especially if a learning organization is to be developed at the same time.

5.1 Limitations and future research

The main limitation of this study is that it was based on a single example of a lean intervention. The small sample size limits the generalization of the results. Hence, we cannot conclude that companies can copy these effects if their organizations are positioned with a different starting point.

Another limitation is that LEGO's lean practice intervention was based on multiple lean practices, and we cannot claim to have found causality between single practices or approaches and outcomes.

Moreover, some of our results are based on questionnaires and therefore on the perceptions of employees. Such perceptions may be skewed when studying an implementation that is also based on changing people's mindsets and thinking. LEGO's implementation sought to change behavior and the employees' judgments of how they solve and analyze problems. Despite being gently pushed in a certain direction by the lean

intervention, there was still room for individual judgment. Such judgment is also based on prior experience, culture, and education, which may be difficult to copy in other contexts. One may also see LEGO's lean intervention as a standard approach where a learning organization would be open to different approaches. However, there was flexibility in the lean intervention, as picking the right analysis tools in the A3s and coaching sessions was flexible. Hence, LEGO standardized some parts – mainly the meta-routines for learning and problem-solving – while being flexible regarding the concrete tools applied in a given situation. If studied over a longer period, there may have been double-loop learning on the meta-routines to be more adaptable and select them based on changing needs.

As we do not find that a learning organization, or the seven dimensions of it, significantly mediates the relationship between lean intervention and efficiency performance, this may be a theme to study in future research in a setting where panel data covers a longer time period than ours. In doing so, one may find this dynamic change (Nielsen *et al.*, 2021). In their seminal paper, Furlan *et al.* (2019) distinguish between the organizational and individual level in the methodological approach. We think that this is an important separation of levels that future studies on learning organization, performance and lean interventions could pursue as a fruitful avenue.

LEGO's lean intervention was facilitated by an internal lean department, and not by external consultants. Hence, if other companies want to imitate LEGO's lean intervention approach, they may be limited by not having a department with these competencies. Such skills may need to be built first as it is uncertain as to whether external consultants can fulfill this role. This could also be studied in future research.

In 2018, LEGO announced (Sommer, 2019) that the LEGO group would embark on a journey toward an agile approach. Our recent conversations with LEGO employees indicate that the lean intervention and learning approach we studied acted as a foundation and enabler of the agile journey. It could be a potential avenue for future studies to research how and whether lean management and an agile approach would complement and/or act as substitutes for each other (Hines *et al.*, 2004) in a firm's pursuit of becoming a learning organization (Putnik and Putnik, 2012). This would be especially interesting in the context of continuously changing tasks and when lean is used as an approach to build learning-to-learn capabilities and not as a tool-oriented exploitative approach.

Notes

1. A double post-test is used to account for the sustainability of effects.
2. Wall *et al.* found that subjective and objective performance data are correlated, but they recommend using both types when possible, as each type of data may contain its own errors.
3. The p-value of the repeated-measures ANOVA test was 0.065. Moreover, a paired t-test from post-measurement to the "sustain" measurement was significantly positive.
4. Notably, a paired t-test for this variable using the post-measurement and the sustain measurement is not significantly changed (p-value of 0.05).
5. The ten factors are: supplier feedback, Just-in-Time by suppliers, Supplier development, customer involvement, pull with kanban, flow, set up time reduction, total preventive maintenance, statistical process control, employee involvement in problem solving. From our description of the LEGO lean intervention it is evident they only partly used some of them as LEGO mainly focused on systematic problem solving and leaders as learning facilitators in an action learning approach.

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(The Appendix follows overleaf)

Appendix 1

Table of survey questions

Learning Organization:

Mark your appropriate response to each item . . .

(1) In my organization (DEPARTMENT), I openly discuss mistakes with colleagues in order to learn from them.

