Knowledge-based Integrated Production Management Model applied to Brazilian glass industry

Jorge Muniz Jr.[1], jorgemuniz@feg.unesp.br
Production Department, São Paulo State University, Brazil
*Corresponding author

Davi Noboru Nakano, dnnakano@usp.br
Production Department, University of São Paulo, Brazil

Edgard Dias Batista Jr., edgard@feg.unesp.br
Production Department, São Paulo State University, Brazil

Abstract: This paper aims to propose a framework that attempts to identify which operation management practices are more supportive to KM, especially to the blue collar workers. Shop-floor personnel interviews were conducted to identify and to confirm the factors relevance. The research was conducted in an important Brazilian glass company. Results have shown relation among knowledge management and Work and Production factors (i.e., Objective, Communication, Problem Solving Method, Standard Operating Procedure). The factors allow managers to promote a favourable context for knowledge sharing, especially tacit knowledge.

Keywords: knowledge management; work; production; blue collar worker; Brazilian glass company; tacit knowledge

[1] *Corresponding author: Jorge Muniz Jr., jorgemuniz@feg.unesp.br, Av. Ariberto Pereira da Cunha, no. 333, Guaratinguetá, SP, Brazil, Zip Code 12.516-410, Phone/Fax: + 55 12 3123 2855.

1. INTRODUCTION

Theory and practice have gone a long way since Taylor´s conception of a non-reasoning worker, whose only contribution was physical strength and abilities. Eastern managerial practices were among the first to make use of shop floor workers´ knowledge to enhance manufacturing performance. Japanese managers were urged not to take decisions within their offices, but to analyze problems right where they happened (at *gem* *ba*), and to make use of workers knowledge and suggestions as everybody was expected to contribute to enhance operations and overall efficiency. In this context, workers´ contributions plays a crucial role, since they possess tacit knowledge on daily procedures and activities, and not surprisingly, work organization and managerial practices have evolved since the 1970´s towards giving workers´ voice and autonomy. Teamwork and participative decision making have become practices in operations management.

However, Knowledge Management (KM) literature has mainly focused on symbolic workers, white collars, and few studies can be found on KM practices for blue collar workers. This paper contribution is to propose a framework that attempts to identify which operation management practices are more supportive to KM. It is based on previous work in automotive industry (Muniz Jr.; Batista Jr.; Loureiro 2010a), which is now applied to a molded and pressed glass factory. Molded Glass production is more dependent on blue collar tacit knowledge than automotive, which makes it a perfect setting for this study. The paper contribution is aligned with knowledge management opportunities and "new waves" identified in literature review, as to discuss factors that affect the tacit knowledge in groups within the organizations (Erden et al., 2008) and guidelines on how the manager can encourage knowledge conversion processes within groups in the organization (Nonaka et al., 2006).

2. WORKERS´ KNOWLEDGE AND KNOWLEDGE MANAGEMENT

KM literature can be roughly divided on two strands: one views knowledge as amenable of being stored, combined and disseminated, while the other stresses the role of social relations and individual and collective action. To the last one, knowledge is embedded in relationships and cannot be separated from acting. The duality can be traced from early KM literature to more recent work: Tsoukas (1996) divided KM studies in two approaches: in one knowledge can be reduced to a portable object, while in the other, it resides in individuals and their relationships. Alvesson and Karrëman's (2001) argue that while information technology imposes knowledge to be explicit, it is also created and shared within groups and relationships. Schultze and Stabell's (2004) duality-dualism dimensions also converges to the same point. In that line of thought, knowledge is explicit, but it also resides in individuals, in their actions and relationships, it is mingled in everyday actions (Tsoukas, 1993; Orlikowski, 2002). A standard operation procedure contains information, but the knowledge enclosed in it has no value until it is actually put into action, and it is enacted by workers. Despite the importance of worker´s knowledge, much of what is found in the KM literature revolves around symbolic workers within knowledge intensive firms (Alvesson, 2001), such as professional service firms and R&D units. Symbolic workers have, in general, some autonomy over their work, making decisions on how to perform it. Blue collars in turn do not have that formal autonomy, their action and resources are usually predefined.

Under such restrictions, they perform activities, internalize knowledge from procedures and develop tacit knowledge. Operations performance, and ultimately firm's performance depends on that knowledge, but there is sparse literature on blue collar workers, and how they develop and incorporate knowledge in their action.

Knowledge creation and internalization processes have best results when performed at a proper environment or context. Nonaka and others (Nonaka and Konno, 1998; Nonaka and Toyama, 2003) called that environment *Ba*, a place where personal interaction and tacit knowledge sharing is stimulated. While white collars may have some action over their work environment, and thus act to foster knowledge creation and sharing, blue collars do have much less formal autonomy. Their work context is defined by human management practices and operation management techniques on the shop floor. Thus, they ultimately define knowledge creation and sharing. Eastern operations management techniques were the first to allow some autonomy and discretion to blue collars, demanding them to participate, analyze and contribute in problem solving. For instance, housekeeping (5S) and participative problem solving (Kaizen) groups are based on workers initiative and participation, and even the use of standard operation procedures in such a context ends up facilitating internalization (Nonaka and Takeuchi, 1995). Practices rooted in eastern operation management practices in which workers opinion and participation are expected are: participative problem solving methods (Kaizen groups) (Garvin, 1993; Kolb, 1984), housekeeping (5S) (Ohno, 1988); simple error proofing methods (poka yoke) (Ohno, 1988; Black, 1991) and quick changeover (Black, 1991; Shingo, 1989). Those practices call for participation and foster knowledge creation and sharing, and as already pointed out, in such a context, the use of standard operating procedures (Bartezzaghi, 1999; Ohno, 1988) also enhance knowledge appropriation.

How business goals are transmitted to operational levels and which incentives are given strongly impacts work context (Smith, 2001). Human resource management (HRM) practices, as training and communication are instrumental for developing good context (Worley and Doolen, 2006, Nonaka, 1994; Darrah, 1995). It is also known that organizational structure have a positive effect on innovation, and thus, on knowledge creation. Those factors support interaction between operators and managers, contributing to take the best from operators' knowledge. They foster creation of socially constructed knowledge; stimulate cooperation and teamwork and learning by doing processes. Thus they should be strongly related to KM processes of socialization, externalization, combination and internalization (Nonaka and Takeuchi, 1995).

Thus participative work practices, HRM and managerial practices are expected to enhance and support knowledge creation and dissemination on the shop floor. To understand their influence and its intensity, a qualitative study was conducted at a pressed glass unit.

3. A STUDY IN A MOLDED AND PRESSED GLASS UNIT

Molded glass technique is used to produce bottles and containers, for applications as diverse as liquor, medicine, perfums and cosmetics and soft drinks. Hot Pressed glass is used in table and kitchenware and home decoration. The process consists on melting glass, cooling to a temperature which allows cutting it into small bits, with were pressed or blown against molds, creating different hollow or solid shapes. After molded, glass artifacts are annealed and cooled, finished and delivered to use. The process is usually split between hot and cold areas: the first refers to the melting furnaces, hot presses and the annealing conveyors, and the second, to the cooling conveyors, quality control and packaging. Hot press machines have several setup parameters to each different product, which are critical to product quality and process productivity. Semi-automated machines require workers´ intervention to set operational parameters, and usually, after years of working, operators develop tacit knowledge over process control and setup parameters, learning how to reduce setup time and enhance productivity and quality.

The unit under study produces glass bottles and containers for cosmetics, pharmaceuticals and special applications, and some tableware. The company market strategy is to produce specialties (intricate shapes and color combinations), to exploit niche markets specially for perfums and cosmetics, being actually the largest in that market. As a result, product line is extensive and production batches are small and frequently changed, making setup a critical issue to operations.

Manufacturing assets are 4 melting furnaces, 21 hot press machines, each equipped with annealing conveyors and cooling conveyors. About 2200 workers run the facility. Semi-automated press machines have over 180 process parameters to be set at each batch and later controlled by blue collar workers. Most of the workers in the hot area have low formal education level, but, they have extensive experience (over 58% workers have more than 10 years of experience), and thus, they are expected to have acquired tacit knowledge over production process parameter setup.

Qualitative in-depth interviews were conducted in one of the unit's production lines. Melting furnaces feed glass for hot presses, and each press, annealing conveyor and cooling conveyor defines one production line. 12 operators work at the hot area, and 27 at the cold area in the line under study. Abilities and knowledge required at each area are very different.

Data collection was made by semi-structured interviews. One of the authors conducted eight in-depth interviews with a operators, production leaders and production supervisors selected following a convenience sampling method (Rea and Parker 2005). Operators were selected by their expertise on the shop floor, as recognized by their peers.

The questions to identify the production factors that contribute to the creation of favourable context (Ba) are shown as follow. The complete questionnaire is presented in the Appendix.

- *Which factors are considered to be relevant in the productive process?*
- *Which factors are considered significant in the improvement of the productive process in its organization?*

All interviews were recorded, transcribed, and analyzed using Contents Analysis, following Stemler (2001) and Bardin (2008), in order to extract conceptual categories. Data Analysis was conducted looking for meaning interviewees attributed to operational and organizational practices, and how they relate them to knowledge creation and sharing. Interview data suffered two reductions: at the first, raw data was condensed in meaning units. Resulting data was then further reduced to condensed meaning units. Table 1 illustrates how Content Analysis was performed.

Table 1: Examples of content analysis (Muniz Jr.; Batista Jr.; Loureiro, 2010a adapted from from Graneheim and Lundman (2004)

Meaning unit	Condensed meaning unit	Code
Often, an operator is selected to learn and train the other colleagues on the machine on a day by day basis during production time	to learn and train other colleagues	Training Socialization
Operator knowledge sharing is essentially based on communication, but many times it is informal and, consequently, there are losses.	Operator knowledge sharing is essentially based on communication	Socialization Communication
What actually happens is that during the shift change [communication] is informal and initiative-driven. For example, an operator tells what happened during his shift and how he dealt with that. Then both try to understand of what happened…	communication during shift change it is informal and initiative-driven operator tells what happened during his shift	Personal Characteristics Socialization Communication Problem Solving

To validate coding, after data reduction, all meaning units and condensed meaning units were discussed with interviewees, to check if data reduction kept information. Reduced data and final coding was also presented and discussed with managers and scholars.

4. RESEARCH FINDINGS

Table 2 lists factors that emerged from data. Some factors were *a priori* defined from literature review (i.e., Muniz Jr.; