Pre-print. This is the Authors' Accepted Manuscript (AAM) of an article accepted for publication in the International Journal of Operations and Production Management. For the final version and citation data, see https://www.emerald.com/insight/content/doi/10.1108/IJOPM-06-2019-0486/full/html

Rethinking Lean Supplier Development as a Learning System

Daryl John Powell, Paul Coughlan

ABSTRACT

Purpose
This paper investigates developing a *learning-to-learn* capability as a critical success factor for sustainable lean transformation.

Design/methodology/approach
Our research design is guided by our research question: *how can suppliers learn to learn as part of a buyer-led collaborative lean transformation?* We adopt action learning research to generate actionable knowledge from a lean supplier development initiative over a three-year period.

Findings
Drawing on emergent insights from the initiative, we find that developing a learning-to-learn capability is a core and critical success factor for lean transformation. We also find that network action learning has a significant enabling role in buyer-led collaborative lean transformations.

Originality/value
We contribute to lean theory and practice by making the distinction between learning about and implementing lean best practices and adopting a learning-to-learn perspective to build organisational capabilities, consistent with lean thinking and practice. Further, we contribute to methodology, adopting action learning research to explore learning-to-learn as a critical success factor for sustainable lean transformation.

Keywords: Lean production, lean implementation, lean transformation, lean supplier development, network action learning, action learning research

Classification: Research Paper

INTRODUCTION

In order to increase operational performance and competitive advantage, many manufacturing firms have developed and deployed lean production programs in an attempt to establish a continuous improvement culture (Netland, 2013a; Netland and Powell, 2017a). Continuous improvement is defined as "*an organization-wide process of focused and sustained incremental innovation*" (Bessant and Caffyn, 1997 p.4). Whilst organization-wide or intra-firm continuous improvement is necessary, it is by no means sufficient, particularly in the context of lean production – where coordinating the supply chain is just as important as running the factory (Womack *et al.*, 1990). Here, efforts must also be made to involve supply chain partners in the continuous improvement activities. For example, Bortolotti *et al*. (2016) highlight the importance of individual firms expanding the scope of internal lean programs to include also firms from the extended supply network – the so-called extended lean enterprise (Liker and Choi, 2004). An organizational form that promotes such expansion is the *Kyoryokukai*, or supplier association. This form is evident in the Japanese automotive industry, where lateral inter-supplier learning has been reported as a major benefit of belonging to such an association (Sako, 1996).

Revans (1998 p.1) advocates that *"in any epoch of rapid change, those organizations unable to adapt are soon in trouble. Adaption is achieved only by learning."* Liker and Choi (2004) suggest that in order to be successful, an extended lean enterprise must have leadership from the manufacturer (buyer), partnerships between the manufacturer and its suppliers, a continuous improvement culture, and joint learning among the companies in the network. Such joint learning is of interest in this article, particularly learning-to-learn as a critical success factor for lean implementation. We seek to contribute to the lean literature by describing a network action learning (NAL) initiative conducted over a three-year period with a Norwegian maritime technology producer and six of its strategic suppliers. We set out to address the research question: *how can suppliers learn to learn as part of a buyer-led collaborative lean transformation?* During the project, a comprehensive NAL approach to lean supplier development was implemented successfully.

The article is structured as follows. First, we introduce the challenge of lean production and lean supplier development as an approach to manufacturing operations management and improvement which may not always be successful in practice. We locate the challenge in theory by exploring, contrasting and synthesizing the lean- and learning literatures. Second, we address this challenge in practice through instigating an initiative led by a buyer in collaboration with its supplier network and focused on improving supplier performance. We reflect then on the initiative, combining lean production and NAL perspectives, and the challenges confronted and overcome by the network of firms as it engaged in collaborative strategic improvement. Finally, from the reflection we discuss and articulate the contributions to theory, practice, and methodology.

LITERATURE REVIEW: LOCATING THE CHALLENGE IN THEORY

Writing on theorizing in organization studies, Hansen and Madsen (2019) see the act of carrying out a literature review as one of finding your academic family. To find our family, in this section we present an interpretative synthesis of the literature. This literature provides the reader with a theoretical frame for the practical phenomenon under investigation, in order to locate and ground the associated challenge in theory. Guided by our research question, we position the research within two domains:

1. Lean: lean production and lean supplier development, and
2. Learning: organizational learning, action learning and network action learning.

In the process, we reflect and rethink lean as a learning system, rather than a production system *per se* (e.g. Powell and Reke, 2019).

Lean Production

Lean production emerged in the 1990s as a better way of organizing and managing production (Womack *et al.*, 1990). It is nowadays more often referred to as lean thinking and practice (Jones and Womack, 2017). Those that have successfully adopted it have witnessed labour productivity soar, errors and defects cut in half, and product development times slashed (Netland and Powell, 2017b). Research also shows that lean companies in comparable industries are at least 50% more profitable than their non-lean counterparts (Camuffo, 2017).

After 30 years of research on lean production, much literature discusses its associated best practices (Shah and Ward, 2003; Bicheno and Holweg, 2009; Bhamu and Sangwan, 2014), how to implement them (Karlsson and Åhlström, 1996; Achanga *et al.*, 2006; Modig and Åhlström, 2012), and what to expect from adopting them (Browning and Heath, 2009; Netland and Ferdows, 2014). As such, the superior performance associated with lean production and its ability to provide competitive advantage is well accepted among academics and practitioners (Krafcik, 1988; Liker, 2004). This has led to the design, development and deployment of company-specific lean production programs, based on the adoption of best practices (Netland, 2013b). Voss (1995) describes such best practice adoption as a paradigm shift in manufacturing strategy, and suggests that this approach is supported by research that shows strong linkages between adopting best practices and operational performance. He concludes that companies with best practices often perform better than those without, but also raises a fundamentally important issue (p.12):

> *"these [best practices] are often treated as the means of solving all of a company's problems, and often lack perspective. Questions such as "is this appropriate for us?" and "would adoption support our key competitive needs?" often fail to be asked."*

Revisiting the best practice approach to manufacturing strategy, Voss (2005) asks, in hindsight, whether or not the adoption of best practices is ever likely to result in sustainable improvement, and raises the question as to whether other capabilities, such as learning, are indeed the core criteria for achieving sustainable competitive advantage. Furthermore, it has been suggested that up to 90% of lean initiatives fail to realise the true promise of lean production (Basin and Burcher, 2006). We return to this fundamental issue in subsequent sections, as it provides critical insight into the disturbingly high failure rate in lean implementation initiatives.

Lean Supplier Development

An established feature of business practice is that supply chains compete, not companies (Christopher, 1998). As such, strategic supply chain improvement has been a popular topic in the extant literature for some time (Lamming, 1996; New, 1996). Simchi-Levi *et al.* (2002 p.5) suggest that "*strategic partnerships between suppliers and manufacturers may have a significant impact on SC performance*." Looking more closely into the operations strategy field, one observes a shift from continuous and strategic improvement *within* the firm, to collaborative continuous and strategic improvement *between* firms (Cagliano *et al.*, 2002; Cagliano *et al.*, 2006; Vereecke and Muylle, 2006; Coughlan and Coghlan, 2011; Wong *et al.*, 2018), often with an implicit focus on cost-reduction and quality improvement (Wee and Wu, 2009). Much of this research focusses on establishing best practices in supplier firms, as well as integration practices within and between firms, where information sharing receives a large share of coverage. Furthermore, there is a shift in focus from simply implementing best practices (Taylor, 2006) to building capabilities through inter-organizational collaboration (Da Silva *et al.*, 2018). A more recent study uses discrete-event simulation to examine lean best practice implementation in a multi-echelon supply chain (Rossini and Portiolo-Staudacher, 2019).

Bessant *et al.* (2003 p.182) suggest that *"continuous learning within and between organizations will be a key strategic requirement for building and sustaining competitiveness […] (Yet) progress towards achieving supply chain learning is still at an early stage and is being made with faltering steps."* In terms of lean supplier development, Jaber *et al.* (2010) describe the results of learning-based continuous improvement in a multi-level supply chain. However, such joint learning initiatives have otherwise received little attention in the extant lean literature. For example, Jasti and Kodali (2015) critically reviewed 30 lean supply chain management frameworks, reported in over 500 scientific articles. None referred to joint learning initiatives throughout the supply chain, and only mentioned the '*development of a learning culture specific organization*' anecdotally. This is a significant shortcoming of the extant literature, despite the previous reflections by Voss (2005).