(2) In my organization (DEPARTMENT), I identify skills I need for future work tasks

(3) In my organization (DEPARTMENT), I help other people to learn

(4) In my organization (DEPARTMENT), I can get money and other resources to support my learning

(5) In my organization (DEPARTMENT), I am given time to support learning

(6) In my organization (DEPARTMENT), I view problems in my work as an opportunity to learn.

(7) In my organization (DEPARTMENT), I am rewarded for learning

(8) In my organization (DEPARTMENT), I give open and honest feedback to my colleagues

(9) In my organization (DEPARTMENT), I listen to others' views before speaking

(10) In my organization (DEPARTMENT), I am encouraged to ask "why" regardless of my rank

(11) In my organization (DEPARTMENT), whenever I state my view, I also ask what others think

(12) In my organization (DEPARTMENT), I treat my colleagues with respect

(13) In my organization (DEPARTMENT), I spend time building trust with colleagues

(14) In my organization (DEPARTMENT), my colleagues openly discuss mistakes in order to learn from them

(15) In my organization (DEPARTMENT), my colleagues identify skills they need for future work tasks

(16) In my organization (DEPARTMENT), my colleagues help each other learn

(17) In my organization (DEPARTMENT), my colleagues can get money and other resources to support their learning

(18) In my organization (DEPARTMENT), my colleagues are given time to support learning

(19) In my organization (DEPARTMENT), my colleagues view problems in their work as an opportunity to learn

(20) In my organization (DEPARTMENT), my colleagues are rewarded for learning

(21) In my organization (DEPARTMENT), my colleagues give open and honest feedback to each other

(22) In my organization (DEPARTMENT), my colleagues listen to others' views before speaking

(23) In my organization (DEPARTMENT), my colleagues are encouraged to ask "why" regardless of rank

(24) In my organization (DEPARTMENT), whenever my colleagues state their view, they also ask what others think

(25) In my organization (DEPARTMENT), my colleagues treat each other with respect

(26) In my organization (DEPARTMENT), my colleagues spend time building trust with each other

(27) In my organization (DEPARTMENT), teams/groups have the freedom to adapt their goals as needed

(28) In my organization (DEPARTMENT), teams/groups treat members as equals, regardless of rank, culture, or other differences

(29) In my organization (DEPARTMENT), teams/groups focus both on the group's task and on how well the group is working

(30) In my organization (DEPARTMENT), teams/groups revise their thinking as a result of group discussions or information collected

(31) In my organization (DEPARTMENT), teams/groups are rewarded for their achievements as a team/group

(32) In my organization (DEPARTMENT), teams/groups are confident that the organization will act on their recommendations

(33) In my organization (DEPARTMENT), we use two-way communication on a regular basis, such as suggestion systems, electronic bulletin boards, or town hall/open meetings

(34) My organization (DEPARTMENT) enables people to get needed information at any time quickly and easily

(35) My organization (DEPARTMENT) maintains an up-to-date database of employee skills

(36) My organization (DEPARTMENT) creates systems to measure gaps between current and expected performance

(37) My organization (DEPARTMENT) makes its lessons learned available to all employees

(38) My organization (DEPARTMENT) measures the results of the time and resources spent on training

(39) My organization (DEPARTMENT) recognizes people for taking initiative

(40) My organization (DEPARTMENT) gives people choices in their work assignments

(41) My organization (DEPARTMENT) invites people to contribute to the organization's vision

(42) My organization (DEPARTMENT) gives people control over the resources they need to accomplish their work

(43) My organization (DEPARTMENT) supports employees who take calculated risks

(44) My organization (DEPARTMENT) builds alignment of visions across different levels and workgroups

(45) My organization (DEPARTMENT) helps employees balance work and family

(46) My organization (DEPARTMENT) encourages people to think from a global perspective

(47) My organization (DEPARTMENT) encourages everyone to bring the customers' views into the decision-making process

(48) My organization (DEPARTMENT) considers the impact of decisions on employee morale

(49) My organization (DEPARTMENT) works together with the outside community to meet mutual needs

(50) My organization (DEPARTMENT) encourages people to get answers from across the organization when solving problems

(51) In my organization (DEPARTMENT), leaders generally support requests for learning opportunities and training

(52) In my organization (DEPARTMENT), leaders share up-to-date information with employees about competitors, industry trends, and organizational directions

(53) In my organization (DEPARTMENT), leaders empower others to help carry out the organization's vision

(54) In my organization (DEPARTMENT), leaders mentor and coach those they lead

(55) In my organization (DEPARTMENT), leaders continually look for opportunities to learn

(56) In my organization (DEPARTMENT), leaders ensure that the organization's actions are consistent with its values

All learning organization questions measured on a 6 point scale from 1 (almost never) to 6 (almost always), and where is says "DEPARTMENT" the respondents' department name was present, but removed here for confidentially reasons.

Questions are grouped into constructs (average of dimensions) based on Marsick and Watkins (2003) suggestion on how to group. Using the numbering stated above: *Question 1–7 is individual continuous learning. Question 8–13 is inquiry and dialog. Question 14–20 is* colleagues *continuous learning. Question 21–26 is* colleagues *inquiry and dialog. Question 27–32 is Collaboration and Team learning. Question 33–38 is Systems to Capture learning. Question 39–44 is Empower people. Question 45–50 is Connect the organization. Question 51–56 is Provide Strategic Leadership for Learning.*

The DLOQ – Dimensions of the Learning Organization Questionnaire

Performance:

Please state the level of job performance . . .

(1) The level of my performance relative to my performance standards (expectations) has increased the last 3 months

(2) The level of my performance relative to my colleagues' performance has increased the last 3 months

(3) The level of my performance has increased the last 3 months

(4) Time per process has been reduced the last 3 months

(5) Variability (fluctuations) of time and quality per process has been reduced the last 3 months

(6) Quality of my work has improved the last 3 months

(7) I have reduced rework (do it right first time) the last 3 months

(8) The value you have participated in delivering to your internal customers has increased the last 3 months

(9) The amount of ideas I generate has increased the last 3 months

(10) My ability to manage my time effectively has increased the last 3 months

(11) Time spend to solve a problem has decreased the last 3 months

(12) The level of my teams' performance has increased the last 3 months

All performance questions measured on the following scale from 1–7:

1: Strongly disagree
2: Disagree
3: Somewhat disagree
4: Neutral
5: Somewhat agree
6: Agree
7: Strongly agree

Appendix 2
Interview guide

NAME: XXX.

Purpose:

To see the difference in the way the leaders think about how to act and behave as an LCI (LEGO continuous improvement) leader as they participate In the LCI thinking program and start practicing LCI in their daily work. The leaders will therefore be interview in 2016 and 2017.

Questions:

(1) What is leadership to you? How do you define it? How do you practice it today?

(2) What is LCI leadership to you?

(3) What does continues improvement mean to you? How do you define it? How do you practice it today?

(4) What is people development? How do you define it? How do you practice it today?

(5) How do you create value today? How do you define it? How do you practice it today?

(6) How does your organization crate values? How do you define it? How do you practice it today?

(7) What do you do when a problem arises? How do you solve problems?

(8) How do you measure performance? (E.g. get KPls)

Questions after first interview:

(1) How has your value creation changed/improved? (Since first interview}

(2) How has your performance changed/improved? (Since first Interview)

(3) How does your organization create value? (Since first interview)

(4) What do you do/behave differently since first interview?

(5) Do you think leadership differently? How?

Appendix 3
Robustness tests - Differences-in-Differences OLS regression – Premeasurement to Postmeasurement

First a differences-in-differences model for each dependent variable is shown (treatment, pre/post, and pre/post x treatment), and next a model only testing the pre to post effect for the lean practices intervention department (no control group).

Dependent variable	Independent variables	Standardized coefficient	Significance coefficient	Model adjusted R square	Model significance (F-value)
Learning org - 7 dimensions average	Treatment	-0.197^{**}	0.012	0.060	0.000 (7.504)
	Pre/post	0.025	0.798		
	Pre/post x Treatment	0.266^{**}	0.020		
	Pre/post (no control group in model)	0.279^{***}	0.000	0.073	0.000 (17.672)

(*continued*)

Dependent variable	Independent variables	Standardized coefficient	Significance coefficient	Model adjusted R square	Model significance (F-value)
Learning org - 9 dimensions average	Treatment	*−0.207***	0.008	0.062	0.000 (7.806)
	Pre/post	0.028	0.777		
	Pre/post x Treatment	*0.266***	0.020		
	Pre/post (no control group in model)	*0.282****	0.000	0.075	0.000 (18.162)
Separate learning org dimensions below					
1. Continuous Learning – individual	Treatment	***−0.208****	0.009	0.030	0.006 (4.218)
	Pre/post	−0.064	0.526		
	Pre/post x Treatment	*0.267***	0.021		
	Pre/post (no control group in model)	*0.199***	0.004	0.035	0.004 (8.645)
2. Inquiry and Dialog – individual	Treatment	*−0.296***	0.000	0.067	0.000 (8.380)
	Pre/post	0.015	0.882		
	Pre/post x Treatment	*0.213**	0.060		
	Pre/post (no control group in model)	*0.224***	0.001	0.046	0.001 (11.133)
3. Continuous Learning – colleagues	Treatment	*−0.175***	0.027	0.038	0.002 (5.077)
	Pre/post	−0.005	0.957		
	Pre/post x Treatment	*0.247**	0.032		
	Pre/post (no control group in model)	*0.246****	0.000	0.056	0.000 (13.531)
4. Inquiry and Dialog – colleagues	Treatment	*−0.226***	0.004	0.059	0.000 (7.493)
	Pre/post	0.068	0.494		
	Pre/post x Treatment	*0.190**	0.094		
	Pre/post (no control group in model)	*0.261****	0.000	0.064	0.000 (15.362)
5. Collaboration and Team Learning	Treatment	*−0.179***	0.023	0.051	0.000 (6.552)
	Pre/post	0.094	0.344		
	Pre/post x Treatment	0.160	0.161		
	Pre/post (no control group in model)	*0.246****	0.000	0.056	0.000 (13.561)
6. Systems to Capture Learning	Treatment	−0.121	0.125	0.050	0.000 (6.391)
	Pre/post	0.010	0.917		
	Pre/post x Treatment	*0.268***	0.019		
	Pre/post (no control group in model)	*0.277****	0.000	0.072	0.000 (17.386)

(*continued*)

Dependent variable	Independent variables	Standardized coefficient	Significance coefficient	Model adjusted R square	Model significance (F-value)
7. Empower People	Treatment	−0.121	0.125	0.047	0.000 (6.099)
	Pre/post	0.045	0.652		
	Pre/post x Treatment	*0.228***	0.047		
	Pre/post (no control group in model)	*0.268****	0.000	0.067	0.000 (16.205)
8. Connect the Organization	Treatment	−0.103	0.190	0.047	0.001 (6.022)
	Pre/post	0.043	0.666		
	Pre/post x Treatment	*0.228***	0.046		
	Pre/post (no control group in model)	*0.271****	0.000	0.069	0.000 (16.599)
9. Provide Strategic Leadership for Learning	Treatment	*−0.189***	0.016	0.070	0.000 (8.686)
	Pre/post	0.096	0.332		
	Pre/post x Treatment	*0.208**	0.066		
	Pre/post (no control group in model)	*0.286****	0.000	0.078	0.000 (18.757

Note(s): ***p-level = 0.00, **p-level = 0.05, *p-level 0.10

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