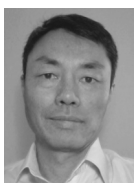
Engaging environments: tacit knowledge sharing on the shop floor

Davi Nakano, Jorge Muniz Jr and Edgard Dias Batista Jr



Davi Nakano is based at the Universidade de Sao Paulo, Sao Paulo, Brazil.
Jorge Muniz Jr is based at the Universidade Estadual Paulista, Guaratingueta, Brazil.
Edgard Dias Batista Jr was based at the Universidade Estadual Paulista, Guaratingueta, Brazil.

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Abstract

Purpose – *The purpose of this paper is to identify factors that facilitate tacit knowledge sharing in unstructured work environments, such as those found in automated production lines.*

Design/methodology/approach – *The study is based on a qualitative approach, and it draws data from a four-month field study at a blown-molded glass factory. Data collection techniques included interviews, informal conversations and on-site observations, and data were interpreted using content analysis.*

Findings – *The results indicated that sharing of tacit knowledge is facilitated by an engaging environment. An engaging environment is supported by shared language and knowledge, which are developed through intense communication and a strong sense of collegiality and a social climate that is dominated by openness and trust. Other factors that contribute to the creation of an engaging environment include managerial efforts to provide appropriate work conditions and to communicate company goals, and HRM practices such as the provision of formal training, on-the-job training and incentives.*

Practical implications – *This paper clarifies the scope of managerial actions that impact knowledge creation and sharing among blue-collar workers.*

Originality/value – *Despite the acknowledgement of the importance of blue-collar workers' knowledge, both the knowledge management and operations management literatures have devoted limited attention to it. Studies related to knowledge management in unstructured working environments are also not abundant.*

Keywords *Tacit knowledge, Blue collar workers, Knowledge management, Shop floor, Knowledge sharing*

Paper type *Research paper*

1. Introduction

Tacit knowledge is regarded as a key competitive resource for companies; this knowledge plays a significant role on the shop floor. Theory and practice regarding work have greatly evolved since Taylor's conception of a worker as a non-reasoning individual whose only contribution to a firm's operations was his/her physical strength and abilities. Shop floor workers develop, share and use tacit knowledge as they perform their daily duties; these processes are fundamental aspects of efficient manufacturing operations.

East-Asian firms were among the first companies to use the knowledge of shop floor workers to enhance manufacturing performance. In particular, instead of making decisions in their offices, Japanese managers were urged to analyze operational problems at the locations where these problem soccurred, i.e. the shop floor (the ''*gem ba*'') (Ohno, 1988) and to make use of the knowledge of laborers in problem-solving by eliciting participation and suggestions from these laborers. All of the members of an organization, regardless of rank, were expected to contribute to enhancing overall organizational efficiency, and knowledge that was developed by blue-collar workers on the shop floor was considered to be extremely valuable.

The widespread acceptance of lean manufacturing caused work organization and managerial practices to evolve toward granting workers a degree of voice and autonomy, and teamwork and participative problem-solving have become recommended practices in operations management. Interestingly, lean manufacturing practices have even been regarded as applicable to knowledge-based tasks and to symbolic workers (Staats *et al.*, 2011).

However, despite widespread acknowledgment of the importance of the knowledge of shop floor workers, the knowledge management (KM) literature has not devoted much attention to it. Instead, this body of literature has focused on symbolic workers, white collars and students' tacit knowledge (e.g. Henttonen, 2010; Wong, 2008), project teams (Erhardt, 2011; Costanzo and Tzoumpa, 2008) and collaborative work (Fransilla *et al.*, 2012). The operations management literature has also overlooked the knowledge of shop floor workers and has instead opted to address tacit knowledge with respect to symbolic workers (Dell'era and Verganti, 2009), knowledge-intensive work (Rosendaal, 2009), knowledge in high-tech firms (Yang, 2010) and knowledge and project management (Hong *et al.*, 2011; Koners and Goffin, 2007).

Studies on the knowledge of blue-collar workers have found that important factors for the creation and dissemination of this knowledge include social networks (Janhonen and Johanson, 2011); social climate and trust (Rosendaal, 2009); and physical space and time (Styhre, 2008). In addition, structured work environments in which procedures are recorded and both communication and knowledge sharing are embedded within routines as those created when lean manufacturing practices are followed, enhance knowledge dissemination (Miyake and Nakano, 2007). Previous research in the automotive industry (Muniz *et al.*, 2010a, b) has also identified that knowledge management and structured practices are related phenomena that combine to enhance knowledge sharing and productivity among blue-collar workers.

However, many shop floors, such as the work environments for flexible manufacturing systems and chemical plant control rooms, are less structured than the shop floors of automakers and global auto part producers. In these less unstructured settings, procedures are not fully recorded, and productivity is dependent on the tacit knowledge of blue-collar workers. These types of work environments may lack documented practices because of high recording costs rather than because of poor management. In these types of operations, workers must take action to address any abnormal working conditions that may arise; these abnormalities may cause non-conformities and require adjustments to the operational parameters of machines. Skilled, high-performing blue-collar workers develop tacit knowledge to quickly make sense of non-routine events and to take actions that return malfunctioning systems to normal conditions. Although these events will occasionally recur, they are frequently unpredictable and involve small variations that create subtle distinctions between separate non-routine events. This issue can render it costly or unfeasible to externalize knowledge regarding how to address these events; thus, this knowledge often remains tacit, only known by blue-collar workers.

The purpose of this paper is to identify factors that facilitate tacit knowledge sharing in unstructured work environments. Knowledge sharing is defined in this study as the ''exchange of explicit and tacit knowledge relevant to the team task'' (Lee *et al.*, 2010, p. 474), and tacit knowledge is restricted to the ability to identify and solve problems by developing mental models of work situations (Harlow, 2008). This latter definition is narrower than many descriptions of tacit knowledge; nevertheless, it is relevant in the work context of blue-collar workers. In this study, field research was conducted for four months at a blown-molded glass production unit that was equipped with semi-automated machines. This unit is successfully operated by under-educated workers, and its efficiency and output are highly dependent on the tacit knowledge of these blue-collars.

It has been determined that knowledge sharing occurs within a favorable environment; in particular, Nonaka and colleagues (Nonaka and Konno, 1998; Nonaka and Toyama, 2003) have used the Japanese word ''*ba*'' to refer to this type of environment. A working context that is favorable for knowledge sharing is created through the use of a combination of

organizational practices and communication tools (Nonaka and Konno, 1998) and is supported by communication, social networks and trust (Malhotra and Majchrzak, 2004).The aforementioned enabling conditions have been discussed in studies of white-collar and symbolic workers; however, it was unclear whether these factors also influence knowledge sharing among blue-collars, who possess lower levels of autonomy and formal education than white-collar and symbolic workers. In this study, it was determined that important factors for the dissemination of tacit knowledge include not only the factors mentioned above but also the presence of active engagement and shared concerns about efficiency among workers and supervisors.

