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How a lean learning system can improve operators' work performance and well-being in a production setting

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Abstract

Purpose – There is a growing body of research that examines lean through the lens of a learning system. The scope of this paper is to understand the characteristics of a lean learning system in production and how it can facilitate operators' basic psychological needs satisfaction despite working in an assembly line.

Design/methodology/approach – A retrospective case study was conducted at a plant renowned for its lean learning system. The study focused on 1999 and 2009, when a comprehensive lean transformation took place, forming a lean learning system.

Findings – The paper shows that operators' basic psychological needs can be fulfilled by designing the work organisation to achieve a lean learning system. By granting operators and production teams authority and responsibility to operate, control and continuously improve their work. When the social system aspects were given the same dedication as the technical system aspects, large improvements in both work performance and well-being became possible.

Practical implications – Both the social and technical subsystems need to be considered when initiating a lean learning system. Daily kaizen and managers are keys, but the paper shows the necessity of having the right organisational structure, production team design, work design, as well as leadership behaviour, production team culture and organisational culture to support a lean learning system.

Originality/value – The originality lies in its interdisciplinary research approach to understand how a lean learning system at individual-, team- and organisation-level can improve operators' work performance and well-being. This complements earlier papers by developing a socio-technical system model, including the importance of production teams and team culture.

Keywords Lean management, Socio-technical systems, Self-determination theory, Operators' work design, Production organisations

Paper type Research article

1. Introduction

Many manufacturing companies operate in a fast-paced, turbulent business environment characterised by high levels of uncertainty, ambiguity and change (e.g. Christopher and Holweg, 2011; Arana-Solaresa *et al.*, 2019). Technological development and digitalisation

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further accelerate the pace of change. Advances in digital technologies and their applications are expected to drive the evolution of industrial production through higher levels of process automation, reshaping operators' roles and altering work design (Waschull *et al.*, 2020). Implementing Industry 4.0 requires more than technological knowledge and adherence to best practices (Saabye *et al.*, 2020, 2022). However, the anticipated benefits of these technologies cannot be realised without addressing operators' capabilities, skills, work procedures and routines (Saabye *et al.*, 2020). Therefore, the ability to learn and innovate are key competitive factors. Additionally, companies today are expected to "promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation" (Target 8,3 in Sustainable Development Goal 8, Agenda 2030).

Companies face the dual challenge of creating workplaces that are, on the one hand, productive, agile and innovative, and on the other, healthy and attractive places to work (Govers and Amelsvoort, 2019). However, many manufacturing companies have not adapted to this new situation; instead, many organisations remain rooted in mass production logic (economies of scale and the idea of a stable external environment with slow change). These organisations are centralised and have resource-intensive support functions (Christis and Soepenberg, 2016), and they share many similarities with the mechanistic view of an organisation described by Morgan (2006). This organisational structure makes the business rigid and unwilling to accept change (Burns and Stalker, 2011). Morgan (2006) argues that this approach to organisations tends to limit rather than mobilise the development of human abilities, shaping human beings to fit the requirements of the mechanical organisation rather than building the organisation around employees' strengths and potentials.

Lean-inspired production systems are often seen as a means to develop operational excellence and continuous improvement, thereby maintaining competitiveness (Toledo *et al.*, 2019). Despite the implementation of lean production in many companies, few initiatives are successful in the long term in terms of operational performance, learning and well-being (Netland, 2016; Holmemo and Ingvaldsen, 2016; Dombrowski and Mielke, 2013; Halling, 2020). Most lean initiatives in Europe and the USA have focused on improving operational excellence, often through event-driven projects led by experts from support functions or consultants and centred on methods and tools (Jasti and Kodali, 2015). Consequently, many companies have tried to imitate Toyota's technical side while ignoring the human side, yet understanding operators' work situation requires considering both sides (Magnani *et al.*, 2019). Because the social and technical aspects of lean are intertwined and must be considered equally (Galeazzo and Furlan, 2018; Galeazzo *et al.*, 2021), it is crucial to ensure that human beings and social systems are respected and brought into balance with the technical system (Pasmore *et al.*, 2019). At Toyota, operators' daily involvement in change and the development of the technical and social subsystems is natural and critical for the organisation's long-term sustainability and for improving operators' work situation (e.g. Liker and Hoseus, 2008). Consequently, operators' situation is crucial for a successful lean organisation, and thus it is essential to understand operators' work situation and work content to create the prerequisites for successful lean organisations from a socio-technical perspective.

RQ1. What socio-technical system dimensions describe operators' work situation in a production setting?

Hines *et al.* (2004) describe how lean thinking has evolved from prescriptive to a high degree of contingency within a learning organisation seeking to maximise learning opportunities for employees, suppliers, customers and even competitors. Thus, learning is closely linked to lean practices that engage employees in improvement activities, fostering learning and knowledge sharing at individual, team and organisational levels (e.g. Tortorella and Fogliatto, 2014; Tortorella *et al.*, 2015; Tortorella *et al.*, 2020; Fenner *et al.*, 2022). This is not surprising, as the success of the Toyota Production System is largely attributable to its dynamic learning capability (Holweg, 2007). Achieving this lean maturity requires a "learn how to learn" capability at all organisational levels and learning through experimentation and scientific thinking (Hines *et al.*, 2004; Powell and Coughlan, 2020; Fenner *et al.*, 2022; Kristensen *et al.*, 2022; Saabye *et al.*, 2022, 2023). Such a learning system facilitates the effective implementation of Industry 4.0 (Saabye *et al.*, 2020, 2022) by enhancing operators' competencies and skills through continuous learning and systematic training (Kaasinen *et al.*, 2020). Thus, the goal is to create a lean learning system in the organisation and to understand how this impacts operators' work situation, work performance and well-being.

Understanding the contextual influences at the shop floor level in a production setting (Cullinane *et al.*, 2013) is important for promoting a positive lean culture characterised by lean job qualities, such as autonomy, skills use, participation, social support, meaning at work, openness and justice, while reducing potential negative aspects (Hasle *et al.*, 2012). It is important not only to focus on lean as a whole concept and its impact on operators' well-being but also to deepen understanding of how different work situation dimensions affect operators' work performance and well-being (Hasle *et al.*, 2012; Beraldin *et al.*, 2022). To understand how the work situation impacts operators' work performance and well-being, several authors within the self-determination theory community have shown that basic psychological needs (BPNs) and types of motivation mediate between the work context, work performance and well-being (e.g. De Cooman *et al.*, 2013; Trepanier *et al.*, 2015). Humans have three BPNs, which must be fulfilled for a person to flourish (Ryan and Deci, 2017).

RQ2. How can a lean learning system fulfil operators' basic psychological needs in a production setting?

To answer this question, a retrospective case study was chosen to represent one of the few assembly plants in Sweden with a well-established lean learning system. It was renowned for providing continuous learning opportunities, high work performance and work satisfaction compared with other production organisations. For example, from 2001 to 2005, productivity increased by 50% and sick leave absences decreased by 80%. The running time of the assembly line increased from 65% to 88%, and the number of workstations with poor ergonomics decreased by 80%. Consequently, operators' work performance and well-being improved, even though they were working on an assembly line where operators are controlled by the technical system. However, the underlying mechanisms linking operators' work situation to their work performance and well-being remain unknown.

This paper is structured as follows. First, an analytical framework is presented, including a socio-technical model for work situations, self-determination theory in work organisations, and a lean learning system. Second, the methodology is presented, followed by a description of the case. Third, the case is analysed using the analytical framework. In the discussion, an extended self-determination theory model, in work organisations, is presented, and three sets of propositions are generated. Finally, theoretical and managerial contributions are presented, and conclusions are stated.

2. Analytical framework

In the first section, socio-technical system dimensions are derived from earlier research to develop a comprehensive model describing operators' work situation. The second section outlines the basic self-determination theory model for work organisations, and the third section describes a lean learning system.

2.1 Lean as a learning system

The goal of working with lean is to become a learning organisation, which can be seen as a learning system (Hines *et al.*, 2004). The success of Toyota is mainly attributed to its dynamic learning capability (Holweg, 2007). Decisions based on facts are key, and consequently, information gathering and visualisation, such as daily management meetings (stand-up meetings), "gemba" walks and "obeya" rooms, are central to lean (Netland *et al.*, 2021). Employees engage in problem-solving by identifying deviations, using structured analysis, experimentation and scientific thinking, which is a typical learning process (Kristensen *et al.*, 2022). Root cause methods such as fishbone diagrams and five whys are used (Liker, 2021). The created knowledge is shared at individual, team and organisational levels, e.g. through updated standardised work procedures (e.g. Tortorella and Fogliatto, 2014; Tortorella *et al.*, 2015; Tortorella *et al.*, 2020; Fenner *et al.*, 2022). However, continuous improvement is not only a method for operational excellence but also about developing learning, reflection and challenging current methods (Liker and Convis, 2011). Thus, time for reflection needs to be facilitated to support learning.

In an advanced lean adopter, managers genuinely care about their team members and their development, acting as coaches and supporting value-adding work (Camuffo and Gerli, 2018; Netland *et al.*, 2021). To accomplish this, they need in-depth knowledge of processes and people (Camuffo and Gerli, 2018). Coaching is mainly carried out at "gemba" based on a "train the trainer" concept (Netland *et al.*, 2019). Managers also set challenging goals and remove obstacles so that teams at all levels can contribute to attaining long-term goals (Liker and Convis, 2011).

2.2 Socio-technical model describing operators' work situation

Socio-technical systems theory emphasises the importance of considering both technical aspects and the social aspects in a work system, when analysing work organisations, since the two subsystems are interdependent (e.g. Fox, 1995). There is a long history of socio-technical systems theory, from the groundbreaking work at Tavistock until today (Mumford, 2006). For example, human factors and engineering principles are rooted in socio-technical values and are the scientific discipline concerned with the understanding of interactions among humans and elements of a system (IEA, 2025).

According to Campion (1988) and Carayon (2009), there are four major approaches to work design: the motivational approach (organisational psychology), the mechanistic approach (industrial engineering), the biological approach (human factors and engineering) and the perceptual/motor approach (human factors and engineering and experimental psychology). In their literature review, Parker *et al*. (2017) identified five research clusters in work design research, four of which focus primarily on the individual level (job characteristics model, job demands-control model, job demands-resources model and role theory), while one focuses more on the team/system level (socio-technical system theory and autonomous work groups). However, Parker *et al*. (2017) argue that a multilevel model is needed to bring these clusters closer together. Therefore, in this paper, an interdisciplinary research approach (organisational psychology, industrial engineering and human factors engineering) is used to operationalise a multilevel socio-technical analytical model to understand operators' work situation. The socio-technical model for operators' work situation is divided into two interrelated subsystems: a technical and a social subsystem (Figure 1). Each subsystem is described at three levels: work, team and organisational (Dul and Ceyland, 2011).

2.2.1 Technical subsystem. The technical subsystem is operationalised as everything designed and created in advance. Therefore, the work organisation is included within the technical subsystem (e.g. Carayon *et al.*, 2015). The work-level dimensions are mainly based on the job design theory research stream (e.g. Morgeson and Humphrey, 2006), the team-level dimensions mainly on Hollenbeck *et al*. (2012) and the organisation-level dimensions (physical work environment and organisational design) are primarily based on the research field of human factors and ergonomics (e.g. Carayon *et al.*, 2015).

2.2.1.1 Work-level dimensions. Work-level focuses on *"how the work itself is accomplished and the range and nature of tasks associated with a particular job"* (Morgeson and Humphrey, 2006). Hackman and Oldham (1976) identify ***work task characteristics*** (task variety – a wide range of tasks; identity – an identifiable piece of work; significance – substantial impact on others), ***feedback of job*** (direct and clear information) and ***work autonomy*** as important. De Treville and Antonakis (2006) divided work autonomy into choice autonomy and responsible autonomy to better fit a lean context.

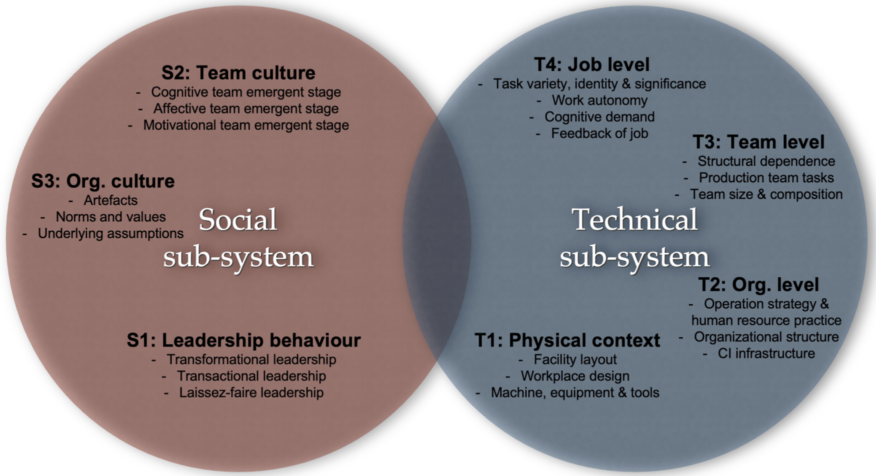

Figure 1. Dimensions describing operators' work situation in a production setting. Source: Authors' own work

Cognitive demand is part of the job design theory, and this involves skill variety (e.g. problem solving, job rotation within lean see de Treville and Antonakis, 2006), job complexity (see Campion, 1988) and specialisation (see Edwards *et al*., 1999). Wall and Jackson (1995) identified two aspects of cognitive demand: active information processing (monitoring) and innovation (the job requires unique ideas/solutions).

2.2.1.2 Team-level dimensions. A common way to organise production work is to use production teams, which typically consist of front-line operators working together full-time (e.g. Sundstrom *et al*., 1990). Parker *et al*. (2001) note that common work characteristics at the individual level, such as ***team feedback***, have often been ignored at the team level.

A production team's characteristic can be described in terms of the ***structural dependence*** of team members along three dimensions: skill differentiation, authority differentiation *and stability* (Hollenbeck *et al*., 2012). According to Hollenbeck *et al*. (2012), skill differentiation is "*the degree to which members have specialised knowledge or functional capacities that make it more or less difficult to substitute members*". Authority differentiation concerns the autonomy within a team, ranging from a formal leader to a self-managed team (Hollenbeck *et al*., 2012). Team stability indicates the development from a one-shot team to a fully functioning team.

Production team tasks can be described as two-dimensional, involving task scope and complexity (e.g. Mathieu *et al*., 2017). Task scope is the number of activities required to complete the task (Mathieu *et al*., 2017). Task complexity has three aspects: activity complexity, coordination demand and dynamic complexity (Wood, 1986). Activity complexity is a "*function of the number of distinct acts that need to be executed in the performance of the task and the number of distinct information cues that must be processed in the performance of those acts*" (Wood, 1986). Coordination demand refers to the interdependence among activities (sequence and timing) and dynamic complexity refers to the degree to which activities need to change (Mathieu *et al*., 2017). Finally, ***team size*** will affect the work carried out within the team (e.g. Smith and Katzenbach, 2015).

2.2.1.3 Organisation level dimensions. ***Machines, equipment and tools*** used to manage work are part of the technical subsystem (Carayon *et al*., 2015; Karltun *et al*., 2017). This is directly connected to where the work tasks are performed, such as surrounding buildings (***facility layout***) and ***workplace design*** (Morgeson and Humphrey, 2006; Dul and Ceylan, 2011). Workplace design can be measured in terms of physical loading (work postures and movements) and physical health hazards (e.g. Edwards *et al*., 1999).

The ***organisational structure,*** including the type of organisation, hierarchy, span of control, chain of command and communication channels (e.g. Daniellou, 2001; Karltun *et al*., 2017). In lean research, there has been a trend towards focusing on how ***operations strategy and human resource practices*** (e.g. pay contingency, introductory processes, formal education and training and leadership model) facilitate lean adoption (Magnani *et al*., 2019). Here, training and development programs are important and need to be conducted at all organisational levels (Shahin and Jaberi, 2011). Improvement processes are a core part of lean, which require a ***continuous improvement infrastructure*** including a clear purpose and goal, developed processes to systematically select and review improvement initiatives, and the spread of the gained knowledge within the organisation, information support processes and training and career paths (Anand *et al*., 2009).

2.2.2 Social subsystem. The social subsystem is operationalised as the relationships among people within an organisation and the organisational culture, including interpersonal behaviour, group dynamics and related factors (e.g. Carayon *et al*., 2015; Davis *et al*., 2014). Dul and Ceylan (2011) suggest that the social-organisational context can be described across three levels within an organisation: the work level, which includes management; the team level; and the entire organisation, encompassing the organisational culture. Operators will interact with their leaders, production team members, colleagues (social support) outside the production team (such as support functions and management) and will operate within an organisational culture. Therefore, in this paper, we adopt a similar approach: at the work level, we focus on social support from the front-line manager; at the team level, we focus on production team members and the culture – such as members' beliefs and perceptions about the team, psychological safety and team efficacy; and at the organisational level, we consider other colleagues and the organisational culture.

2.2.2.1 Work-level dimensions. Parker *et al*. (2001) describe how leadership style affects employees' autonomy. In lean, the leadership style is close to transformational leadership behaviours and is described as lean leadership (e.g. Van Dun and Wilderom, 2016, 2021). Therefore, the leadership style will be operationalised using the well-established full range leadership model (Bass and Avolio, 1991).

Transformational leadership comprises four dimensions: idealised influence, inspirational motivation, intellectual stimulation and individualised consideration (Judge and Piccolo, 2004; Bass and Reggio, 2006). Idealised influence describes a leader's behaviour that fosters follower identification with the leader and serves as a role model (Judge and Piccolo, 2004). Inspirational motivation involves behaviour that motivates and inspires by providing meaning and challenge to followers' work and by envisioning attractive future states (Judge and Piccolo, 2004). Intellectual stimulation occurs when leaders encourage followers to innovate and be creative by questioning assumptions, reframing problems and approaching old situations in new ways (Judge and Piccolo, 2004). Individualised consideration is demonstrated by leaders who pay special attention to each follower's need for achievement and growth by acting as a coach or mentor (Judge and Piccolo, 2004; Bass and Reggio, 2006).

In contrast, there is a ***transactional leadership*** style that motivates followers by appealing to their self-interests and offering benefits (Yukl and Gardner, 2020). The transactional leadership style consists of three dimensions: contingent reward (establishing rewards for meeting clarified expectations), active management by exception (monitoring followers' behaviour, anticipating problems and taking corrective actions) and passive management by exception (waiting until behaviour causes problems before taking action) (Judge and Piccolo, 2004). There is also a type of "non-leadership", the ***laissez-faire leadership*** style (absence of leadership) (Judge and Piccolo, 2004).

2.2.2.2 Team-level dimensions. Fenner *et al*. (2022) recently used team emergent states to understand lean teams. Marks *et al*. (2001) describe teams' emergent states as cognitive, affective and motivational states, "*constructs that characterise properties of the team that are* *typically dynamic in nature and vary as a function of team context, inputs, processes, and outcomes."* Rapp *et al*. (2021) extend the work of Marks *et al*. (2001) by showing that there are also amalgams of these states, but these amalgams will not be used in this paper. Based on the review by Rapp *et al*. (2021), this paper uses the most common constructs in research.

Cognitive team emergent states refer to team members' beliefs and thoughts about the team, and the most common constructs have focused on team climate, team cognition and team trust (Rapp *et al*., 2021). One team cognition construct is shared mental models, and Mathieu *et al*. (2000) describe four types of mental models: technology (equipment functioning, operating procedures, etc.), tasks (procedures, contingencies, scenarios, etc.), interactions (roles, information sources, interaction patterns, etc.) and team (teammates' knowledge, skills, attitudes, etc.).

Affective team emergent states are the team members' *"feelings, attitudes, and emotions"* and the most common constructs used in research have been on team cohesion and team psychological safety (Rapp *et al*., 2021). Mullen and Cooper (1994) found in their meta-analysis that task cohesion was a critical component of team performance. The team's psychological safety also affects the work and is defined as *"a shared belief that the team is safe for interpersonal risk taking"* (Edmondson, 1999).

Motivational team emergent states are the team members' *"intensity, direction, and regulation of effort toward task accomplishment"* and the most common constructs used in research have been on team efficacy (Rapp *et al*., 2021). Team efficacy occurs when team members share beliefs about general effectiveness across multiple tasks that impact the group's performance (Stajkovic *et al*., 2009).

2.2.2.3 Organisation-level dimensions. The organisational culture is important for operators' work situation (Berglund and Karltun, 2007). Because the organisational culture influences how its employees interact with the technical solutions, and this interaction may not be in the way the designer intended (Shahin and Jaberi, 2011; Carayon *et al*., 2015).

Organisational culture can be analysed at three different levels (Schein and Schein, 2016). The first level comprises ***artefacts*** (Schein and Schein, 2016), but some of these are already covered under the technical system, work-level (front-line manager) and production team-level. Therefore, the artefacts here include behavioural artefacts of colleagues outside the production team. The second level involves ***norms and values*** (Schein and Schein, 2016), such as openness to ideas and valuing differences. The third level is the level of ***underlying assumptions***, which are "taken for granted" and offer little variation within the social unit (Schein and Schein, 2016).

2.3 Operators' work situation impact on work performance and well-being

In a work system, work can generate psychosocial, cognitive and/or physical loads on the individual, affecting work performance and well-being (Carayon, 2009). Self-determination theory, a theory of human motivation, can be used to understand how the production workplace setting impacts operators' work performance and well-being. Deci *et al*. (2017) developed the basic self-determination theory model in work organisations, which comprises two independent variables, work context and individual differences; two dependent variables, work performance and health and well-being; and two mediating variables, BPNs and types of motivation. The mediating role of BPNs has been demonstrated by several authors (e.g. De Cooman *et al*., 2013; Trepanier *et al*., 2015). However, in the self-determination theory model for work organisations, the workplace context is not clearly operationalised, and thus a combination of the basic self-determination theory model and the developed socio-technical model for operators' work situation is needed (Figure 2).

The individual differences variables (e.g. studied by employees' general causality orientations) and the mediator type of motivation (external, introjected, identified, integrated and intrinsic) in the basic self-determination theory are outside the scope of this paper.

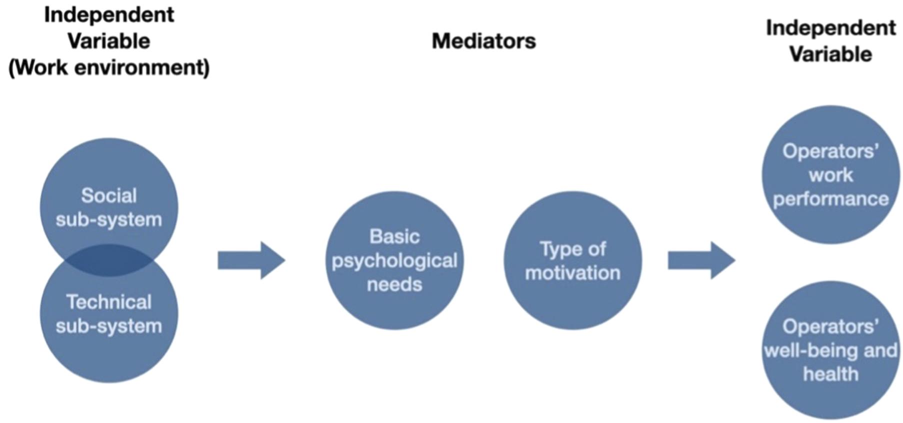

Figure 2. Adapted basic self-determination model in work organisations (work context is shown as a socio-technical systems and individual differences are outside the scope and not included). Based on Deci *et al.* (2017)

2.3.1 Basic psychological needs. Humans have three BPNs that must be fulfilled for a person to flourish (Ryan and Deci, 2017). A failure to satisfy these needs will result in reduced growth, integrity and well-being (Ryan and Deci, 2017). However, there can also be need frustration, which is not the same as lack of need satisfaction, meaning that "not feeling volitional, competent, and related" is not the same as "feeling oppressed, incapable, and isolated" (Trépanier *et al.*, 2015). In this study, positive and negative impact on need satisfaction will be used and need frustration is outside the scope. The following definitions of needs are used: "autonomy or the need to self-regulate one's experience and actions," "competence, (which) refers to our basic need to feel effectance and mastery" and "relatedness concerns (about) feeling socially connected" (Ryan and Deci, 2017).

The meta-analysis by Van Broeck *et al.* (2016) demonstrates that many aspects of both the technical system (e.g. skill variety, task variety, task significance and role ambiguity) and the social system (e.g. social support, feedback, organisational politics, leader–member exchange) correlate with autonomy, competence and relatedness. In a lean setting, the work organisation, tools and methods, such as daily management meetings, "gemba" walks, problem-solving, root cause analysis, standardised work procedures and continuous improvement – all focused on developing learning, reflection and challenging current methods - will impact the technical system. Furthermore, lean leadership and teamwork, together with the goal of fostering an organisational culture, facilitate learning and development, thereby impacting the social system.

2.3.2 Work performance and well-being. According to Ryan and Deci (2000), workplaces that support psychological needs promote psychological and physical well-being and improve work performance, particularly in heuristic activities. In the model by Deci *et al.* (2017), there are two types of effect variables: "performance variables (e.g. quantity or quality of performance)" and "well-being/ill-being variables (e.g. job satisfaction, vitality, or somatic symptoms)". In the meta-analysis by Van Broeck *et al.* (2016), three basic psychological needs were found to be correlated with well-being. Moreover, the basic psychological needs were positively related to performance outcomes and effort and negatively related to deviant workplace behaviours.

3. Methodology

To identify subsystem dimensions in the socio-technical model, we used the research stream of work systems within human factors and ergonomics (e.g. Dul and Ceyland, 2011; Carayon *et al.*, 2015), job design theory (e.g. Hackman and Oldham, 1976; Morgeson and Humphrey, 2006), team description (Hollenbeck *et al.*, 2012), team emergent stages (e.g. Marks *et al.*, 2001; Rapp *et al.*, 2021), organisational culture (Schein and Schein, 2016), full range leadership model (Bass and Avolio, 1991) and lean practices (e.g. de Treville and Antonakis, 2006; Anand *et al.*, 2009; Cullinane *et al.*, 2013; Butler *et al.*, 2018). The grouping of the identified dimensions was an iterative process carried out by the researchers.

Multiple data sources have been used. First, two of the authors followed this transformation through visits and discussions, conducting 15 unstructured interviews with front-line managers. To deepen the knowledge, eight semi-structured interviews were conducted with former front-line managers between 2020 and 2022. There were twelve front-line managers working in the plant at any given time, working two shifts. The interviewed were chosen based on their backgrounds, depth of experience as front-line managers and their different careers after this job. These interviews served as the primary data collection method. These were carried out online, due to COVID-19 pandemic. These interviews lasted approximately 90 min and were recorded. The interview guide covered five main areas: 1, front-line manager's development journey; 2, the relationship between the front-line manager and the operator; 3, improvement work; 4, goal images; and 5, in retrospective. Consequently, all authors could familiarise themselves with the data and develop a comprehensive understanding. As a complement, internal documents (e.g. internal reports regarding performance, workshops, staff development, staff surveys etc.) were used for triangulation.

To identify how the production work environment affected operators' BPN, the research group conducted an analysis and assessment. Each researcher assessed each dimension individually, and the results were then discussed together, and a consensus was obtained for all dimensions. The impact of the production work environment dimensions on operators' BPN was mapped using a five-point Likert scale (major negative impact on BPN satisfaction, minor negative impact on BPN satisfaction, no impact on BPN satisfaction, minor positive on impact BPN satisfaction and major positive on impact BPN satisfaction).

4. Case setting

A comprehensive transformation of the production organisation and leadership began in 1999, based on lean practices, and continued throughout the study period 2006–2008. Until the early 1990s, the plant was characterised by a hierarchical, "Tayloristic" organisational philosophy and functional division, with engineering and production separated. Front-line managers' span of control included approximately fifty operators. An intermittently moving assembly line formed the basis for production, and the work content was limited. Industrial engineers developed standardised work and were also responsible for process improvements and changes. Indirect work, e.g. maintenance, quality control and production control, was performed by support functions. The plant's performance was characterised by a high turnover rate, low productivity, poor product quality, poor ergonomics and a high number of sick leave absences. In the early 2000s, a few managers initiated a fundamental change. The production philosophy was altered, with lean practices and coaching leadership as inspirations, which, in the long run, resulted in a learning organisation. This change involved decreased span of control, increased employee involvement, decentralised decision-making, etc. and had a strong impact on operators' continuous learning opportunities, work performance and well-being.

5. Analysis

In this section, the technical and social subsystems are presented as they existed between 2006 and 2008, after the plant had worked for almost ten years to establish a lean learning system and build organisational capability.

5.1 Lean learning system impact on operators' basic psychological needs

5.1.1 Technical subsystem's impact on operators' basic psychological needs. 5.1.1.1 Work-level dimensions impact on operators' basic psychological needs. *Task characteristics:* Operators were hired to assemble, improve and develop professionally. Work consisted of standardised work procedures, with low task variation and a work cycle of seven minutes. Operators rotated between workstations with similar work content. The assembly sequence was designed based on component proximity rather than a logical sequence. However, training sessions were arranged to help operators learn about the products, understand customer needs and recognise how their contribution affected the products. In addition to assembly work, each operator would generally devote 15–20% of their working time each week to specialist role tasks. The specialist role tasks were organised into the following areas: standardised work, quality, maintenance, production flow, work environment, product and engineering change, team leader and vice team leader. The front-line manager was responsible for matching each operator with an appropriate specialist role based on talent and interest, with the intention of creating long-term career paths. Operators received continual training, education and development within a specific engineering field, and every week there were specialist role team meetings (24 min), led by engineers from the support functions. They contributed in-depth knowledge and acted as coaches, aiming to discuss tasks, build competence, foster ownership and promote organisational learning among production teams. Assembly tasks had no substantial impact on others and did not contribute to a whole and identifiable piece of work. Together, the specialist roles created a base for autonomous production teams responsible for managing, controlling and improving their line segment. The specialist role tasks contributed to an identifiable and whole piece of work.

Cognitive demand: The need to process information and the job complexity during assembly were low, and the work could be learned in weeks. Specialist role tasks involved high job complexity and required information processing. The operators were enabled to develop knowledge and expertise as a foundation for unique ideas, solutions and innovation. Creativity was stimulated through continuous improvement work and the specialist role tasks. Meaning through their specialist roles, the operators were involved in monitoring their own process and its outcome, including analysing, reflecting and problem solving, which resulted in both high task and skill variety and responsible autonomy.

Work autonomy: The work was highly controlled by the technical subsystem, limiting choice autonomy. For example, operators did not influence work scheduling, decision-making or work methods. However, when operators worked on specialist role tasks, they could influence work scheduling to some extent and work methods by undertaking improvement activities and establishing new standardised work procedures. The specialist role tasks also included job complexity, information processing, innovation and specialisation, with responsible autonomy.

Feedback from the job: Operators received direct feedback from their assembly work, as well as feedback from their specialist role coach, front-line manager, co-workers and customers.

5.1.1.2 Team-level dimensions impact on operators' basic psychological needs. *Team size:* A production team consisted of ten operators with responsibility for eight workstations. Eight operators assembled, and two worked with continuous improvement and specialist role tasks. The team leader was responsible for scheduling this rotation. However, if one of the team's operators was absent, one operator working in a specialist role needed to assume the assembly task.

Team tasks and structural dependence: Each production team had authority and responsibility for operating, controlling and improving their line segment and for assembly work. There was a weekly structure for meetings. The team leader was responsible for a daily visual management meeting (8 min) to visualise the status, identify absenteeism and plan assembly and specialist role tasks. The front-line manager facilitated a weekly continuous improvement team meeting (24 min) to keep track of improvements, specialist role tasks, ongoing and planned activities and to receive input from other team members. During the weekly continuous improvement meetings, the operators shared information related to their area of responsibility within their production team. The improvement work in the production team was role-integrated, and there was clear interdependence among team members to innovate and address deviation problems. However, assembly work did not involve task interdependence between the operators; each worked independently. The production teams had the authority and responsibility to operate and make daily production decisions.

Team feedback: The production team held a daily visual management meeting to review their status (yesterday's results and deviations), identify absenteeism and plan assembly and specialist role tasks. There was also a longer weekly improvement meeting, which included following up on the previous week's specialist role tasks and the status of improvements. Based on the company's operations management strategy, the production teams established their own vision and goals, considering their working situation together with their front-line manager. These goals were sometimes discussed and followed up on during these improvement meetings.

5.1.1.3 Organisation-level dimensions impact on operators' basic psychological needs. *Facility layout:* Two main product types were assembled on a single intermittently moving assembly line, with no buffers between workstations.

Workplace design: Operators assembled heavy components and endured physical demands and challenging postures. They had their own equipment and tools at each workstation. The physical work context was a traditional production facility that neither facilitated nor hampered the learning opportunities.

Organisational structure: Front-line managers' span of control was set at 20 operators, organised into two production teams. Second-line managers were responsible for ten front-line managers. Many traditional centralised engineering tasks were decentralised to the production teams. Consequently, each operator was assigned to a specialist area (see task characteristics), in which they worked approximately 15–20% of their time.

CI infrastructure: The company changed the role of the support function from a traditional centralised specialist role to a support role for the production teams. Consequently, many traditional centralised engineering tasks were decentralised to production teams. Engineers from support functions led and coached the specialist teams, contributed in-depth knowledge in the area and acted as mentors. This organisational change gave engineers more time to work on long-term development projects.

Operations strategy and human resource practices: The operating strategy consisted of values, principles and goals and was illustrated as a production system. There was a vision of humanistic leadership, meaning to empower subordinates, act as a coach and work actively with images and metaphors to provide energy and create consensus around the overall vision.

> Days when we actively discussed our Production System, what it means, what it means for us. We had off-site meetings where we presented and got to know each other and ourselves using different tools, and we were also paired up, so you worked with the person who was closest to the line. We were also paired up based on different skills, different backgrounds. (Front-line manager)

Front-line managers continuously worked to translate each principle and goal into day-to-day work activities and strategies for both individuals and their team. This was done by including it on the agenda for continuous improvement meetings. Front-line managers were expected to act in line with the agreed values and to spend 50% of their time on the shop floor.

Table 1 shows the BPN ratings for the technical subsystem across the different dimensions. The rating is based on the characteristics considered most significant for each dimension.

5.1.2 Social subsystem dimensions impact on operators' basic psychological needs. 5.1.2.1 Work-level dimensions impact on operators' basic psychological needs. *Transformational leadership:* Leadership was characterised by a humanistic view and encouraged all employees to seek learning opportunities. There was a strong emphasis on building trust and relationships with each operator.

Table 1. Technical subsystem's impact on operators' basic psychological need satisfaction. It is a five-point Likert scale

Dimensions	The technical sub-system characteristics	A	C	R
Task characteristics	• The short cycle assembly work had standardised work procedures with low task variation	–	–	0
	• Through their specialist role, operators were involved in designing their own process and its outcome (containing both task and skill variety)	++	++	+
	• Assembly work had no substantial impact on others, but activities were arranged to make the operators aware of customer needs and how their contribution affected the end product	0	0	+
	• Assembly work did not contribute to a whole and identifiable piece of work	0	0	–
	• Operators' specialist role tasks contained identifiable and whole tasks	0	+	+
Cognitive demand	• Assembly work was characterised by low process information and job complexity	0	−	0
	• Operators' specialist role tasks were high in job complexity, and there was need for information processing	0	++	0
	• Operators' specialist role tasks were specialised, and there was need for innovation	+	++	+
Work autonomy	• Operators' assembly work did not include freedom in choice autonomy	−	0	0
	• In operators' specialist role tasks, they had responsible autonomy	++	0	+
Feedback from the job	• Operators received direct feedback from their assembly work	0	+	0
Team size and composition	• The team size of ten made the operators feeling to be part of a team	0	0	++
Team tasks and structural dependence	• Each team owned their line-segment and had the authority and responsibility of developing it	++	+	+
	• The skill differentiation in the team helped them to operate, control and improve their line segment (e.g. capacity planning, product changes, process deviations, etc.)	+	+	++
	• Assembly work did not have task interdependence between the operators	0	0	–
	• Continuous improvement work was role-integrated in nature and created a structural dependence between operators to innovate and solve deviation problems	0	+	++
Facility layout	• An intermittently moving assembly line controlled the work	−	0	–
Workplace design	• Operators assembled heavy products with physical demands and challenging postures	0	0	–
Org. structure	• Front-line managers' span of control was set to maximum 20 operators, which facilitated the relatedness	0	0	++
CI infrastructure	• The production team had a daily management meeting to visualise status (yesterday's results and deviations), identify absenteeism and plan the assembly and the special role tasks	+	+	+
	• The production team had weekly improvement meeting, which included both following up on previous weeks, specialist role tasks and improvement status	++	+	++
Operations strategy	• The production teams established their own vision and goals according to their work situation	+	+	+

Note(s): – major negative impact, - minor negative impact, 0 no impact, + minor positive impact and ++ major positive impact

Source(s): Authors' own work

Front-line managers spent one hour every shift with individual operators, discussing and coaching. They began each dialogue by asking “how are you”, picking up on potential personal problems. They spent a total of about 50% of their time on the shop floor and were expected to, and strived to, act on the basis of the values and principles agreed within the organisation, thus serving as role models.

Front-line managers spent a lot of time understanding team dynamics (group dynamic result analysis) and met weekly with the team leaders to discuss the team atmosphere. They worked actively with the team’s values and norms, especially with those individuals who had a strong impact on the culture. If needed, leaders worked individually with those who did not fit in. The intention was to understand the operator’s situation and develop individuals based on their own preconditions. Front-line managers focused on training and developing the operators and on establishing a culture and structure that improved work.

Front-line managers also worked on developing their leadership skills and had their own development plan outlining the kind of leader they wanted to be. They held weekly meetings with the team leaders, during which each team leader had to describe how their team was performing. Was there anyone who did not or was unable to contribute in a desirable way? Often, it was about preparing the team leader to have a discussion with the operators.

> It was also discovered over time how much it was appreciated and rewarding to have this common value base and culture together with the structure [organisation]. I have reflected on that afterwards. It is both the cultural and structural. You only get the culture by taking all the individual components and starting to form them together to put them together, what is important and not, what does presence on the line mean? (Front-line manager)

The individual discussions that front-line managers had with operators fostered relationships. They sought to provide ongoing feedback on operators’ performance and supported their employees in developing their talents and skills. By encouraging operators to take part in the improvement work, front-line managers contributed to intellectual stimulation. Within the framework of the improvement work, operators were encouraged to find new, better ways of carrying out the work and to develop the standards that had been established. Creativity was stimulated through this improvement work and the specialist role tasks in which they were involved. This enabled operators to develop their talents in areas that interested them while simultaneously supporting the development of the company.

Transactional leadership and laissez-faire: The leaders’ behaviours appear to be, to a small extent, associated with transactional leadership. If undesirable behaviours were observed, they engaged in dialogue with those concerned. If necessary, they acted, and to some extent, this can be associated with active management by exception. The leaders did not exhibit laissez-faire behaviours.

5.1.2.2 Team-level dimensions impact on operators’ basic psychological needs. *Cognitive team emergent stage:* Front-line managers and team members spent a lot of time building trust within the team, developing group norms and creating a healthy team climate. The managers worked actively with team cognition (shared mental models) within the teams, emphasising the importance of creating images of the future that gave meaning to everyday work.

Affective team emergent stages: The team’s authority of the line segment contributed to task cohesion, along with the daily visual management meeting to visualise the team’s shared tasks. The specialist role team members exchanged experiences and collectively developed knowledge, which strengthened team cohesion. Top management worked for several years to increase psychological safety by establishing a culture where it was acceptable to speak up, to make mistakes and take initiative.

Motivational team emergent stages: Through awareness, responsibilities and activities, the production teams developed team efficacy in solving problems and running their line segment. At the daily management meeting, the team brought forward deviations from the previous day, including incidents and accidents, quality, assembly tasks and stop time. Production teams were responsible for solving problems and developing processes during improvement work and specialist role tasks. Thus, production team members developed confidence in their ability to solve problems and perform role tasks to run their line segment. They built a deep collective knowledge base from their specialist roles.

5.1.2.3 Organisation-level impact on operators' impact on operators' BPNs. *Artefacts:* The production management group worked actively with images and metaphors to energise and build consensus around the vision. The group met every other week for 1.5 h to discuss the vision and other leadership-related topics. In this context, the plant manager played an important role in coaching front-line managers, both individually and in groups. The driving force was to establish images of the future that made sense in the present, thereby enabling operators and leaders to create their own images. Based on this inner image, they began to change the outer reality to move closer to the desired future state. Consequently, front-line managers, together with each operator, created a desirable mental image of the future state and demanded commitment.

> . . . in a leadership forum, where all the leaders gathered in a room where one was responsible for bringing up a topic to discuss openly. Notebooks were not allowed; it was just supposed to be dialogue. . . . . . . In addition, in the spring and autumn we had two days off-site where we focused both on the hard topics, i.e. setting new goals, but also on the soft topics - who we are, what we need to develop, and what our strengths and challenges are. (Front-line manager)

Norms and Values: Operators were regarded as experts in their processes and working methods. Everyone was expected to help one another and operators received advice and social support. All employees should be given the opportunity to develop, and they were expected to do so. The leaders believed that every individual had the potential to develop under the right conditions, but that past experiences could hinder them.

Table 2 shows, for the social subsystem, the results of the BPN rating across the different dimensions. The rating is based on the characteristics considered most significant for each dimension.

6. Discussion

The section begins by discussing lean as a learning system and the key factors in the case company that formed a lean learning system. The second part examines how operators' work situations, based on the socio-technical model developed in the analytical framework, impact work performance and well-being. This discussion generates three propositions and extends the basic self-determination theory model for work organisations by exploring and proposing how the social and technical systems relate to work performance and well-being.

6.1 Lean as a learning system

The view of lean production has gone from isolated tools to a philosophy and management model (Jörgensen *et al.*, 2007). Furthermore, many of the failed lean implementations are explained by shortcomings in leadership and involvement of employees (Loh *et al.*, 2019; Dombrowski and Mielke, 2013; Mann, 2009). There are descriptions of managers' behaviour in successful lean settings (e.g. Emiliani, 1998; Mann, 2009; van Dun and Wilderom, 2016; Camuffo and Gerli, 2018) and descriptions of operation strategies that involve employees (Liker and Convis, 2011) as well as the importance of building problem-solving skills (Worley and Doolan, 2015). Here, operators' problem-solving skills are mostly described in terms of generic problem-solving capabilities (e.g. Worley and Doolan, 2015). However, to build a learning system with autonomous production teams that can operate, control and improve their line segment, complementary skills are necessary. Because, in this case, the production team members had different specialist roles, it created both depth and a width of knowledge and formed a structural dependence, in terms of skill differentiation, team authority and team stability. This resulted in a high level of cognitive, affective and motivational team emergent states. The lack of structural dependence and specialisation within production teams can be

Table 2. Social subsystem's impact on operators' basic psychological need satisfaction. It is a five-point Likert scale

Dimensions	The social sub-system characteristics	A	C	R
Transformational leadership	• Great emphasis was placed on creating trust and a relationship with each operator	0	+	++
	• Front-line managers' intentions were to understand each operator's situation and develop the individuals based on their own preconditions	0	++	++
	• Front-line managers tried to match each operator's talent and interests with dedicated special role tasks to create development paths	+	++	++
	• Front-line managers coached and supported operators to develop talents and skills	0	++	++
	• By supporting and expecting operators to take part in the improvement work, front-line managers contributed to intellectual stimulation	0	++	+
Transactional and laissez-fair	• If undesirable behaviours were observed, they engaged in dialogue with those concerned and acted if necessary	–	0	–
Cognitive team emergent stage	• A lot of efforts were put on building trust and relationships in the teams	0	+	++
	• Front-line managers and team members spent a lot of time developing group norms and creating a healthy team climate	0	0	++
	• The front-line managers worked actively with team cognition (shared mental models)	+	+	+
Affective team emergent stage	• A culture where it was okay to speak up, to make mistakes and to take initiative	+	+	++
	• The specialist role team members exchanged experiences and developed knowledge collectively, which created team cohesion	+	+	++
Motivational team emergent stage	• The production teams developed efficacy regarding their ability to solve problems and run their line segments	0	++	++
Artefacts, Norms and Values	• Together with each operator, the front-line managers tried to create a desirable mental image of a future state and demanded commitment	+	+	+
	• Operators were seen as experts in their process and working methods	0	++	+
	• All employees should be given the opportunity to develop, and they were expected to do so	+	++	+
	• The leaders believed that every individual had the potential to develop under the right conditions, but that individuals were formed by past experiences, which could hinder them	0	+	++

Note(s): – major negative impact, - minor negative impact, 0 no impact, + minor positive impact and ++ major positive impact

Source(s): Authors' own work

one of the reasons why continuous improvement solutions don't reach high levels of innovation and why it is so difficult to achieve a truly lean learning system.

Leadership is emphasised as a key factor for success given the socio-technical nature of lean systems (Mann, 2009; Shah and Ward, 2007; Seidel *et al*., 2019). Consequently, leaders at all organisational levels need to work with lean culture and, in many cases, change their mindset and behaviour (Aij and Rapsaniotis, 2017). Front-line managers' coaching behaviour and social aspects within the production team had a strong impact on operators' BPNs, e.g. the dedication of one hour for individual dialogue. The intention was to understand each operator's specific situation and develop individuals based on their own preconditions, thereby meeting the basic psychological need for relatedness. This humanistic leadership vision, where "every employee has a hidden potential", aligns with behaviours associated with transformational leadership and lean leadership, supporting the findings of van Dun and Wilderom (2016, 2021) and is close to Whitmore's (2017) description of coaching. The production team had authority (team autonomy) over its process, and all 10 operators held different specialist roles, leading to interdependence and production team efficacy, which strongly impacted the operators' BPNs for relatedness and competence. Each operator's specialist role was matched to their talent and interests and also belonged to a team coached by an expert, leading to knowledge and personal growth and fulfilling the BPN of competence.

To sum up, the technical system (design values, principles, methods and processes) in the case company was quite ordinary from a lean perspective. What made the case company unique was the social system and the interrelation between the social and technical systems, meaning an appropriate organisational design for developing and supporting people. They succeeded in creating an environment where operators had their BPNs satisfied, despite working on an assembly line with a high level of control. This was achieved through a humanistic leadership model and the decentralisation of engineering tasks and continuous improvement work for the production team and the operators. This resulted in team autonomy and, for the individual operator, increased autonomy, competence and relatedness.

6.2 Technical subsystem impacts on the social subsystem, work performance and well-being

The design of the technical system impacts work performance. For example, Kovács (2020) suggests a methodology for layout design and lean tool applications to achieve performance improvements. In serial flow, various inefficiencies arise and system losses stemming from technical system design and human behaviour are often attributable to the chosen system design (Wild, 1975). Furthermore, many studies show that poor physical working conditions have a negative effect on health, causing musculoskeletal disorders (Punnett and Wegman, 2004). Repetitive motions, especially in short-cycle work at assembly lines, cause musculoskeletal disorders (Ranney *et al.*, 1995).

The social subsystem dimensions had a greater impact on operators' BPNS than the technical subsystem dimensions (Tables 1 and 2). However, these results would not have been possible without the right design, supporting the view that the two subsystems must be jointly optimised (Pasmore *et al.*, 2019; Fox, 1995). The front-line manager's span of control was set at approximately 20 operators, equivalent to two teams, and the manager was expected to co-create the teams' goals as well as individual goals aligned with the company's overall vision and goals. Fifty percent of the planned work for the front-line manager was spent on the shop floor, supporting the teams and operators in their development. Thus, the technical subsystem sets boundaries for what is possible in the social subsystem; for example, time for coaching and developing subordinates was made possible by reducing the span of control and removing administrative tasks. These relations suggest that the design of the technical system impacts the operators' social system (Figure 3), and the findings support Bortolotti *et al*. (2017), who found that social outcomes are impacted by continuous improvement design and processes, organisational and work area management.

P1a. The technical subsystem impacts operators' work performance and well-being

P1b. The technical subsystem moderates operators' social subsystem.

6.3 BPNs and motivation as mediators between operators' work situation and work performance and well-being

The assembly line with no buffers created a high workload and limited work content, and it meant that the operator's assembly work was controlled by the technical system (e.g. no work schedule or work method autonomy). This had a strongly negative impact on the operators'

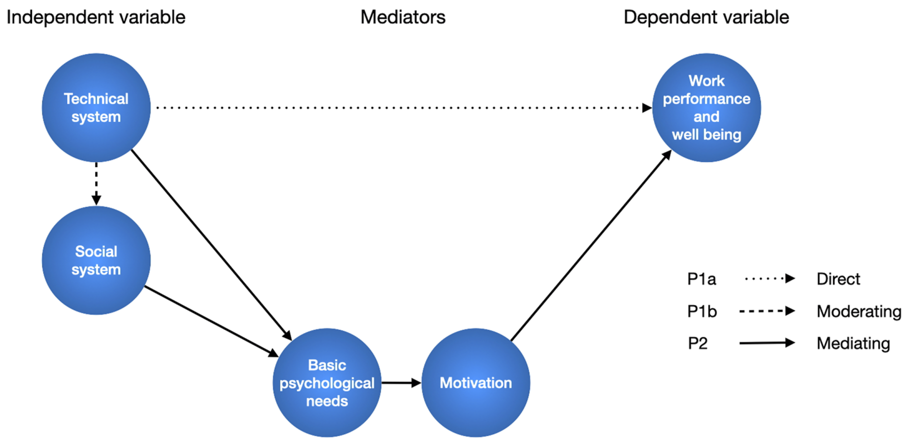

Figure 3. Extended self-determination model for work organisations with the suggested propositions. Individual differences variable was outside scope of this paper and therefore shaded. Source: Authors' own work

BPNs, especially autonomy (Table 1). What made this case unique was the operational strategy and the creation of an organisational structure to design a lean learning system with continuous learning opportunities. This was done by shifting the division of labour between operators and support functions, so each operator became responsible for a specialist role and was included in a specialist role team, where an engineering specialist contributed deep knowledge and acted as a coach. Operators' specialist roles included job complexity, information processing, innovation and specialisation. Furthermore, the role tasks and improvement work contained identifiable, whole tasks where the operators were responsible for planning, conducting and reflecting on results (individual and team autonomy). Furthermore, responsibility for managing, controlling and improving the line segments was delegated to the production teams, allowing them to operate as autonomous teams. Thus, the organisational design with production teams and specialist role teams, together with the design of individual- and team-level task characteristics, had a strong, positive impact on all three BPNs, enabling operators to make choices and increasing their capability and opportunity to work together with others (Table 1).

Front-line managers played a central role in operators' social subsystem, spending considerable time gaining in-depth knowledge through dialogue, often discussing private matters with their subordinates, which was important for building trust. They needed this deep knowledge to match each operator's talent and interest with appropriate specialist role tasks, and their intention was to understand each operator's specific situation and develop individuals based on their own preconditions. It was necessary for front-line managers to trust, respect and have high expectations of their subordinates; otherwise, the managers would have to shift teams. The above description closely aligns with transformational leadership theory and this leadership had a strong, positive impact on operators' BPNs (Table 2). The production teams were given opportunities to decide and solve a range of upcoming problems (team autonomy), which led to high task cohesion, high group efficacy and high interdependence among team members, positively affecting operators' fulfilment of their BPNs (Table 2). The operators also felt support from persons outside the production team, especially the engineering specialist.

The relationship between the operators' work situation (shaped by both technical and social systems) and outcomes (performance and well-being) is mediated by the satisfaction of the operators' BPNs and their motivation (Figure 3). When technical and social systems jointly support autonomy, competence and relatedness, operators experience higher motivation – particularly autonomous motivation – which is associated with better performance and greater well-being. In the case of this company, the change of the production organisation had a clear impact on work performance and improved well-being, with productivity increasing by 50% and sick leave absences decreasing by 80%. These findings support earlier studies indicating BPNs as a mediating variable (Baard *et al.*, 2004). Motivation (autonomous and/or controlled) has also been shown by earlier studies to have a mediating effect (e.g. Fernet *et al.*, 2015).

P2. Basic psychological needs and motivation are mediating variables between the social and technical subsystems and operators' work performance and well-being.

7. Conclusions

This study demonstrates that operators' BPNs can be fulfilled despite working on an assembly line by designing a work organisation based on lean as a learning system. Operators' BPNs are fulfilled through work enrichment, in terms of operators' and production teams' authority and responsibility to operate, control and improve their assembly line segment. This creates awareness, responsibility and structural dependence within production teams, where operators have complementary skills and there are team authority and stability. To achieve this, organisational strategy, production teams, work design and leadership behaviour are key. The findings show that social dimensions have a strong impact on operators' BPNs, and, in the case company, when social system aspects were given the same level of dedication as the technical system aspects, considerable improvements in work performance and well-being were achieved.

7.1 Theoretical implications

The research extends the basic self-determination model for work organisations by operationalising the workplace context through both social and technical subsystem dimensions. The developed model shows how the social and the technical subsystems, separately and in relation to each other, impact operators' BPNs and motivation. The division into social and technical systems also generates propositions about relations between the work situation and work performance and wellness.

7.2 Practical implications

The practical implications include the need to consider both the social and technical systems of a work situation when initiating a lean learning system and to deepen understanding of how it will impact operators' BPNs and how this can benefit an organisation. Daily kaizens are key to successful lean organisations and to operators' work satisfaction. The manager's role in supporting operators' work and development is crucial. It is important to have an organisational structure and job design that support the lean learning system, e.g. span of control, team sizes and compositions, work tasks, etc. The model with operationalised social and technical subsystems dimensions can be used by managers to analyse and understand operators' work situation. This model can also be used to increase operators' work performance and well-being.

7.3 Future research and research limitations

The findings are based on a single case in a specific industrial context, which may limit the study's generalisability. The retrospective design and reliance on interviews and internal documents may also introduce bias. Therefore, further validation and refinement of the extended self-determination theory (SDT) model proposed in this study are needed. Quantitative, survey-based research could be employed to test the relationships within the extended model across different organisations and contexts. Additionally, mixed-methods studies that combine in-depth organisational case studies with standardised measures would allow triangulation of findings, offering both breadth and depth in understanding these interactions.

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