Nevertheless, in practice, the *Kyoryokukai* is an institution that has had a significant presence in the Japanese automotive industry since 1939 (Hayami, 1998). Hines and Rich (1998 p.526) define Kyoryokukai as "*a mutually benefiting group of a company's most important suppliers brought together on a regular basis in order to achieve strategic and operational alignment through the development of awareness, education and implementation programmes designed to achieve both radical and incremental improvements.*" Specifically, it focusses on collaborative improvement and learning throughout the supply chain. The Kyoryokukai promotes integration activities amongst its members, such as top-management group meetings, quality awards and audits. It tries to achieve better coordination in the supply network through collaborative learning as well as information sharing (Dequiedt and Martimort, 2004). Hines (1994) suggests that Kyoryokukai is the most important factor in building Japanese inter-company relationships and creating a world-class supplier base. Rich and Hines (1997) adds that supplier associations have enabled radical changes in supplier behaviour and performance, including rapid introduction of technologies and practices to support time-based competition in consumer markets.

The disturbingly high rates of lean implementation failure – a lack of focus on learning?

While critical success factors for lean implementation are seemingly well documented in the extant literature, there remains a high rate of failure (Bhasin and Burcher, 2006; Scherrer-Rathje *et al.*, 2009; Jadhav *et al.*, 2014). Even though Liker (2004) highlights that lean involves becoming a learning organization via constant reflection and continuous improvement, the strategic importance of organizational learning for [lean] success seems still to have been overlooked. As mentioned earlier, learning has emerged in operations management literature as both a strategic enabler and key requirement for building capability and enabling sustainable improvement in and across organizations (Bessant *et al.*, 2003; Coughlan and Coghlan, 2011). More recently, Netland and Powell (2017a) suggest that improvement without learning is not lean thinking, whilst Ballé *et al.* (2019) position learning at the core of lean thinking. Nevertheless, it appears that a lack of awareness regarding the significance of learning presents a considerable hurdle to the success of a lean implementation, both within the individual firm context as well as in the inter-organizational supplier network setting.

Organizational Learning

Nevis *et al.* (1995 p.73) define organizational learning as *"the capacity or processes within an organization to maintain or improve performance based on experience."* They note three learning-related factors which are important for organization success:

1. well-developed core competencies that serve as launch points for new products and services,
2. an attitude that supports continuous improvement in the business's added value,
3. the ability to fundamentally renew and revitalize.

Furthermore, Crossan *et al.* (1999) present four key premises that underpin organizational learning:

1. Organizational learning involves a tension between assimilating new learning (exploration) and using what has been learned (exploitation).
2. Organizational learning is multi-level: individual, group, and organization.
3. The three levels of organizational learning are linked by social and psychological processes: intuiting, interpreting, integrating, and institutionalizing (4I's).
4. Cognition affects action (and vice versa).

These premises emerge as important factors for understanding the role of learning in a lean implementation, perhaps more correctly referred to as a lean *transformation*.

The organizational learning literature also focuses on how firms develop organizational learning mechanisms to enhance organizational capabilities. Shani and Docherty (2008) present three learning mechanisms: procedural, structural and cognitive. *Procedural learning mechanisms* are institutionalized procedures that promote and support learning; *Structural learning mechanisms* consist of organizational, physical and technical infrastructures to cater for learning; and *Cognitive learning mechanisms* provide language, symbols, theories, values and concepts for thinking about and understanding learning issues. Stebbins and Valenzuela (2008) argue that all three mechanisms are required to create a sustainable learning organization. To these three mechanisms, Coughlan and Coghlan (2011) added a fourth – *action learning*.

Action Learning

A critical challenge facing organizations is how to make learning sustainable. As presented earlier, Crossan *et al.* (1999) suggested that cognition affects action (and vice versa). Revans (1998 p.83) also proposed that *"there can be no learning without action and no (sober and deliberate) action without learning."* As such, action learning is indeed a mechanism for developing, improving, accumulating and assimilating learning in organizations.

Though he resisted efforts to define action learning (saying that it was too simple to define it), Revans outlined the assumptions that underpin it:

- Learning is cradled in the task and formal instruction is not sufficient,
- Solving problems requires insightful questions,
- Learning involves doing, is voluntary, spurred by urgent problems or enticing opportunities and is measured by the results of action.

Revans (1982) formulated his action learning concept around the formula $L=P+Q$, where L stands for learning, P for programmed knowledge and Q for questioning insight. In his theory of action, Revans (1971) presented his science of praxeology of cyclical systems – alpha, beta and gamma. *System alpha* focuses on investigating a problem. *System beta* focuses on solving the problem, and the negotiation cycles required to implement the solution. *System gamma* focuses on the learning as experienced by participants, and involves self-awareness, reflection and questioning. It is important to emphasize that the three systems (alpha, beta and gamma) are neither linear nor sequential, nor entirely discrete. The three are best understood as a holistic system of interlocking yet overlapping parts which deserve differing emphases at different times (Coughlan and Coghlan, 2011).

At the heart of Revans' concept is his distinction between issues facing managers. *Puzzles* are those issues which are amenable to specialist and expert advice and for which a correct solution exists. Puzzles are not amenable to action learning. In contrast, most complex organizational improvement initiatives are *problems*: there is no single solution and there may be many opinions throughout the organization regarding the optimal course of action reflecting the managerial value system, the external environment and the internal organizational situation. For Revans, such problems are amenable to action learning where those involved can advocate

different courses of action reflecting their own value systems, past experience and intended outcomes (Coughlan and Coghlan, 2011).

Network Action Learning

Coughlan and Coghlan (2011) suggest that collaborative strategic improvement requires developing a capacity to learn within and across a network, not just as individuals but especially within and between organizations. With roots in action learning, Coughlan and Coghlan (2011 p.33) propose network action learning (NAL) as a useful and usable approach to collaborative strategic improvement:

> "*Continuous and collaborative improvement are, in essence, processes of action and learning: problems are identified; solutions are created, analysed, selected and implemented; resulting not only in improved operational performance but also in improved capability (through learning)."*

They extend the action learning formula and define NAL as $L=P+Q+O+IO$. This formulation captures the action learning process in the context of both intra- and inter-organizational learning. Here, *P* refers to the established knowledge of collaborative improvement, *Q* relates to the questioning process, and *O* and *IO* relate to emerging insights in the organizational and inter-organizational contexts. As such, "*the action learning by the network is built on exposing programmed knowledge to questioning, combined with organizational- and inter-organizational insights created in action*" (p.69). In order to increase competitive advantage, however, the network must be capable of exploiting this learning. As such, participants within and across organizations in the network must engage in appropriate learning interventions in a structured way, consistent with Shani and Docherty (2003) who argue that organizational design is critical to building learning mechanisms that develop and sustain learning capabilities.

Theoretical Summary

From the two literature domains reviewed, the emergent challenge seems to be one of *learning [how] to learn* during a lean implementation. On the one hand, the learning literature is quite specific in that learning (particularly through action) leads to improved operational performance and more importantly improved capability. The lean literature, on the other hand, seems to focus primarily on improved operational performance through implementing best practices alone. This can be explained using Revan's action learning formula, L=P+Q.

Lean best practices can be considered as programmed knowledge (P). Thus, if we regard a lean implementation merely as applying lean best practices alone, we risk approaching it simply as a *puzzle* that can be solved by experts. This may indeed result in improved operational performance in the short-term but will be unlikely to result in the sustainable improvement of organizational capabilities, as promised by lean thinking and practice. If, however, we regard a lean transformation as a complex organizational *problem* through the action learning lens, we propose that it can only be solved by combining best practices (P) with insightful questions (Q). In this way, lean best practices become learning frames to complement actions to develop individual-, team- and organizational capabilities. So, re-interpreting extant literature, we see lean as learning in action, consistent with Cusumano's (1988) observation that small lots and rapid feedback regarding defects and problems at Toyota resulted in improved learning rates and enhanced capabilities. Ballé *et al.* (2014) also suggest that the Toyota Production System (TPS) is a tool for learning how to learn. As such, a conscious and disciplined application of the theory and practice of (network) action learning may have the capacity to improve the success rate and sustainability of buyer-led collaborative lean transformations.

RESEARCH DESIGN: ADDRESSING THE CHALLENGE IN PRACTICE

Fundamental to our research design is the distinction between Mode 1 and Mode 2 knowledge production (Gibbons, 1994). In contrast to traditional positivist experimental science (Mode 1), our research question requires an investigation that is built on socially distributed, application-oriented knowledge production (Mode 2). As such, and guided by our research question, we adopt action learning research (Coghlan and Coughlan, 2010; Coughlan and Coghlan, 2011; Coghlan and Coughlan, 2015), an approach in which actionable knowledge is produced by both the researcher and the participants in the action.

Action learning research is a related but different activity to action learning. Though action learning and action learning research share an intrinsic focus on learning and questioning insight (Zuber-Skerritt, 2002), Coughlan and Coghlan (2011) suggest that the key to understanding the difference is distinguishing between learning (through action) and actionable knowledge (Argyris, 1993). When engaging in action learning, two commitments are relevant: commitment to action and commitment to learning (Marquardt, 2004). There is no expectation, however, that on realising these commitments, there will be a redeployment of that learning beyond the group, through creating and sharing actionable knowledge. In contrast, action learning research requires one further commitment – adding to existing actionable knowledge. For action learning research, reflecting on the story of the action is from a theoretical perspective with a view to identifying emergent theory to contribute to actionable knowledge. The action learning research methodology is based on Revans' (1971) theory of action and science of praxeology of cyclical systems - alpha, beta and gamma:

- *System Alpha*: In action learning research, system alpha focuses on identifying and analysing a real organizational problem including analysing the external environment, current organizational performance, and management values (what the managers want to achieve).
- *System Beta*: In action learning research, system beta involves exploring the problem-solving process, through multiple cycles of action and reflection. The researcher uses appropriate theoretical perspectives to frame the results of the action and reflection cycles, with a view to identifying emergent theory and contributing to actionable knowledge.
- *System Gamma:* The (individual and collective) learning is the focus of system gamma. In action learning research, active researcher involvement in developing and executing systems alpha and beta has implications for the scope of system gamma. The researcher's involvement in system gamma exposes the process of how his/her engagement with the problem has challenged his/her own thought processes, to further inquiry. The interpretation and evaluation of the researcher's own involvement underpins the emergent actionable knowledge as a quality research process outcome.

Data collection

In the action learning research process, data come through engagement with others during action cycles. This means that the act of collecting data is itself an intervention (Coghlan and Brannick, 2010). As such, the observations made during the action cycles are not simply seen as collecting data *per se*, but rather as generating learning for the researcher and the participants in the action. Such an approach provided a rich foundation of data with which to generate knowledge and learning: the data generated throughout the lean supplier development program were collected in formal settings, such as meetings and workshops, as well as in informal settings. Observations and reflections were documented through notetaking during interventions, as well as through direct consultation with participants in the action learning network using telephone, email and direct conversation. Where necessary, technical and contractual documents were consulted.

To make sense of the data, we adopt two of the five strategies described in Langley (1999). Firstly, we use the narrative strategy to construct a detailed story from the raw data. Secondly, the narrative builds on a grounded theory strategy (Strauss and Corbin, 1990) to construct a system of categories (e.g. lean best practices, action learning, learning interventions, exploration and exploitation, cognitive, structural and procedural learning mechanisms etc.) to describe the phenomenon under investigation – *learning-to-learn in a buyer-led collaborative lean transformation*.

Research quality and rigour

As Mode 2 knowledge production, action-oriented research approaches cannot and should not be judged by positivist science criteria, but rather require their own quality criteria (Coghlan and Brannick, 2010). The approach should be rigorous, reflective and relevant (Coughlan and Coghlan, 2016). Building on Reason and Bradbury's (2006) guidance for assessing action research quality, this study:

- is explicit in developing a praxis of relational participation,
- is guided by a reflexive concern for practical outcomes – governed by constant and iterative reflection as part of organizational change and improvement,
- extends our ways of knowing and (as such) has a methodological appropriateness,
- engages in significant work,
- results in sustainable change.

Furthermore, consistent with Willis (2004), the action learning research approach in this study engages with real life issues, is collaborative and reflective in nature and aims to produce actionable and usable knowledge.

Research site: The Subsea Division of Kongsberg Maritime

As with other action-oriented research initiatives, the origin of this initiative was in the practice. Our research site is the Subsea Division of Kongsberg Maritime (KM), a wholly owned subsidiary of Kongsberg Group (KOG). With over 7000 employees across 34 countries, KM delivers systems for dynamic positioning and navigation, marine automation, safety management, cargo handling, subsea survey and construction, maritime simulation and training, and satellite positioning. The Subsea Division hosts the organization's hydro-acoustic activities, developing and delivering underwater sensor systems for mapping, positioning and communication, fish-finding and catch-monitoring, naval sonars and marine robotics. Our unit of analysis is the main office and production site of KM Subsea as the buying firm (located in Horten, Norway) and the network of its six strategic suppliers.

Faced with pressure from low-cost competitors and increasingly tough market conditions, in 2014, KM Subsea launched its own lean production program – The Kongsberg Way. The program formed the basis for a holistic lean business system that built on KOG's 'World Class' vision and core values. It aligned the organization with a lean transformation objective through adopting five fundamental lean principles: customer value, process stability, total quality, flow efficiency and continuous improvement. Together, these principles provided a common direction towards the company's goal of *sustained lean growth*. In 2017, the company received Lean Forum Norway's Lean Enterprise of the Year Award, recognizing the company for successfully implementing lean in an extremely complex production process. The award also recognized the efforts that the company had made with lean supplier development thorough the Network for Supplier Innovation initiative, during the period 2014-2017.

THE INITIATIVE: THE NETWORK FOR SUPPLIER INNOVATION

Approximately 80% of KM Subsea's value-add occurs in its supplier network. In 2014, KM Subsea established the first Kyoryokukai in Norway, coincident with launching its corporate

lean program. In collaboration with Innovation Norway, the Norwegian Centre for Expertise in Systems Engineering (NCE-SE) and SINTEF Manufacturing (SIM), KM Subsea selected six strategic suppliers to join the Network for Supplier Innovation (NSI) initiative – a NAL initiative with the main objective of achieving collaborative supply chain improvement through establishing a common understanding of lean thinking and practice throughout the strategic supply network. The six companies were Flaatnes ElectroMek. (FEM), Fosstech, Hapro, Kristiansand Skrufabrikk og Mekanisk Verksted (KSMV), Norautron Norway (NAN) and Oswo. The relationships between these companies are interesting: several companies themselves demonstrated customer-supplier relations (E.g. FEM and Fosstech; KSMV and Oswo), while several were also direct competitors (E.g. FEM and Fosstech, Hapro and NAN). Table 1 outlines brief company descriptions:

Table 1: Companies in KM Subsea's Supplier Association

Company	Number of employees*	Turnover** (MNOK)	KM Subsea Supplier Classification	Distance from KM Subsea (km)
FEM	13 (10)	22.0 (20.8)	Preferred	30
Fosstech	40 (70)	62.2 (98,6)	Strategic	30
Hapro	225 (263)	416.9 (448.7)	Preferred	150
KSMV	60 (125)	99.4 (206.1)	Preferred	260
Norautron	140 (210)	299.6 (481.8)	Preferred	2
Oswo	50 (90)	130.7 (149.4)	Preferred	2.5

*2017 figures with 2014 in parenthesis. **2016 figures with 2014 in parenthesis.

All six companies in the strategic supplier network and KM Subsea as the lead (buying) organization received different forms of lean training, firstly to learn relevant lean best practices and, secondly (and more importantly) to promote learning-to-learn in action – as individuals and in groups, both at home and away. Company representatives were top level managers (e.g. CEO, CFO), middle managers (e.g. production manager, supply chain manager), and front-line staff (e.g. team leaders & operators). The different learning interventions that developed throughout the program (some sequentially, others concurrently) were as follows:

1. Co-learning lean basics at Lean Lab, Raufoss, Norway,
2. Best practice study visits to exemplary lean-enterprises in Sweden, the Netherlands and Germany,
3. Individual company lean self-assessments,
4. Lean coaching and individual company consultations,
5. Extended value stream mapping,
6. Rapid lean assessments.

These interventions were carefully selected based on two criteria: firstly, the distinction between exploration and exploitation, and secondly, that of learning away versus learning at home. For example, the first two intervention types (co-learning lean basics and best practice study visits) can be classified as exploration away and exploitation at home, while lean coaching and individual company consultations is considered as both exploration and exploitation for learning at home. Extended value stream mapping represents a third intervention type – namely exploration and exploitation for learning both at home and away.

Learning interventions refer to planned organizational structures and processes that encourage dynamic learning, particularly to enhance organizational capabilities (Coughlan and Coghlan, 2011). The six interventions were structured as action cycles and were applied at individual, group, organizational and inter-organizational levels which aimed to initiate, facilitate, monitor and reward learning. Categorically, they exhibited characteristics of procedural, structural and cognitive learning mechanisms (Docherty and Shani, 2008).

Lean Lab: Lean Lab is Norway's first and only full-scale lean simulator and training centre. In order to establish a common understanding of the lean philosophy for the inter-firm network, the initiative enrolled the expertise of SINTEF Manufacturing (SIM) and Lean Lab to give participating top level and middle managers a simple theoretical introduction to lean thinking and practice, and practical training in the simulator. The simulator introduced all to basic lean tools and techniques for improvement, including standardized work, 5S workplace organization, single minute exchange of dies (SMED), Kanban and Andon. Consequently, and in line with the extant lean literature, the lean supplier development program began by participants simply learning lean best practices. As the program continued, however, learning-to-learn become an emergent theme from the action cycles, and as such, subsequent action cycles became cycles of action AND learning.

Best practice study visits to exemplary lean enterprises: Study visits were arranged during the three-year program in order to allow participants to look at and see real life examples of lean thinking and practice. Company visits included Parker Hannifin (Sweden), Bosch Hinges and Variass Electronics (the Netherlands) and Bosch Rexroth (Germany). The best practice study visits allowed participants to reflect over what they saw and apply questioning insight.

Individual company lean self-assessments: The SIM consultants facilitated lean self-assessments at each participating company, including the lead organization. The self-assessment survey instrument was based on Liker's (2004) 14 principles of the Toyota Way, and enabled the management teams to assess perceptions of their company's culture. The survey instrument was completed by the individual managers at each company, and the results compiled to illustrate both average scores and the range of responses per company. This activity provided participants with rich data on which to reflect and identify opportunities for further learning and improvement.

Lean coaching and individual company consultations: Consultants from SIM were also engaged in supporting the lean implementations at the individual companies in KM Subsea's supplier association – facilitating action and promoting learning and organizational development throughout the three-year period. The consultants were financed through project funding from Innovation Norway and KM Subsea – importantly at no cost to the partner organizations.

Extended Value Stream Mapping: Groups of two or more participating companies were formed to carry out extended value stream mapping (EVSM) of a product-line. Four EVSM exercises were carried out. The lead organization was present during all EVSM sessions – representing the customer – while the total number of suppliers varied from product-line to product-line (from one supplier in the least instance and three suppliers in the greatest).

Rapid Lean Assessments: Following the EVSM interventions, a round of rapid lean assessments was felt timely, given the increased level of network maturity achieved through the collaboration and the resultant mutual trust that had been gained (to enable the giving and receiving of critical feedback). The Rapid Plant Assessment (RPA) tool (Goodson, 2002) was used by inter-firm representatives during Gemba walks at each participating company. This intervention allowed participants to assess the lean implementations at all companies in the network, 'away' as well as 'at home'. The assessment also provided ample time for reflection and insight.

Operational outcomes

Though we cannot conclude that things improved only because of the supplier development program, consistent improvement in supplier performance was observed and measured by the lead organization over the three-year period. There was an average 26.8% improvement in on-time-delivery (OTD), and a marginal improvement in quality conformance (QC), as shown in Table 2:

Table 2: Results (companies requested anonymity)

Company	OTD % (Before)	OTD % (After)	QC % (Before)	QC % (After)
A	65	99	99.88	99.99
B	76	98	96.39	98.54
C	73	97	99.86	99.52
D	71	91	99.04	99.44
E	75	80	93.98	96.11
F	69	79	98.25	98.00
Average Improvement	**+26.8%**		**+0.72%**	

REFLECTION – SYSTEMS ALPHA AND BETA

In this paper we adopted action learning research to address the research question: *how can suppliers learn to learn as part of a buyer-led collaborative lean transformation?* In this section, we reflect on the rich data and insights generated and frame these reflections in terms of systems alpha and beta.

Firstly, as a general reflection, the participants (as an action learning "set") considered the supplier development program as "*three interesting and [yet] demanding years*". All organizations achieved successes as a result of the action learning that had taken place. However, the companies also experienced turbulent and testing market conditions in 2015/2016 and many were required to downsize and re-organize their operations. Any downsizing was handled separately to the lean initiative (in light of the Respect-for-Human principle (Sugimori *et al.*, 1977)), though in some cases it raised speculation amongst some individuals who sought to portray "*lean as mean*". However, the CFO at one company suggested that being part of the network was *"a positive measure, providing insight to the other companies in the project that are struggling with the same problems"*, which allowed for *"better input to solving the problems"*. Discussions with the participants also confirmed that there had been a shift from *'us and them'* to *'we'*, with regards KM Subsea and its suppliers, as well as new relationships among the suppliers themselves. This shift reflected an increase in trust and cooperation between the companies in the supplier network. The CEO of one company stated, "*the program has fostered good dialogue with KM Subsea*" and that "*experiences have been further transferred to [our] second tier suppliers*".

System alpha

In terms of system alpha, the buying firm set out to address a fundamental organizational problem: faced with pressure from low-cost competitors and increasingly tough market conditions (*external environment*), management wanted to increase quality, cost and delivery (QCD) performance (*current organizational performance*) by implementing lean production and realising a continuous improvement culture (*management values*). The company embarked on a lean initiative, where simultaneously involving a core set of the organization's strategic suppliers was identified as critical for success.

System beta

System beta comprised six learning interventions (*cycles of action and reflection*) that were planned as a result of the initial problem-framing in system alpha. These cycles began with a kick-off event and progressed to best practice study visits to exemplary lean enterprises, individual company lean self-assessments, lean coaching and individual company consultations, extended value stream mapping and rapid lean assessments. These interventions were organic, with some occurring in parallel, others in series, some cycles being unique while others were repeated, and some even emerged as outcomes of previous interventions. In accordance with Alfaro *et al.* (2019), this project was cyclical in nature with cyclic learning loops. In this spiral of cycles, each activity was systematically and self-critically implemented and interrelated, applying the learning that emerged in subsequent cycles. In each cycle, two learning phases emerged – learning during the interventions and learning post-intervention (applying the newly acquired knowledge and identifying new opportunities for learning). The following section describes each action cycle in turn.

Action cycle 1: Lean Lab

Participant reflections from the kick-off Lean Lab activity were mainly positive. Many described it as *"an eye opener"*, introducing participants to fundamental lean knowledge and creating understanding of an otherwise largely misunderstood concept. The Quality & HSE Manager from one company stated, *"it was useful…we were able to think about things we don't necessarily think about otherwise"*. Also, considering the sometimes-confusing terminology used in lean – Kaizen, Kanban, Hoshin Kanri – *"we are now able to speak the same language"* was an outcome recognized by most participants. On the other hand, bringing together representatives from six companies that were somewhat unfamiliar with each other beforehand *"forced many out of their comfort zones"*. At the beginning of the program, some scepticism was expressed, particularly amongst the companies that were openly competing for KM Subsea's business. However, this soon surpassed, with the VP Supply Chain from one supplier commenting *"following the Lean Lab event, we arranged an [unplanned] informal dinner. This led to several interesting discussions around the table and was a first step towards more open dialogue within the network"*. Such an ad-hoc event helped to *"create openness"* – an observation that was recurrent during the social events that proceeded during the three-year program (particularly during the study visits). For those organizations that had been working with lean for some years (for example one organization had helped to create the Lean Lab already in 2010), the main positive outcome from the initial Lean Lab activity was *"getting closer to the customer and [the] other suppliers"*.

Action cycle 2: Best practice study visits to exemplary lean enterprises

One of the study visits began at the European Quick Response Manufacturing (QRM) Centre, at the University of Applied Sciences in Arnhem, the Netherlands. This sequencing was collectively considered *"more rewarding"* as *"we were [first] given a good theoretical introduction at a university…with knowledgeable instructors"*. On returning from the Netherlands, one company implemented a Quick Response Office Cell (QROC) *"to offer quicker confirmations to call-offs / purchase orders from the customer"*. Referring to the visit to the Dutch exemplar, Bosch Hinges, a company CFO added *"in the Netherlands we learned that we should not plan for more than 70% machine utilization [where we have high variation]. Decreasing our planned machine utilization has increased our active spindle up-time"*.

One participant was especially satisfied with the visit to Parker Hannifin in Sweden since one of the SIM consultants was previously employed as Operations Manager / Lean and Quality Manager at the site, which had a long history of lean success. One observation was *"all suppliers [to Parker Hannifin] were located within one hour of the site…enabling reduced*

inventory and increased flexibility…an extremely good example". This was particularly relevant as all six suppliers in the supplier association were located within a short distance from KM Subsea.
A frequent challenge with site visits, however, is that *"it is a different type of production to what we have at home"*. Furthermore, *"those that have participated in the study visits have seen the effect [of lean], but it is difficult to get others on board back home"*. Another participant added that one big takeaway from the study visits was *"the exchanges (dialogue) with people [from other companies in the network] on the bus or in the pub"*. One CEO summarized the study visits as *"interesting…allowed us to take time for reflection…many takeaways"*. His company was *"inspired to digitalize its Kaizen boards"*.

Action cycle 3: Individual company lean self-assessments
The self-assessments based on Liker's 14 principles allowed the companies to *"understand how we perceive our organizational culture"*. The assessment result allowed the individual organizations to identify areas for improvement, including leadership development: *"The self-assessment created a greater sense of agreement in the organization…greater harmonization…helped us to achieve a lean[er] culture organization-wide"*. The CEO of one supplier agreed that the self-assessments led to more in-depth discussion regarding competence building. *"We hadn't discussed our core competencies [so much] before"*.
On the other hand, one company witnessed extensive scoring variation in the self-assessment, demonstrating *"discontent and distrust"* (given the current *"uncertainty"* of the situation with downsizing the organization, which saw significant layoffs in 2016). *"It is extremely difficult to implement lean and benefit from it at the same time the company is handling an extreme re-organization and downsizing"*.

Action cycle 4: Lean coaching and individual company consultations
The individual company consultations provided the opportunity for learning at home. The SIM consultants ('coaches') were *"talented"* and *"knowledgeable"* and demonstrated *"a positive attitude to organizational development and learning"*. Several suppliers subsequently entered into agreements with SIM for additional consultation and coaching, beyond the NSI program scope. *"It is always useful to have new / fresh [experienced] eyes look at the process…we thought we were quite good, but now we know otherwise…and to think we operated like that for 10-15 years!"* To foster and support learning at home, a common focus across all participating companies was on establishing Kaizen (continuous improvement) teams and boards to focus on improving flow (amongst other things) and *"to know why not just know how"*; daily layered accountability practices (such as daily stand-up meetings), *"morning meetings are the secret to success"*; as well as standardized work and one-point lessons (OPLs), *"we use OPLs actively to train and multi-skill our operators"*. One CEO summarized: *"it has been a long way to go, but now we think differently"*, presenting a form that had been introduced such that, proactively, operators could identify and eliminate waste (*"disturbances and annoyances"*) in operations.

Action cycle 5: Extended Value Stream Mapping
The extended value stream mapping exercises allowed for *"increased insight"* into the supply chain activities and performance. One company came to understand the *"extent of [improved] communication that is required"* to be successful. Another company was able to *"introduce rules and processes for more regular deliveries of smaller batches to the customer"*. There were however limited opportunities for action learning activities following the initial mapping exercises in most other cases, where authorities outside of KM Subsea's Supply Chain Organization were required to carry out changes and improvements. This led to frustrations

within the supply network (e.g. *"the value of the [EVSM] exercise hasn't yet shown itself"*, and *"we haven't got so much out if it"*). This outcome has since resulted in an increased focus on lean thinking and practice at KM Subsea, where an initiative is now in place to foster collaborative, enterprise-wide continuous improvement across the organization's core value streams. The CEO of one supplier summarized this activity as follows: *"the key is tighter integration with the customer"*.

Action cycle 6: Rapid Lean Assessments

A key account manager at one supplier suggested that *"it's always interesting to go and see how others do it [lean]"*. In several cases this provided participants with *"'Eureka!' moments"*. Another participant said that the opportunity to carry out rapid plant assessments (RPAs) within the inter-firm network was *"interesting"* and provided a means to assess *"the state of the union"*. Being able to see what others are doing 'away' allowed participants to reflect over what they had done 'at home' *"What we are doing may be different, but we are certainly on the right path"*. The assessment, which was divided into 11 specific lean dimensions, provided participants with *"a way to systemize improvement work and have a positive impact on quality, cost and delivery performance"*. One company was *"inspired by another to update its 5S revision checklist and TPM practices"*.

The timing of the RPA activity towards the end of the three-year period was also beneficial, as the network was *"collaborating more"*, was *"less protective"*, and no one tried to hide anything – *"this is how it is here"*. *"To go around [the partner companies] at the end was positive…we were much more familiar with each other…it was a pleasant experience and very educational"*. Being more familiar and open to each other also promoted better dialogue – for example it became much easier to pose such questions as *"how did YOU get this to work?"* The RPA round also gave opportunities to *"identify and share best practices"*. An important observation following the round of RPAs is that most participants identified the significance of continuing the collaboration – *"It is only now [after three years] that the network offers real [strategic] benefits"*.

DISCUSSION – SYSTEM GAMMA

System gamma focusses on the learning that emerged from the initiative. This learning is the core result of investigating how suppliers can learn to learn in a buyer-led lean transformation. After participating in the three-year NAL initiative, the participants (both as individuals, teams and organizations) "*experienced [and learned] a lot during the learning interventions*". We structure the emergent learning and share this new, actionable knowledge as implications for theory, practice and methodology.

System Gamma and Implications for Theory

Table 3 captures the reflection over the learning types that emerged from the NAL process and summarises how, through NAL, the six interventions contributed to organizational and inter-organizational learning through procedural, structural and cognitive insights for the network. This reflection leads us to an emergent, critical insight as we demonstrate that lean is not simply about learning and implementing best practices (procedural/structural learning). To realise the true potential of lean, it must be a cognitive transformation – where individuals, teams and organizations develop a learning-to-learn capability through action. This critical insight concerns the progression, through NAL, to a learning-to-learn capability, which may reduce the high failure rate of lean implementation initiatives. It contrasts with the received tradition, evident in Shah and Ward (2003) and Browning and Heath (2009), which has focused on learning about and implementing lean best practices in order to improve performance and

reduce costs. This traditional approach is to conceptualise the lean implementation as a *puzzle* in action learning terms, and from such a perspective, L=P.

In contrast, we have identified a different characterisation of the challenge and progression towards an outcome. As observed, a lean implementation requires progressive transformation and is, as such, a *problem*. The transformation is a learning journey where, having first set out to learn and implement lean best practices in order to improve operational performance (L=P), the buyer and supplier firms were in fact enabled to learn [how] to learn. This learning was both as individuals (L=P+Q) and intra-firm teams within the organizations (L=P+Q+O), and, ultimately, as an inter-organizational network (L=P+Q+O+IO).

Reflecting on the first intervention, co-learning lean basics was, as Cagliano *et al.* (2005) presents, structured and directive instead of emergent and spontaneous. The Lean Lab intervention in action cycle 1 provided the setting for developing the project structure required (at least in the beginning) and allowed specific attention to aligning the various company goals (Cagliano *et al.*, 2005). Then, the individual company lean self-assessments were consistent with Liker (2004) in becoming a learning organization, where top management commitment is a prerequisite for developing the necessary learning culture, also reflected in Jasti and Kodali (2015). The resultant learning from the self-assessments was very much oriented around the individual organizational cultures, but with a particular focus on how to become learning organizations within a learning network. As a final example, the sixth intervention – Rapid Lean Assessments – allowed the network to exchange and reflect on the inter-organizational insights required to realize a true transformational learning network (Coughlan and Coghlan, 2011).

Table 3: Organizational & Inter-organizational Learning and Procedural, Structural and Cognitive Insights

	Org. / Inter-org. learning	***Procedural***	***Structural***	***Cognitive***	***Enfolding literature***
Co-learning lean basics	Exploration away and Exploitation at home	"we are now able to speak the same language"	"forced many out of their comfort zones"	"an eye opener" "able to think about things we don't think about otherwise"	Cagliano *et al.* (2005); Rother (2010)
Study visits to exemplary lean-enterprises	Exploration away and Exploitation at home	"we learned that we should not plan for more than 70% machine utilization"	"it is difficult to get others on board back home" "establishing QROC to offer quicker response to customer" "inspired to digitalize kaizen boards"	"allowed us to take time for reflection …many takeaways" "Eureka moments" "How do we achieve this [at home]"	Suri (2010); El-Tally and Gallear (2011)
Individual company lean self-assessments	Exploration and Exploitation at home	"created more discussions about competence development" "Never before have we focussed more on competence mapping and development"	"helped us to achieve a lean[er] culture organization-wide"	"understand how we perceive our organizational culture"	Liker (2004); Jasti and Kodali (2015)
Individual company consultations	Exploration and Exploitation at home	"establishment of specific practices and procedures – daily layered accountability, waste identification forms" "we use OPLs to train our operators"	"formalization of kaizen teams and implementation of boards" "daily meetings are the secret [to succeed]"	"it is useful to have new / fresh [experienced] eyes look at the process" "we thought we were good…now we know otherwise" "now we think differently"	Imai (1986); Taylor (2006)
Extended Value Stream Mapping	Exploration and Exploitation at home and away	"established rules and processes for more regular deliveries of smaller batches"	"the key is tight integration with the customer"	understanding the "extent of [improved] communication that is required" to be successful	Wee and Wu (2009); Jones and Womack (2011)
Rapid lean assessments	Exploration and Exploitation at home and away	"a common way to systemize improvement work" "updated 5S revision and TPM practices"	"the network offers real [strategic] benefits"	"it's always interesting to go and see how others do it [lean]" "'Eureka!' moments"	Coughlan & Coghlan (2011) Goodson (2002)

Overall, this transformational learning journey is analysable in terms of competitive progression theory which builds on Ferdows and De Meyer's (1990) “sand cone” model. This model proposes that capabilities are cumulative (as opposed to either/or choices), and exhibit a progression sequence (Rosenzweig and Roth, 2004). Our critical insight from the supplier development program is visualized as a *Learning-to-Learn Sand Cone Model*, as shown in Figure 1. At the cone's base is an understanding of lean tradition and a corresponding focus on lean principles. Then, the network begins its collective learning initiative in order to learn about lean best practices – the programmed knowledge (P) of lean. Learning intervention 1 then represents L=P. During the subsequent learning intervention – best practice study visits to lean exemplars – participants reflect and begin adding questioning insight (Q) to the programmed knowledge acquired in the first intervention. Further interventions add organizing insight (O) and inter-organizational insight (IO) to previous intervention outcomes, finally arriving at a successful NAL outcome after intervention 6, where L=P+Q+O+IO.

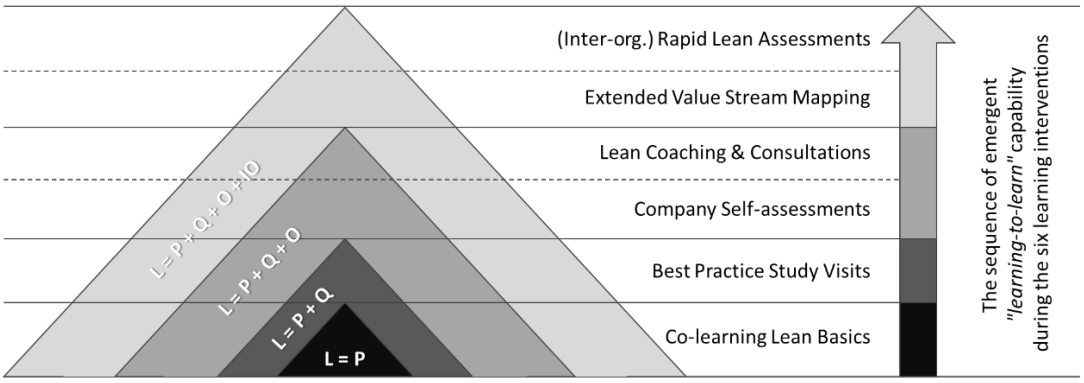

Figure 1: *Learning-to-Learn Sand Cone Model*

System Gamma and Implications for Practice

The learning that emerged from the NAL initiative has specific implications for managers and lean practitioners. Different intervention types can be used to foster intra- and inter-organizational learning in the context of lean transformation through NAL. Though not intended as a strict procedure to follow, we suggest that each intervention offers value in achieving quantifiable supply chain improvement:

1. Co-learning lean basics: participating in a common training program together with managers and leaders from other firms in the supplier network proved to be a rich learning experience, providing the foundations for further learning and development. The practical nature of the lean lab experience enabled participants to begin learning-in-action from the program beginning.
2. Best practice site visits: again, together with representatives from other firms, visiting best practice lean exemplars provided valuable insights, which formed the basis for further reflection and discussion back home as well as identifying improvement / learning opportunities throughout the supplier network.
3. Lean self-assessments: the lean self-assessments based on Liker’s (2004) 14 principles encouraged the seven individual management teams to assess their own behaviours and attitudes by reflecting on those required to achieve a lean culture. It was also valuable to share the individual assessment results with other firms in the network, to spark further learning and engagement.
4. Lean coaching: engaging with an experienced lean coach or indeed *sensei* (Ballé *et al.*, 2019) provides managers with a greater understanding of the changes required to succeed with lean transformation. One cannot simply implement lean. Lean is a discovery process

– a transformational learning journey on which all employees engage in problem-solving and improvement, every day.

5. Extended value stream mapping: finally, learning to see the flow of value across different players in the network, rather than simply adopting a wall-to-wall view of the individual firm, offers potential for gains. However, we identified that other stakeholders (e.g. product managers, engineers, etc.) must also be engaged throughout, otherwise the success of the intervention may be jeopardized.
6. Rapid Lean Assessments: participating in lean assessments throughout the network gave participants the opportunity to *"go and see"* the lean transformation progress at the other sites. Implications are twofold – one naturally identifies key takeaways from the other sites: *"steal with pride!"* was a term used. The Gemba walks also presented away-participants with the chance to suggest improvement opportunities to the home-participants. This was indeed identified by the network as a positive measure for the NAL process.

System Gamma and Implications for Methodology

Finally, system gamma challenges us to reflect on the implications that this initiative presents for methodology – namely research design. Such implications can be drawn from the way in which we have undertaken this research in action. In this work, we used action learning research as a novel approach to critical inquiry into improvement and learning processes during a lean implementation in a strategic supplier network. Through collaborative engagement with the firms in the network and further examination of documents where necessary, we engaged in NAL towards a relevant outcome. This privileged access enabled us, as action learning researchers, to generate and reflect upon data in a clear, scholarly and systematic way. We attended to expectations for rigor through articulating our method and exploring in action the interpretations of learning and events as they unfolded.

The actionable knowledge generated is rigorous, reflective, and relevant, consistent with the criteria for quality action-based research. The research relevance was demonstrated in a subsequent, additional action cycle (following the strategic supplier development program), where several suppliers were enabled to participate effectively in the early-phase of a new product development (NPD) project together with the buying firm. This suggests that developing the inter-organizational learning-to-learn capability in the program had fostered the trust and collaboration required for developing an open innovation culture (Enkel *et al.*, 2009). This outcome is consistent also with Lawson *et al.* (2015) who suggests that involving suppliers in NPD can generate substantial improvements in operational performance and supports the proposition that collaborative strategic improvement should not only focus on improving operations, but must also reach upstream to the product development process, what Sakai (2018) suggests is the true source of value creation in manufacturing.

CONCLUSION

In this article, we set out to answer the research question: *how can suppliers learn to learn as part of a buyer-led collaborative lean transformation?* In doing so, we present reflections and insights arising from participating in a three-year, network action learning-based, lean supplier development program. We studied the initiative in the Norwegian Maritime sector through an action learning research lens. We discovered that approaching a lean transformation simply as a *puzzle* (by implementing lean best practices to improve operational performance) is not as effective as approaching it as a complex organizational *problem* requiring both programmed knowledge and insightful questioning to foster deeper learning within and across organizations. By adopting the latter perspective, firms and supplier networks can strengthen operational performance and capability by developing and exploiting a *learning-to-learn* capability. We

visualize the network developments towards such capability using a *Learning-to-Learn Sand Cone Model.*
The major findings of this work are summarized as two core outcomes:

1. Developing a learning-to-learn capability is a core construct and critical success factor for lean transformation,
2. Network action learning (NAL) has a significant enabling role in buyer-led collaborative lean transformations.

Learning-to-learn as a core construct of lean production and lean supplier development
We were able to identify the learning-to-learn capability as both a core construct and critical success factor for the buyer-led collaborative lean transformation. This insight is consistent with Fruin and Nishiguchi (1993 p.232) who describe the supply function model at Toyota Motor Co. as evolving from an "*extremely dominant Toyota and rather passive suppliers"* in the pre-1950s to one of "*reciprocal long-term contracting, profit sharing and interdependent learning*" thereafter. Such a learning model presents a shift from unidirectional information flows to multidirectional flows of information and learning throughout the inter-firm supplier network. They go on to describe learning as two sorts: "*the accumulated efforts of many individuals to improve, and the enhanced capabilities of organizations to harness those improvements*".

The enabling role of network action learning in lean supplier development
We were also able to explore the usefulness and usability of the NAL approach as an enabler of intra- and inter-firm learning in a supplier association ambitious to achieve sustainable, collaborative strategic and operational improvement. In choosing NAL, we were guided by three considerations: the shift from continuous and strategic improvement *within* the firm to collaborative continuous and strategic improvement *between* firms; the criticality of learning-to-learn as a central tenet of lean production and a core construct of the supplier association; and the importance of NAL as a stimulus for scientific learning and improvement.
Specifically, we can conclude that NAL has been a successful mechanism for learning-to-learn in a buyer-led collaborative lean implementation. We explored how the action learning in and by the network transpired through individual and combined interventions and resulted in sustainable improvement in the operational performance of the network. From the data generated and collected, we have demonstrated (through participation, observation and reflection) how a NAL approach can foster joint learning in a buyer-led collaborative lean transformation, contributing towards greater performance from the supply network.
Framing this action learning research investigation using Revan's (1971) theory of systems alpha, beta and gamma has provided us with a rigorous and reflective process in which both the research and organizational problems were framed, addressed and have contributed to learning through the actions taken. Consistent with Coughlan and Coghlan (2011), we frame this learning about lean as L=P, and the learning-to-learn in action in a network (such as a Kyoryokukai) for the individuals as L=P+Q, for the intra-firm teams as L=P+Q+O, and for the inter-organizational network as L=P+Q+O+IO.

To conclude, we suggest that both buyers and suppliers can learn to learn collaboratively by adopting a NAL approach to lean supplier development. This leads not only to improved operational performance through applying lean best practices but also to improved organizational capability through learning-to-learn. After all, an organization with improved capability is an organization that has learned.

Acknowledgements
The authors acknowledge the support of the Research Council of Norway for the project *Lean Management* and research program *SFI Manufacturing*, Innovation Norway for the project *Network for Supplier Innovation* and the EU for the Erasmus+ initiatives *EuroLEAN+* and *LEAN 4.0*.

References

ACHANGA, P., SHEHAB, E., ROY, R. & NELDER, G. 2006. Critical success factors for lean implementation within SMEs. *Journal of Manufacturing Technology Management,* 17**,** 460-471.

ALFARO, J. A., AVELLA, L., MOSCOSA, P. & NASLAND, D. 2019. Action research in operations management: an analysis of its contribution to research and managerial practice. *26th EurOMA Conference.* Helsinki, Finland.

ARGYRIS, C. 1993. *Knowledge for action: A guide to overcoming barriers to organizational change,* San Francisco, Jossey-Bass.

BALLÉ, M., CHAIZE, J. & JONES, D. 2014. Learning to Learn - Knowledge As a System of Questions. *Reflections. The SoL Journal on Knowledge, Learning and Change,* 14.

BALLÉ, M., CHARTIER, N., COIGNET, P., OLIVENCIA, S., POWELL, D. & REKE, E. 2019. *The Lean Sensei. Go. See. Challenge.,* Boston, MA, Lean Enterprise Institute, Inc.

BESSANT, J. & CAFFYN, S. 1997. High-involvement innovation through continuous improvement. *International Journal of Technology Management,* 14**,** 7-28.

BESSANT, J., KAPLINSKY, R. & LAMMING, R. 2003. Putting supply chain learning into practice. *International journal of operations & production Management*.

BHAMU, J. & SANGWAN, K. S. 2014. Lean manufacturing: literature review and research issues. *International Journal of Operations & Production Management*.

BHASIN, S. & BURCHER, P. 2006. Lean viewed as a philosophy. *Journal of Manufacturing Technology Management,* 17**,** 56-72.

BICHENO, J. & HOLWEG, M. 2009. *The Lean Toolbox,* Buckingham, PICSIE Books.

BORTOLOTTI, T., ROMANO, P., MARTÍNEZ-JURADO, P. J. & MOYANO-FUENTES, J. 2016. Towards a theory for lean implementation in supply networks. *International Journal of Production Economics,* 175**,** 182-196.

BROWNING, T. R. & HEATH, R. D. 2009. Reconceptualizing the effects of lean on production costs with evidence from the F-22 program. *Journal of Operations Management,* 27**,** 23-44.

CAGLIANO, R., CANIATO, F. & SPINA, G. 2006. The linkage between supply chain integration and manufacturing improvement programmes. *International Journal of Operations & Production Management*.

CAGLIANO, R., CANIATO, F. F. A., CORSO, M. & SPINA, G. Fostering collaborative improvement in extended manufacturing enterprises: a preliminary theory. Proceedings of 4th International CINet Conf, 2002. 131-143.

CAGLIANO, R., CANIATO*, F., CORSO, M. & SPINA, G. 2005. Collaborative improvement in the extended manufacturing enterprise: lessons from an action research process. *Production Planning & Control,* 16**,** 345-355.

CAMUFFO, A. 2017. *Lean Transformations for Small and Medium Enterprises: Lessons Learned from Italian Businesses*, Productivity Press.

CHRISTOPHER, M. 1998. *Logistics and Supply Chain Management: Strategies for Reducing Cost and Improving Service*, Financial Times: Pitman Publishing, London.

COGHLAN, D. & BRANNICK, T. 2010. *Doing Action Research in Your Own Organization,* London, Sage.

COGHLAN, D. & COUGHLAN, P. 2010. Notes toward a philosophy of action learning research. *Action Learning: Research and Practice,* 7**,** 193-203.

COGHLAN, D. & COUGHLAN, P. 2015. Effecting change and learning in networks through network action learning. *The Journal of Applied Behavioral Science,* 51**,** 375-400.

COUGHLAN, P. & COGHLAN, D. 2011. *Collaborative strategic improvement through network action learning: The path to sustainability,* Cheltenham, Edward Elgar Publishing.
COUGHLAN, P. & COGHLAN, D. 2016. Action Research. *In:* KARLSSON, C. (ed.) *Research Methods for Operations Management.* Abingdon: Routledge.
CROSSAN, M. M., LANE, H. W. & WHITE, R. E. 1999. An organizational learning framework: From intuition to institution. *Academy of management review,* 24**,** 522-537.
CUSUMANO, M. A. 1988. Manufacturing innovation: lessons from the Japanese auto industry. *MIT Sloan Management Review,* 30**,** 29.
DA SILVA, E. M., PAIVA, E. L. & NETO, M. S. 2018. Development of capabilities, operational practices and interorganisational collaboration *25th Annual EurOMA Conference.* Budapest, Hungary.
DEQUIEDT, V. & MARTIMORT, D. 2004. Delegated monitoring versus arm's-length contracting. *International Journal of Industrial Organization,* 22**,** 951-981.
DOCHERTY, P. & SHANI, A. B. R. 2008. Learning mechanisms as means and ends in collaborative management research. *In:* SHANI, A. B. R., MOHRMAN, S. A., PASMORE, W. A., STYMNE, B. A. & ADLER, N. (eds.) *Handbook of collaborative management research.* Los Angeles: Sage.
ENKEL, E., GASSMANN, O. & CHESBROUGH, H. 2009. Open R&D and open innovation: exploring the phenomenon. *R&d Management,* 39**,** 311-316.
FERDOWS, K. & DE MEYER, A. 1990. Lasting Improvements in Manufacturing Performance: In Search of a New Theory. *Journal of Operations Management,* 9**,** 168-184.
FRUIN, W. M. & NISHIGUCHI, T. 1993. Supplying the Toyota Production System: Intercorporate Organizational. *Country competitiveness: technology and the organizing of work***,** 225.
GIBBONS, M. 1994. *The new production of knowledge: The dynamics of science and research in contemporary societies*, Sage.
GOODSON, R. E. 2002. Read a plant-fast. *Harvard business review,* 80**,** 105-113.
HAYAMI, Y. 1998. Toward the Rural-Based Development of Commerce and Industry: Selected Experiences from East Asia (Washington DC: The World Bank Economic Development Institute).
HINES, P. 1994. *Creating world class suppliers: Unlocking mutual competitive advantage*, Pitman Publishing.
HINES, P. & RICH, N. 1998. Outsourcing competitive advantage: the use of supplier associations. *International Journal of Physical Distribution & Logistics Management*.
JABER, M. Y., BONNEY, M. & GUIFFRIDA, A. L. 2010. Coordinating a three-level supply chain with learning-based continuous improvement. *International Journal of Production Economics,* 127**,** 27-38.
JADHAV, J. R., MANTHA, S. S. & RANE, S. B. 2014. Exploring barriers in lean implementation. *International Journal of Lean Six Sigma*.
JASTI, N. V. K. & KODALI, R. 2015. A critical review of lean supply chain management frameworks: proposed framework. *Production Planning & Control,* 26**,** 1051-1068.
JONES, D. T. & WOMACK, J. P. 2017. The Evolution of Lean Thinking and Practice. *In:* NETLAND, T. H. & POWELL, D. J. (eds.) *The Routledge Companion to Lean Management.* New York: Routledge.
KARLSSON, C. & ÅHLSTRÖM, P. 1996. Assessing changes towards lean production. *International Journal of Operations & Production Management,* 16**,** 24-41.
KRAFCIK, J. F. 1988. Triumph of the lean production system. *Sloan Management Review,* 30**,** 41-52.
LAMMING, R. 1996. Squaring lean supply with supply chain management. *International Journal of Operations & Production Management*.
LANGLEY, A. 1999. Strategies for theorizing from process data. *Academy of Management review,* 24**,** 691-710.
LAWSON, B., KRAUSE, D. & POTTER, A. 2015. Improving supplier new product development performance: the role of supplier development. *Journal of Product Innovation Management,* 32**,** 777-792.

LIKER, J. K. 2004. *The Toyota Way: 14 Management Principles From the World's Greatest Manufacturer,* New York, McGraw-Hill.
LIKER, J. K. & CHOI, T. Y. 2004. Building deep supplier relationships. *Harvard business review,* 82**,** 104-113.
MARQUARDT, M. J. 2004. *Optimizing the power of action learning: solving problems and building leaders in real time,* Palo Alto, CA, Davies-Black Publishing.
MODIG, N. & ÅHLSTRÖM, P. 2012. *This is lean: Resolving the efficiency paradox,* Stockholm, Rheologica.
NETLAND, T. H. 2013a. Company-specific production systems: Managing production improvement in global firms.
NETLAND, T. H. 2013b. Exploring the phenomenon of company-specific production systems: one-best-way or own-best-way? *International Journal of Production Research,* 51**,** 1084-1097.
NETLAND, T. H. & FERDOWS, K. 2014. What to expect from corporate lean programs. *MIT Sloan Management Review,* 55**,** 83.
NETLAND, T. H. & POWELL, D. J. 2017a. A Lean World. *In:* NETLAND, T. H. & POWELL, D. J. (eds.) *The Routledge Companion to Lean Management.* New York: Routledge.
NETLAND, T. H. & POWELL, D. J. (eds.) 2017b. *The Routledge Companion to Lean Management,* New York: Routledge.
NEVIS, E., DIBELLA, A. & GOULD, J. 1995. Understanding organizations as learning systems. *Sloan Management Review,* 36**,** 73-85.
NEW, S. J. 1996. A framework for analysing supply chain improvement. *International Journal of Operations & Production Management*.
POWELL, D. & REKE, E. 2019. No Lean Without Learning: Rethinking Lean Production as a Learning System. *In:* AMERI, F., STECKE, K. E., CIEMINSKI, G. V. & KIRITSIS, D. (eds.) *Advances in Production Management Systems: Production Management for the Factories of the Future.* Cham, Switzerland: Springer.
REASON, P. & BRADBURY, H. (eds.) 2006. *Handbook of Action Research,* London: Sage Publications.
REVANS, R. W. 1971. *Developing effective managers: A new approach to business education,* New York, Praeger.
REVANS, R. W. 1982. *The Origins and Growth of Action Learning,* Bromley, Chantwell Bratt.
REVANS, R. W. 1998. *The ABC of Action Learning,* London, Lemos & Crane.
RICH, N. & HINES, P. 1997. Supply-chain management and time-based competition: the role of the supplier association. *International Journal of physical distribution & logistics management*.
ROSENZWEIG, E. D. & ROTH, A. V. 2004. Towards a Theory of Competitive Progression: Evidence from High-Tech Manufacturing. *Production and Operations Management,* 13**,** 354-368.
ROSSINI, M. & PORTIOLO-STAUDACHER, A. 2019. Lean Supply Chain: the roles of SC partners in the lean journey. *26th EurOMA Conference.* Helsinki, Finland.
SAKAI, T. 2018. *The Secret Behind the Success of Toyota,* London, Amazon.
SAKO, M. 1996. Suppliers' associations in the Japanese automobile industry: collective action for technololgy diffusion. *Cambridge Journal of Economics,* 20**,** 651-671.
SCHERRER-RATHJE, M., BOYLE, T. A. & DEFLORIN, P. 2009. Lean, take two! Reflections from the second attempt at lean implementation. *Business horizons,* 52**,** 79-88.
SHAH, R. & WARD, P. T. 2003. Lean manufacturing: context, practice bundles, and performance. *Journal of Operations Management,* 21**,** 129-149.
SHANI, A. & DOCHERTY, P. 2008. Learning by design: Key mechanisms in organization development. *In:* CUMMINGS, T. (ed.) *Handbook of Organizational Change and Development. .* Thousand Oaks, CA: Sage.
SHANI, A. R. & DOCHERTY, P. 2003. *Learning by design: Building sustainable organizations,* Oxford, Blackwell.
SIMCHI-LEVI, D., KAMINSKY, P. & SIMCHI-LEVI, E. 2002. *Designing and Managing the Supply Chain. Concepts, Strategies, and Case Studies,* Boston, Massachusetts, McGraw-Hill/Irwin.

STEBBINS, M. W. & VALENZUELA, J. L. 2008. 9 Learning mechanisms in sustainable work systems design. *In:* DOCHERTY, P., KIRA, M. & SHANI, A. B. R. (eds.) *Creating Sustainable Work Systems: Developing Social Sustainability.* Abingdon: Routledge.

STRAUSS, A. & CORBIN, J. 1990. *Basics of Qualitative Research: Grounded Theory Procedures and Techniques,* Newbury Park, CA, Sage.

SUGIMORI, Y., KUSUNOKI, K., CHO, F. & UCHIKAWA, S. 1977. Toyota production system and Kanban system Materialization of just-in-time and respect-for-human system. *International Journal of Production Research,* 15**,** 553 - 564.

TAYLOR, D. H. 2006. Strategic considerations in the development of lean agri-food supply chains: a case study of the UK pork sector. *Supply Chain Management: An International Journal*.

VEREECKE, A. & MUYLLE, S. 2006. Performance improvement through supply chain collaboration in Europe. *International Journal of Operations & Production Management,* 26**,** 1176-1198.

VOSS, C. A. 1995. Alternative paradigms for manufacturing strategy. *International Journal of Operations & Production Management*.

VOSS, C. A. 2005. Paradigms of manufacturing strategy re-visited. *International Journal of Operations & Production Management*.

WEE, H. & WU, S. 2009. Lean supply chain and its effect on product cost and quality: a case study on Ford Motor Company. *Supply Chain Management: An International Journal*.

WILLIS, V. J. 2004. Inspecting cases against Revans''gold standard'of action learning. *Action Learning: Research and Practice,* 1**,** 11-27.

WOMACK, J. P., JONES, D. T. & ROOS, D. 1990. *The Machine that Changed the World,* New York, Harper Perennial.

WONG, C. W., WONG, C. Y. & BOON-ITT, S. 2018. How does sustainable development of supply chains make firms lean, green and profitable? A resource orchestration perspective. *Business Strategy and the Environment,* 27**,** 375-388.

ZUBER-SKERRITT, O. 2002. A model for designing action learning and action research programs. *The Learning Organization*.