Individual engagement and shared concerns regarding performance were observed to be critical enabling factors for knowledge sharing that engender group bonding and collective action. In an examination of aircraft carrier deck teams, Weick and Roberts (1993) found that if team members share concerns regarding efficiency and safety, these team members are able to make decisions and take action in challenging situations. Weick and Roberts (1993) referred to these conditions as a ''heedful environment''. However, these researchers limited the conception of this environment to organizations that were concerned about reliability instead of operational efficiency; thus, their notion of a ''heedful environment'' is not applicable to routine operations.

In this study, it was found that engagement and shared concerns regarding efficiency help to maintain and disseminate tacit knowledge on the shop floor. Adapting the concept devised by Weick and Roberts (1993), we refer to these conditions as an ''engaging work environment''. Data and field observations revealed that this type of context is created if blue-collar workers are made aware of both their responsibilities and the importance of good practices and if managers are concerned both with operational performance and with allowing workers to obtain opportunities to undergo professional development.

To achieve the aforementioned objectives, this paper is structured as follows. Section 2 discusses knowledge management and the sharing of knowledge among blue-collar workers. Section 3 describes the research setting, section 4 the methods of this study, and section 5 presents an analysis of the results of this investigation. Section 6 presents the conclusions of this paper.

2. Blue-collar workers' knowledge and knowledge management

The KM literature can be roughly divided into two streams. One regards knowledge as an asset that is capable of being stored, combined and disseminated, whereas in the second literature stream, knowledge is embedded in relationships and cannot be separated from actions. Thus, this second perspective stresses the role of social relationships and both individual and collective actions in knowledge management. These two literature streams can be traced back to the early KM literature. In particular, Tsoukas (1996) divided KM studies into two approaches: in one, knowledge can be reduced to a portable object, whereas in the other approach, knowledge is present in individuals and their relationships. Alvesson and Kärreman (2001) and Hazlett *et al.* (2005) argued that knowledge can be not only stored and disseminated by information technology-based systems, but can also be created and shared within groups and relationships. Although it is analytically useful to study knowledge in accordance with one of these two views, the actual nature of knowledge varies along a continuum (Leung, 2009); specifically, knowledge regarding operations is not only stored in documents, files and folders but also resides in individuals, actions and relationships, and it is mingled in everyday activities (Tsoukas, 1996; Orlikowski, 2002).

Much of what is found in the KM literature is associated with symbolic workers within knowledge-intensive firms (Alvesson, 2004), such as professional service firms and R&D units. Symbolic workers, which include researchers, lawyers, consultants and accountants, have a degree of autonomy over their work and can make decisions regarding how and when this work is performed. Symbolic workers also have high levels of formal education and training, and professional norms both grant these workers autonomy and require them to collaborate with their peers. Thus, in their professional roles, these workers are expected to consult with their colleagues, receive and provide advice and share knowledge.

Relative to symbolic workers, blue-collars have less formal education (particularly in developing countries) and are not guided by professional norms that require peer collaboration. Their work is repetitive. Moreover, in many cases, such as situations in which total quality management (TQM) has been adopted, operational procedures are highly formalized; these procedures are recorded, predefined and enforced. Although a large amount of knowledge on operations may be encoded in procedures, blue-collar workers develop tacit knowledge as they perform their duties; this tacit knowledge is critical for operational performance (Vallas and Beck, 1996). A standard operational procedure incorporates explicit knowledge derived from previous experiences; however, this procedure is useless until it is actually enacted by workers on the shop floor. As these workers follow procedures and perform their tasks, they create tacit knowledge, which is individual and context-related and, due to its nature, it is not easily shared.

Participative practices can foster knowledge sharing on the shop-floor level. Japanese operations management techniques were the first management approaches that not only allowed a degree of autonomy and discretion to blue-collar workers, but also demanded that these workers enhance the results of existing procedures and create new protocols by participating in, discussing, analyzing and contributing to problem-solving processes. Various practices, such as housekeeping (5S) (Ohno, 1988), problem-solving groups (*kaizen*) (Garvin, 1993; Kolb, 1984), simple error-proofing methods (*poka yoke*) (Ohno, 1988; Black, 1991) and quick changeovers (Black, 1991; Shingo, 1989), are based on the initiative and participation of workers, and the positive influence of workers on knowledge sharing has already been established. For instance, *kaizen* fosters knowledge creation and sharing by requiring the following organizational practices that are enablers of knowledge creation and sharing:

- horizontal structures in which power distances are small and cross-functional relationships are encouraged;
- collective membership approaches in which individuals recognize that their interests are fulfilled by their organization;
- informal, *ad hoc* relationships; and
- knowledge exploitation that has been enriched by a certain degree of exploration (Magnier-Watanabe, 2011).

In addition, structured operational practices (Bartezzaghi, 1999; Ohno, 1988) work in combination with knowledge management practices to enhance productivity (Muniz *et al.*, 2010a, b). These organizational practices are prescribed by TQM and have been adopted extensively in the automotive industry. Structured practices provide a common language and a shared knowledge base that facilitate knowledge dissemination; thus, these practices can emulate *ba*, which refers to a favorable environment for tacit knowledge creation and sharing that is based on good communication, trust and empathy and involves the stimulation of personal interactions (Nonaka and Konno, 1998; Nonaka and Toyama, 2003). As blue-collar workers are trained in structured practices, they acquire shared language and knowledge resources, which combine to overcome their lack of formal education and professional norms and help establish a common mindset on the shop floor.

Thus, the literature demonstrates that the adoption of participative operational practices and structured procedures on the shop floor promotes knowledge creation and sharing. These practices utilize cross-functional relationships and promote cooperation, the formation of *ad hoc* relationships and the creation of structures that are less hierarchical than traditional organizational configurations. These practices also create a sense of membership, common language and shared understanding, which synergize to enable knowledge sharing.

However, structured practices are not used by every manufacturing unit. Structured practices may be neglected either because for certain firms these practices are not a client requirement or because they are too difficult or costly to be recorded and implemented. This issue arises in situations involving manufacturing units that possess automated machinery. In these types of operations, workers' tasks are primarily related to completing equipment set-up, quality control and repairing malfunctioning equipment. Although set-up and quality

control procedures are readily able to be standardized and recorded, deviations from standard parameters may have numerous causes and high variability; thus, it is not feasible to record all of these deviations and define standard procedures for addressing all possible situations. Additionally, in the case of new and unpredicted situations, existing standard procedures can become useless. Thus, structured practices may not be regarded as important and may not be adopted, and the side effects of these practices with respect to fostering knowledge sharing will not occur.

The literature suggests that to engage in effective and reliable responses to critical, highly demanding situations, it is necessary to create an environment in which all individuals are actively engaged in heedful action (Weick and Roberts, 1993). Similarly, in less critical and demanding situations, such as automated equipment operation, it can be argued that to cope with unpredicted events, all relevant individuals must be not only engaged in problem solving but also committed to avoiding deviations and to enhancing performance. This type of collective behavior can fulfill the role of structured practices in fostering knowledge sharing and can create a common language and knowledge base among workers.

To face unpredicted situations, creativity and initiative are required; in other words, knowledge creation must occur. Nonaka, Takeuchi and colleagues (Nonaka and Takeuchi, 1995; Von Krogh *et al.*, 2000) revealed the following enablers, which foster a context in which creativity and knowledge creation are promoted:

- strategic intent;
- autonomy;
- fluctuation and creative chaos;
- redundancy; and
- requisite variety.

Strategic intent is revealed in the level of emphasis that the managerial team of a firm devotes to knowledge creation, acquisition and sharing in strategic planning. Individual autonomy derives from an organization's structure and practices and results in self-motivation and initiative. Fluctuation and creative chaos are related to an organization's relationship with its environment, the ways in which an organization reacts to crises that have been triggered by external sources, and how organizational members both make sense of these crises and change their approaches to address appropriately the situations that they face. To be able to take action in face of an environmental change, managers and organizational members should generate creative chaos by reflecting on and questioning their assumptions and beliefs.

Redundancy refers to information circulation and availability. Information must be disseminated to various individuals, including those who do not immediately need the information in question. This encourages tacit knowledge sharing because it enables members to detect what their colleagues are doing and thinking. Redundancy also creates not only a sense of belonging and connectedness but also an understanding of each member's position within an organization. Finally, requisite variety is related to an organization's environment. To ensure that an organization can respond effectively to its challenges, the organization's internal information diversity should match the complexity of its environment. Requisite variety is connected to the previous factors that have been described, especially redundancy and autonomy.

A context that is based on collective effort also requires individual commitment to dedicate time to knowledge sharing, even if this time is not provided by the organization. Tacit knowledge sharing is more effective in informal settings than in formal contexts (Seidler-de Alwis and Hartmann, 2008). Thus, members should be personally committed to sharing their knowledge, particularly in highly bureaucratic organizations in which knowledge sharing is not the norm (Baskerville and Dulipovici, 2006). Collective action also requires levels of openness and trust among organizational members that allow these members to express their impressions and to make sense to each other (Malhotra and Majchrzak, 2004; Rosendaal, 2009; Seidler-de Alwis and Hartmann, 2008).

In accordance with the work of Weick and Roberts (1993), who coined the term ''heedful environment'' to describe the context that they discovered in high-reliability systems, a context in which individual and collective actions reinforce each other on the shop floor and in which all individuals are committed to efficient operations will be referred to as an ''engaging environment''. An engaging environment facilitates tacit knowledge dissemination.

According to the extant literature, an engaging environment is more likely to occur if an organization is structured such that its power distance is small, allowing organizational members to develop a sense of collegiality and develop *ad hoc* relationships to solve problems collectively. Organizational members should also possess individual autonomy and share a common understanding and knowledge base. Furthermore, openness, trust and good communication among organizational members are important aspects of an engaging environment. Managers should make decisions that emphasize the importance of collective and individual action and recognize the value of knowledge sharing. Moreover, important enablers of an engaging environment include a level of knowledge diversity that matches the complexity of an organization's environment and the ability to make sense of and respond to external changes.

Because the aforementioned enablers have largely been identified and discussed in studies of product development and software teams and examinations of structured work environments, the next section of this paper reports on a qualitative study that was conducted to verify whether these enablers are also applicable among blue-collar workers on a less-structured shop floor.

3. Sharing knowledge: a study of a blown-molded glass unit

Blow molding is an ancient technique that is used to produce glass bottles and hollow and solid shapes for industrial and domestic applications. In the past, bottles were handmade; however, modern processes utilize high-capacity furnaces and press machines to produce a variety of glass bottles and containers. The same equipment can also be used to press glass into solid items, to create glass objects that serve as home decoration pieces, tableware and kitchenware, and to produce various other glass artifacts.

The process of producing glass artifacts consists of first fusing silica and additives into molten glass and then cutting the hot, viscous mass of glass into blobs, which are then either blown-pressed or pressed against molds in hot press machines to create hollow or solid items, respectively. After glass artifacts have been molded, they are annealed to prevent cracking and then cooled; these artifacts are then finished, a process that may include sanding and painting.

The glass manufacturing process is typically split into hot and cold phases. The former phase, which is the more important of the two phases, includes the use of melting furnaces, press machines and annealing conveyors. For hot press machines, several setup parameters are critical for product quality and process productivity; these parameters must be determined and controlled through human intervention. The cold phase of the glass manufacturing process includes the use of cooling conveyors, quality control activities, finishing procedures and the packaging of the created artifacts. These activities are less complex than the events that occur during the hot phase. Tasks that occur during the cold phase of the glass manufacturing process are largely related to dimensional and visual inspection and are performed at room temperature.

The unit that is examined in this study produces glass bottles for cosmetics, pharmaceuticals and various special applications. The company's market strategy is to produce specialty glass items with elaborate shape and color combinations, targeting niche markets, such as beauty products and perfume flasks, but avoiding commodity markets, such as liquor and soft drink bottles. This strategy has proven successful, and the company is actually the largest firm in its market. As a result, this company's product line is extensive, and production batches are small and frequently changed, causing set-up to be a critical issue for operational efficiency.

The hot phase is the heart of a blown-molded glass unit. The set-up and operation of press machines requires a deep understanding of each machine; moreover, because the temperature of molten glass is approximately 1,600 degrees Celsius, safety is a concern. There are very few schools that provide technical instruction in glass manufacturing (in fact, only two schools offer this type of instruction in the Greater Sao Paulo area, which is the most industrialized region in Brazil). Thus, knowledge regarding process control and set-up parameters is developed by workers on site during the course of on-the-job training and daily operations.

In the unit's hot phase area, a straightforward career path exists. New operatives start as aides, who assist others but have the primary responsibilities of cleaning the premises and taking care of supplies. The most promising aides are assigned to mold exchange teams; during the course of their tasks, these teams acquire knowledge regarding the glass production process and the way in which press machines operate. The mold exchange team members who deliver the best performance are promoted to the role of press machine operators, which is the blue-collar position with the most prestige and the highest pay. The company provides technical training to new press operators; this training is provided by experienced (and sometimes retired) team leaders and managers. During both formal and on-the-job training, press machine operators learn how to reduce set-up time, deliver quality products, assure safety and enhance productivity.

The company's primary manufacturing assets include four melting furnaces and 21 production lines, which are composed of semi-automated press machines, annealing conveyors and cooling conveyors. At this firm, approximately 2,200 workers work in three shifts to produce 300 tons of glass items per day. Each press machine has more than 200 process parameters that must be established at the start of each different product batch; these parameters must be controlled and adjusted during production to ensure conformity to specifications. As explained above, hot-area tasks are more complex than cold-area tasks. Workers in both areas possess low levels of formal education (less than eight years). However, hot-area workers have greater experience with the firm than cold-area workers; specifically, more than 58 percent of hot-area workers have more than ten years of experience with the firm, whereas 74.1 percent of cold-area workers have less than five years of experience with the firm. This difference in experience can be explained in terms of task complexity with respect to technical content. To attain a press machine operator position, a worker must both obtain formal training and undergo years of on-the-job training. The company acknowledges the value of these positions and consequently pays higher salaries to hot-area workers than to cold-area workers and strives to keep turnover low in the hot area.

The company has its own tool shop, which performs maintenance activities for all furnaces and production lines. This tool shop is in charge of producing molds and has developed itself to be responsible for designing and constructing press machines. Similarly to hot-area tasks, tool-shop activities demand a high level of tacit knowledge.

4. Data collection and analysis

The research work that is reported in this paper was a component of a larger 16-month project that was conducted by a team of two researchers and three assistants. The findings that are reported here were obtained during the first four months of this project. During this period, the research team visited the examined unit on one or two days each week, and the activities were divided into three phases. In the first month of the research period, researchers attended several formal and informal meetings with the managerial team. During these meetings, the researchers obtained information about the company as a whole, the firm's market and strategy and the glass production process. The researchers visited production facilities several times and became acquainted with production supervisors and workers. The researchers engaged in informal conversations with supervisors, leaders and workers; moreover, they immersed themselves in the environment, which allowed them not only to understand operational tasks and the ways in which workers perform their duties, but

also to break down communication barriers and develop relationships of trust with production teams.

After the first phase of the investigation, formal and in-depth qualitative interviews were conducted at one of the unit's production lines. Melting furnaces feed molten glass to all 21 hot press machines, and each press machine, its annealing conveyor and its cooling conveyor constitute a single production line, which is divided into hot and cold areas. During each production shift, one team is responsible for each production line. The line examined was worked in three shifts by a team of 12 operators in the hot area and 27 operators in the cold area. There was one supervisor for each production shift, and each production line had its own hot-area and cold-area leaders.

Data collection occurred through semi-structured interviews, and informants were selected using a convenience sampling method (Rea and Parker, 2005). A total of 14 in-depth interviews were conducted with operators, production leaders, production supervisors, tool shop workers and tool shop leaders who were recognized by their peers as possessing particularly high levels of expertise on the shop floor (see Table I).

The interview questions were related to which factors workers and supervisors considered to be most relevant for maintaining and improving manufacturing process and product quality (see the Appendix). The relationships of trust that were developed during the first month of the research process were important for obtaining accurate information by ensuring that interviewees did not feel threatened by or suspicious of talking to the researchers. The interviews were recorded, and the average duration of each interview was 1.5 hours.

All of the interviews were fully transcribed, corresponding to a total of 86 A4 pages. To identify conceptual categories, the interview responses were analyzed using content analysis techniques (Stemler, 2001; Bardin, 2008). Data analysis was conducted looking for the importance that the interviewees attributed to operational and organizational practices and the ways in which these interviewees related these practices to knowledge creation and sharing. The data were reduced in two consecutive processes. First, the raw data from the interviews were reduced to meaning units; these meaning units were then further reduced to condensed meaning units. The condensed meaning units were then translated into codes. The data reduction and coding processes were performed by the researchers of this study.

Table II illustrates how the content analysis of this study was performed. The first column of Table II presents the meaning units that were extracted from interview transcripts (the extraction of meaning units from these transcripts constitutes the first step of the interpretation process). The second column of Table II provides condensed meaning units, which are interpreted from the meaning units in the first column; one meaning unit may contain more than one condensed meaning unit. The third column indicates the concepts that were produced by comparing several condensed meaning units; these concepts represent the final results of the interpretation process. To allow for analysis and further discussion, these concepts were based to the greatest possible extent on the notions that were discussed in the literature review presented in this paper.

To validate the coding process and the interpretations of researchers, after each analysis and data reduction all of the meaning units and condensed meaning units were presented and discussed with each interviewee; this procedure enabled the interviewees to verify that these meaning units and condensed meaning units faithfully represented the sentiments that they wished to communicate. The interviews, coding and verification procedures of this

Table I Number of interviewees by area and function

Area	*Function*	*Number of interviewees*
Hot area	Operator	3
	Production line leader	3
	Shift supervisor	2
Tool shop	Worker	3
	Leader	3

Table II Examples of data reduction

Meaning unit	*Condensed meaning unit*	*Codes*
Often, an operator is selected to learn and train other colleagues on the machine on an everyday basis during production time	To learn from other colleagues To train other colleagues	Socialization (social networks) Training (HRM practices)
Operator knowledge sharing is essentially based on communication; however, this knowledge sharing is frequently informal and, consequently, there are losses	Knowledge sharing is essentially based on communication Informal communication	Socialization (social networks) Communication
What actually happens is that during the shift change, [communication] is informal and initiative-driven. For example, an operator tells [his colleague] what happened during his shift and how he dealt with that [occurrence]. Then, both [operators] try to make sense of what happened	Communication is initiative-driven, operator tells what happened during his/her shift	Communication Collective problem-solving

study required one month to complete. After this period, the reduced data and codes were presented and discussed with the managers of the firm examined. During this discussion period, used to challenge and verify the coding accuracy of this study, the researchers visited manufacturing facilities several additional times, spoke with workers and gathered observations. Subsequently, the findings from this investigation were also discussed with scholars who are knowledgeable in the field but were not part of the research team.

5. Research findings

Hot-area operators had little formal education and did not receive training in TQM practices. In contrast, tool shop workers had higher levels of formal education and had received some training in TQM. Despite their lack of training, operators discussed the importance of various best practices in manufacturing with respect to various processes, such as standard operational procedures, work area organization (5S), rapid die exchange and other issues. This awareness was noteworthy given that these operators had received little formal training and possessed low levels of education, and the importance that operators attributed to these practices was evidenced by the examined unit's clean and well-maintained work floor, high operational efficiency and low accident levels. The absence of structured practices was striking, particularly compared with the working environment of the automotive industry; there were very few formal standard operational procedures. The following statement from a worker illustrates this situation:

> [Knowledge is created and acquired] during daily tasks; sometimes, we take some short courses, but it isn't enough, it isn't enough, OK? I think we should have more knowledge, but to work with glass, there is no recipe, you have to find [out] day after day what needs to be done to improve things (Operator, first shift).

Only parameter data were recorded; however, even this information was typically recorded in an informal manner by workers, due to their individual initiatives. Many workers were uncertain whether the processes that they perform habitually could be referred to as an operational procedure. An answer from a press operator provides a clear example of this issue:

> We have some machine parameter sheets, OK? This one [taking a paper sheet from his pocket] is for set-up, OK? When I fine-tune the press, I write it on a card, I put all parameters on it, OK? Is that what you call ''recording information''? (Operator, second shift).

Surprisingly, however, no negative effects from the dearth of operational procedures were observed with respect to either operational efficiency or knowledge sharing. Under-educated operators set nearly 200 parameters and controlled press machines that functioned at four-digit temperatures at high productivity and safety levels. Information

flowed smoothly on the shop floor, even during shift changes, and operational issues were solved rapidly.

In the absence of structured practices, the knowledge sharing and learning of blue-collar workers depend on word of mouth and personal contacts (Styhre, 2008). In fact, these practices represent precisely how learning occurs on the shop floor:

> . . . I teach a new aide what he [a new worker] needs to do. Everything he needs to do, he does every day, and I watch how he is doing. I watch [to see] if he is already able to cover for [an operative who is on] vacation [. . .] he should come to me when he has a problem, and I [will] explain everything [. . .] after some time, in two or three months, I don't want to tell him what to do any more. Then, I expect him to deliver, I want to see if he has understood what I taught him (Operator, third shift).
>
> Talking and passing what you know on. When a new aide starts, we talk; when he gets into some difficulty, he asks us. This [process] is how it [knowledge] is passed on (Operator, third shift).

The interviewees were expected to evince differences in their knowledge bases that would result in differences in answers between individual respondents and between workers from different shifts. However, no relevant differences were found. Thus, the operators interviewed clearly possessed the same level of operational knowledge, and operators, leaders and supervisors have developed a shared language and a common knowledge base.

The lack of structured practices in the examined firm sometimes resulted in the use of non-technical language to refer to operational issues and occasionally caused operatives to experience difficulties in explaining certain problems that they faced in their daily duties to researchers. However, these conditions did not result in either poor performance or poor communication. During visits to and observations of the unit examined, it was clear that problems received timely and appropriate solutions, and a collective concern regarding efficiency and safety was distinctly observed. This concern overcame operators' deficiencies in technical language and facilitated the exchange and sharing of tacit knowledge. In the firm examined, efforts to communicate and understand created shared sense-making and collective problem-solving. The following quotations illustrate how operators share their concerns:

> I'm working on my machine, and my fellow calls me to solve a problem on his machine and vice versa; in these situations, we exchange what we know to overcome the problem (Operator, second shift).
>
> Many times, when we come up with something new, we start to pass that [knowledge] on. If my work mate is going through a difficulty that I had [experienced] before, I talk to him. I say, look, I went through that [difficulty] too, and I did this [action] and it worked. He sometimes uses my experience [. . .] we are always learning from each other. I think that in a collective task, we have to learn from each other (Operator, first shift).

In the firm examined, knowledge sharing and problem solving were possible due to a combination of individual action and collective concern regarding the attainment of operational goals, suggesting the existence of an engaging work environment, as discussed above. An engaging environment fosters the creation of shared language and facilitates the dissemination of tacit knowledge.

Collective action frequently emerges from individual traits. In many of the responses in this study, problem solving and knowledge sharing were reported to occur spontaneously as a result of an individual's own initiative. Individual action is a key aspect of knowledge sharing and group learning: workers must take action and risk to share what they know, and they must feel confident and free to do so. Seniority in a company provides a partial explanation of why workers easily share knowledge; however, the most important facilitator of knowledge sharing in the firm examined was that the career path within this company provided a natural selection mechanism for this type of behavior. In the unit examined, managers and supervisors selected individuals with those traits for promotion; thus, individuals' career paths became learning paths with respect to not only operational issues but also expected attitudes toward operational duties and collaborative behaviors among team members. A leader expressed this sentiment in the following way:

> To me, he [a new worker] has to show something extra in his first days; he has to show that what he wants is what we want [. . .] He has to be careful and disciplined, otherwise it won't work [. . .] To me he has [. . .] to be directed, and after [his first days], we watch his behavior. What I do is first talk to him and explain how I work and what I expect from him, then I watch [to see] if he is doing what he needs to do (Leader, second shift).

Managerial action was also a key ingredient in the development of an engaging environment. In the firm examined, operators indicated that efforts by top management to share company goals helped contribute to knowledge dissemination. This result is consistent with findings in the extant literature that indicate that a social climate in which team members feel valued is supportive of knowledge sharing (Weick and Roberts, 1993) because this type of climate helps build trust and commitment (Lee *et al.*, 2010; Renzl, 2008). Blue-collar workers may not need to be involved in the concerns of a firm's top management, but efforts to communicate company goals and results appropriately and to ensure that all of a firm's workers are well informed are typically regarded as indications of care and trust; these sentiments promote committed behaviors from employees. Similarly, the availability of material resources for daily duties was also regarded as an important factor for improving efficiency; thus, an attentive managerial team strives to ensure that resources are available in an appropriate location and a timely manner. Higher-order issues, such as knowledge sharing and operations improvement, can only be addressed after basic needs have been fulfilled. The following quotations illustrate this point:

> I have worked here for some time, and I feel supported. I need support from my leader, from my partner at my shift and at my machine [. . .] The tool shop guys listen to you, and they work hard to give you what you need. The process guys listen to you, I feel supported by everybody from every department (Operator, second shift).

> I get incentives from my supervisor. He is always with me, he talks to me, and he always gives me advice because although I worked at furnace A for approximately 20 years, then they moved me to furnace B, and I hear the [furnace B] night shift got better (Operator, third shift).

Human resource management (HRM) practices, such as training and incentives, also emerged in this study as positive factors for creating an engaging environment. This result is consistent with the findings in the literature; in particular, previous studies note that formal and on-the-job training contribute to knowledge sharing and that blue-collar workers learn both by observing more experienced workers and by receiving direct instructions (Rooke and Clark, 2005). HRM contributes to the creation of an open environment in which workers feel free to talk and contribute:

> I think a person needs freedom to work [. . .] he has to feel free to give his opinion, to talk about others' work, to say what he thinks (Operator, first shift).

In the same way, social capital was indicated as an important feature for knowledge sharing. Interpersonal relationships have already been identified as facilitating factors for knowledge sharing (Styhre, 2008; Cohen, 2007), and interviewees stressed the importance of these relationships in the dissemination of knowledge:

> Through communication from team to team, we end up becoming friends, close friends, which makes it easier. We are involved in what we are doing at work all of the time, so everybody gets informed (Operator, second shift).

In summary, the findings of this study suggest that an engaging environment is based on a collective concern for efficiency, which is supported by a shared language and a common knowledge base that facilitate communication and knowledge sharing. These results are consistent with literature findings that indicate that knowledge dissemination is facilitated by a common understanding (Malhotra and Majchrzak, 2004) and that knowledge conversion processes occur in a context of collective knowledge and beliefs (Baskerville and Dulipovici, 2006).

Good communication is a key aspect of developing shared language and knowledge (Malhotra and Majchrzak, 2004), and it is facilitated by a sense of collegiality and openness (Magnier-Watanabe, 2011). Those factors were present in the unit examined and promoted good communication. Interestingly, social capital was used both to search for and to actively

share knowledge, indicating that initiative was also an important enabling factor for promoting an engaging environment.

Another enabling factor that has been identified in the extant literature and was clearly present in the data of this study was trust among operatives, leaders and managers. In the firm examined, trust is fundamental to the establishment of good communication and the creation of collegiality and openness. Two factors may be related to the development of this trust in the studied firm. The first factor is the typical career path of employees in this firm. In this path, line operators begin their careers as aides and are promoted in accordance with their abilities and the results that they are able to deliver. The requirements for career development are clearly proposed and consistently followed; this adherence to the stated promotion requirements helped to build trust. In addition, the efforts that managers exerted to communicate the company's goals to employees were interpreted as an indication that the company examined cared about its employees; this sense of caring also facilitated the creation of an environment of trust.

Three factors from the literature that would also promote an engaging environment were not clearly observed in the data from the field study:

1. autonomy;
2. fluctuation; and
3. requisite variety (Nonaka and Takeuchi, 1995).

In contrast to the propositions of the extant literature, line operators contributed to the creation of an engaging environment despite having only limited autonomy. This divergence between the findings of previous studies and the results of this study may reflect differences in the workers that were studied; in particular, this study focused on blue-collar workers, whereas most of the published literature involved examinations of white collar workers. Line operators do not have the same level of autonomy as higher ranking employees; instead, the tasks of these line operators are limited, and their scope of action is restricted, creating a situation that is similar to the context of *kaizen*(Magnier-Watanabe, 2011). Thus, the concept of autonomy and the relevance of this concept to knowledge sharing among blue-collar workers must be relaxed. In addition, fluctuation and requisite variety were not clearly observed in this study because the examined unit was not exposed to external variation. Manufacturing lines are structurally insulated from environmental variation and therefore have little need to demonstrate a response capability to external variation. Again, relative to previous results for white collars, the importance of requisite variety and fluctuation is diminished in the case of blue-collar workers.

In contrast, this study found that HRM practices such as training and incentives were important for knowledge sharing. Line leaders and experienced operatives were assigned as mentors to new colleagues. These mentors passed their knowledge and vocabulary on to their colleagues during the course of everyday routines, informal conversations and *ad hoc* problem-solving discussions. On-the-job training was one of the first knowledge sources for new line operators, and this training provided a starting point for the development of a shared language.

Simple managerial tasks, such as ensuring the availability of material resources, represented important aspects of creating a collaborative environment because these tasks constituted signals that managers were concerned with ensuring appropriate working conditions and that these managers were aware of their responsibility to achieve results and maximize efficiency. Managerial efforts to report the examined company's goals and performance levels, which created a sense of participation, were also cited as important factors in the creation of an engaging environment.

Thus, the findings of this study suggest that an engaging environment is produced by collective concerns regarding efficiency and that this type of environment promotes tacit knowledge sharing. The development of these collective concerns is promoted by a shared language and a common knowledge base. In accordance with the findings of the extant literature, this shared language and knowledge base arise from good communication and a

social climate in which openness, trust and a sense of collegiality are present. Those factors are facilitated by HRM practices, managerial actions and individual characteristics. However, autonomy, fluctuation and requisite variety are not significant factors on the shop floor.

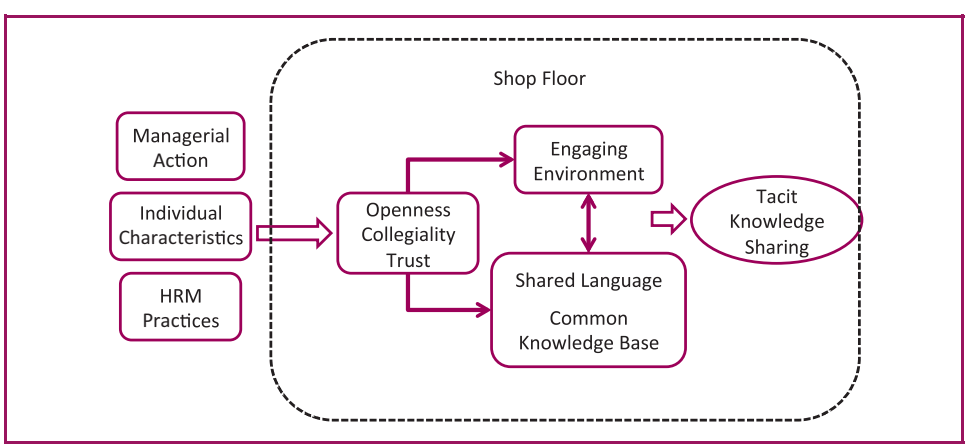
Figure 1 illustrates the results that have been discussed above. An engaging environment in which participants are committed to efficient and safe operations is supported by a shared language and a common knowledge base and fosters tacit knowledge sharing. A collegial atmosphere involving openness and trust among operatives, leaders and managers is important for the development of this type of environment. Individual initiatives to exploit social capital and search for knowledge in problem-solving situations are also critical for the creation of an engaging environment; moreover, there must also be managerial efforts to communicate business goals, assure proper work conditions and reward adequate performance. Finally, HRM practices such as formal and on-the-job training are also important considerations in the establishment of an appropriate atmosphere for the sharing of tacit knowledge.

It is important to note that the responses from the interviewees of this study suggest that it is the interactions among all of the aforementioned factors that create an engaging environment, since each of these factors was almost always cited in combination with at least one other factor. Thus, openness, trust, formal training, on-the-job training, social capital, individual initiative and managerial action work together to create an engaging environment. In addition, there were no relevant differences between the interview responses of operators, production leaders and supervisors in this study, indicating that all of these interviewees share the same understanding of the influence of those factors. Moreover, it is interesting to note that the workers' answers were richer than the answers of the other interviewees in this study; in particular, the workers' responses contained more factors per answer, suggesting that among the interviewees, the workers have the strongest perception and understanding of the interplay among the factors examined.

6. Conclusions

Structured practices, as recommended by TQM and lean manufacturing, result in the encoding and storing of explicit knowledge; as these practices are internalized, they contribute to the creation of tacit knowledge (Nonaka and Takeuchi, 1995). Structured practices also form the foundation of individual action and social relationships on the shop floor, creating a shared language and knowledge base that support the sharing of tacit knowledge. However, in the absence of structured practices, an environment in which every worker is engaged in efficient and safe operations can also create a shared language and knowledge base. An engaging environment not only improves performance but also favors knowledge dissemination.

Figure 1 Engaging environment and tacit knowledge sharing



An engaging environment is supported by shared language and knowledge, which are developed through intense communication and facilitated by both a strong sense of collegiality and a social climate that is dominated by openness and trust. Other factors that contribute to the creation of an engaging environment include not only managerial efforts to provide appropriate work conditions and to communicate company goals but also certain HRM practices, such as the provision of formal training, on-the-job training and incentives. The aforementioned factors enhance personal involvement and interaction, thereby facilitating the sharing of tacit knowledge and the maximization of operational efficiency. None of these factors functions in isolation; instead, interactions and synergy among these factors are required for the creation of an engaging environment.

This discussion regarding knowledge sharing among blue-collar workers contributes to the extant literature on knowledge management and knowledge sharing, which has largely focused on symbolic workers and white collars. Previous research that examined the knowledge of blue-collar workers concentrated on structured work environments, particularly contexts in which TQM and lean manufacturing practices have been adopted. However, there are several less-structured work environments, such as in plants that use automated processes, where operators must take actions to address abnormal working conditions. Although this study investigated a plant that is operated by under-educated operatives, automated processes are obviously not limited to this type of situation. Flexible manufacturing systems, digital manufacturing operations, maintenance shops and chemical plant control rooms are examples of work environments in which highly skilled, well-educated operators are employed; in these environments, tacit knowledge is of paramount importance. Efficient operators are able to anticipate and correct problems based on their tacit knowledge, and the findings from this research can be used to study tacit knowledge sharing in these situations.

Studies have already been conducted regarding knowledge creation and sharing among blue-collar workers in the context of *kaizen*. However, *kaizen* represents an offline knowledge-sharing event. In particular, *kaizen* groups convene after work hours; thus, *kaizen* participants are out of their working environment and away from the stresses of a production line. This research has examined knowledge sharing among blue-collar workers in an online condition, i.e. communication during process operations, a much more complex situation than the *kaizen* scenario. Thus, the personal commitment and initiative of operatives assumes an even more important role: they must be fully engaged to be willing to help, share their knowledge and solve problems under pressure to produce.

This paper also has practical implications in that it clarifies the scope of managerial actions that impact knowledge creation and sharing among blue-collar workers. It has already been observed that good communication and goal sharing are important practices to achieve this type of knowledge creation and sharing; moreover, although it may appear obvious, managers must also provide appropriate working conditions if they expect their workers to engage in autonomous knowledge creation and sharing. The results of this study were presented and discussed with the managers of the unit examined, and these managers agreed with the conclusions that were obtained from the study data.

Interestingly, the results of this study indicate that blue-collar workers, particularly those with low levels of education (such as the workers examined in this investigation), require an appropriate environment to share their tacit knowledge. White-collar workers and highly educated analysts may engage in discussions and arguments and demand the assets that they require to enhance their productivity, whereas blue-collar workers may be less vocal. Many blue-collar workers do not feel confident or prepared to express their opinions, and certain blue-collar workers may have poor self-images. Thus, certain workers must be supported until they consider themselves to be capable operators; subsequently, these workers will engage in knowledge exchange. In other words, as blue-collar workers feel confident about their knowledge, they will begin to take the initiative to share this knowledge. In an engaging environment, these workers will take autonomous actions, talk with other operators, step forward to draw the attention of managers to problems and suggest and/or demand operational improvements. An engaging environment supports socially constructed knowledge, cooperation and teamwork, stimulating learning by doing and the

sharing of tacit knowledge. This type of environment cannot completely prevent losses of tacit knowledge, but can postpone and reduce its decay.

This paper possesses the typical limitations of qualitative research. Because the study data were obtained from a single firm, the findings of this study have limited generalizability. Moreover, the results of this study reflect the context of automated production systems. Further research could examine less automated production lines or engage in quantitative studies that strengthen the conclusions that have been presented in this paper.

References

Alvesson, M. (2004), *Knowledge Work and Knowledge-intensive Firms*, Oxford University Press, Oxford.

Alvesson, M. and Kärreman, D. (2001), ''Odd couple: making sense of the curious concept of knowledge management'', *Journal of Management Studies*, Vol. 38 No. 7, pp. 995-1018.

Bardin, L. (2008), *Análise de Conteúdo* (*Content Analysis*), 5th ed., Edições 70, Lisbon (in Portuguese).

Bartezzaghi, E. (1999), ''The evolution of production models: is a new paradigm emerging?'', *International Journal of Operations & Production Management*, Vol. 19 No. 2, pp. 229-50.

Baskerville, R. and Dulipovici, A. (2006), ''The theoretical foundations of knowledge management'', *Knowledge Management Research & Practice*, Vol. 4, pp. 83-105.

Black, J.T. (1991), *The Design of the Factory with a Future*, McGraw-Hill, New York, NY.

Cohen, D. (2007), ''Enhancing social capital for knowledge effectiveness'', in Ichijo, K. and Nanaka, I. (Eds), *Knowledge Creation and Management: New Challenges for Managers*, Oxford University Press, Oxford, pp. 240-53.

Costanzo, L.A. and Tzoumpa, V. (2008), ''Enhancing organizational learning in teams: has the middle manager got a role?'', *Team Performance Management*, Vol. 14 Nos 3/4, pp. 146-64.

Dell'era, C. and Verganti, R. (2009), ''The impact of international designers on firm innovation capability and consumer interest'', *International Journal of Operations & Production Management*, Vol. 29 No. 9, pp. 870-93.

Erhardt, N. (2011), ''Is it all about teamwork? Understanding processes in team-based knowledge work'', *Management Learning*, Vol. 42, pp. 87-112.

Fransilla, H., Okkonen, J., Savolainen, R. and Talja, S. (2012), ''The formation of coordinative knowledge practices in distributed work: towards an explanatory model'', *Journal of Knowledge Management*, Vol. 18 No. 4, pp. 650-65.

Garvin, D.A. (1993), ''Building a learning organization'', *Harvard Business Review*, Vol. 71 No. 4, pp. 78-90.

Harlow, H. (2008), ''The effect of tacit knowledge on firm performance'', *Journal of Knowledge Management*, Vol. 12 No. 1, pp. 148-63.

Hazlett, S.A., McAdam, R. and Gallangher, S. (2005), ''Theory building in knowledge management: in search of paradigms'', *Journal of Management Inquiry*, Vol. 14 No. 1, pp. 31-42.

Henttonen, K. (2010), ''Exploring social networks on the team level: a review of the empirical literature'', *Journal Engineering Technology Management*, Vol. 27, pp. 74-109.

Hong, P., Doll, W.J., Revilla, E. and Nahm, A.Y. (2011), ''Knowledge sharing and strategic fit in integrated product development projects: an empirical study'', *International Journal of Production Economics*, Vol. 132 No. 2, pp. 186-96.

Janhonen, M. and Johanson, J. (2011), ''Role of knowledge conversion and social networks in team performance'', *International Journal of Information Management*, Vol. 31, pp. 217-25.

Kolb, D.A. (1984), *Experiential Learning: Experience as the Source of Learning and Development*, Prentice Hall, Englewood Cliffs, NJ.

Koners, U. and Goffin, K. (2007), ''Managers' perceptions of learning in new product development (Review)'', *International Journal of Operations & Production Management*, Vol. 27 No. 1, pp. 49-68.

Lee, P., Gillespie, N., Mann, L. and Wearing, A. (2010), ''Leadership and trust: their effect on knowledge sharing and team performance'', *Management Learning*, Vol. 41 No. 4, pp. 473-91.

Leung, Z.C.S. (2009), ''Knowledge management in social work: types and processes of knowledge sharing in social service organizations'', *British Journal of Social Work*, Vol. 39, pp. 693-709.

Magnier-Watanabe, R. (2011), ''Getting ready for kaizen: organizational and knowledge management enablers'', *Journal of Information and Knowledge Management Systems*, Vol. 41 No. 4, pp. 428-48.

Malhotra, A. and Majchrzak, A. (2004), ''Enabling knowledge creation in far-flung teams: best practices for IT support and knowledge sharing'', *Journal of Knowledge Management*, Vol. 8 No. 4, pp. 75-88.

Miyake, D. and Nakano, D. (2007), ''Implementation of corporate production systems in the Brazilian auto industry: managing knowledge through practice'', *International Journal Automotive Technology and Management*, Vol. 7 Nos 2/3, pp. 153-67.

Muniz, J. Jr, Batista, E.D. Jr and Loureiro, G. (2010a), ''Knowledge-based integrated production management model'', *Journal of Knowledge Management*, Vol. 14 No. 6, pp. 858-71.

Muniz, J. Jr, Batista, E.D. Jr and Loureiro, G. (2010b), ''Knowledge-based integrated production management model applied to automotive companies'', *International Journal of Knowledge Management Studies*, Vol. 4 No. 3, pp. 301-18.

Nonaka, I. and Konno, N. (1998), ''The concept of ''ba'': building a foundation for knowledge creation'', *California Management Review*, Vol. 40 No. 3, pp. 40-54.

Nonaka, I. and Takeuchi, H. (1995), *The Knowledge-creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press, New York, NY.

Nonaka, I. and Toyama, R. (2003), ''The knowledge-creating theory revisited: knowledge creation as a synthesizing process'', *Knowledge Management Research and Practice*, Vol. 1, pp. 2-10.

Ohno, T. (1988), *Toyota Production System: Beyond Large-scale Production*, Productivity Press, New York, NY.

Orlikowski, W.J. (2002), ''Knowing in practice: enacting a collective capability in distributed organization'', *Organizational Science*, Vol. 13 No. 3, pp. 249-73.

Rea, L.M. and Parker, R.A. (2005), *Design and Conducting Survey Research: A Comprehensive Guide*, 3rd ed., Jossey-Bass, San Francisco, CA.

Renzl, B. (2008), ''Trust in management and knowledge sharing: the mediating effects of fear and knowledge documentation'', *Omega: International Journal of Management Science*, Vol. 36, pp. 206-20.

Rooke, J. and Clark, L. (2005), ''Learning, knowledge and authority on site: a case study of safety practice'', *Building Research & Information*, Vol. 33 No. 6, pp. 561-70.

Rosendaal, B. (2009), ''Sharing knowledge, being different and working as a team'', *Knowledge Management Research and Practice*, Vol. 7, pp. 4-14.

Seidler-de Alwis, R. and Hartmann, E. (2008), ''The use of tacit knowledge within innovative companies: knowledge management in innovative enterprises'', *Journal of Knowledge Management*, Vol. 12 No. 1, pp. 133-47.

Shingo, S. (1989), *Study of the Toyota Production System: From an Industrial Engineering Viewpoint*, Productivity Press, New York, NY.

Staats, B.R., Brunner, D.J. and Upton, D.M. (2011), ''Lean principles, learning, and knowledge work: evidence from a software services provider'', *Journal of Operations Management*, Vol. 29, pp. 376-90.

Stemler, S. (2001), ''An overview of content analysis'', *Practical Assessment, Research & Evaluation*, Vol. 7 No. 17, pp. 1-10.

Styhre, A. (2008), ''The role of social capital in knowledge sharing: the case of a specialist rock construction company'', *Construction Management and Economics*, Vol. 26 No. 9, pp. 941-51.

Tsoukas, H. (1996), ''The firm as a distributed knowledge system: a constructionist approach'', *Journal of Strategic Management*, Vol. 17, pp. 11-25.

Vallas, S.P. and Beck, J.P. (1996), ''The transformation of work revisited: the limits of flexibility in American manufacturing'', *Social Problems*, Vol. 43 No. 3, pp. 339-61.

Von Krogh, G., Ichijo, K. and Nonaka, I. (2000), *Enabling Knowledge Creation: How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation*, Oxford University Press, New York, NY.

Weick, K.E. and Roberts, K.H. (1993), ''Collective mind in organizations: heedful interrelating on flight decks'', *Administrative Science Quarterly*, Vol. 38, pp. 357-81.

Wong, S. (2008), ''Task knowledge overlap and knowledge variety: the role of advice network structures and impact on group effectiveness'', *Journal of Organizational Behavior*, Vol. 29, pp. 591-614.

Yang, J. (2010), ''The knowledge management strategy and its effect on firm performance: a contingency analysis'', *International Journal of Production Economics*, Vol. 125 No. 2, pp. 215-23.

Appendix. Semi-structured interview questions

- What factors are considered to be most important for the work of operators on the shop floor?
- What factors help to improve performance and create synergy and proactive approaches in the group of operators on the shop floor?
- What factors are considered to be relevant in the production process?
- What factors are considered to be significant for the improvement of the production process in this organization?
- What factors contribute most to the integration between operators and the production process? How are these factors addressed?
- What abilities and knowledge are important for facilitating the involvement and contribution of operators in the production process?
- What motivates operators to continuously improve the production process?
- What practices promote integration between operators and the production process?
- What difficulties exist with respect to the integration between operators and the production process?

About the authors

Davi Nakano is Professor of Economics and Business Administration at Escola Politecnica, Universidade de Sao Paulo, Production Engineering Department. He is Research Fellow at the Institute of Advanced Studies of Universidade de Sao Paulo and an instructor on executive courses at Fundacao Vanzolini. He is a mechanical engineer, and he has a Doctorate and Master's degree in Production Engineering from Escola Politecnica. He has worked on several research projects funded by public and private agencies. His research interests include knowledge management and creative economy. Prior to his academic career, he worked for 12 years at several companies.

Jorge Muniz Jr is Professor of Production Management at Sao Paulo State University (UNESP), Brazil. He holds a research doctorate from the Production Department, Sao Paulo State University (UNESP) and a Master's in Production Engineering from Sao Paulo University (USP). He has worked for many years in the Brazilian automotive industry in production management assignments.

Edgard Dias Batista Jr is a retired Professor of Information System, Statistics and Transport Planning Field at the Production Department, Sao Paulo State University (UNESP), Brazil. He holds a doctorate title in Computation and System Engineering from the Federal University of Rio de Janeiro (COPPE/UFRJ) and a Master's in System Analysis and Application from the National Space Research Institute (INPE), Brazil. He has been a consultant to government in public transport planning.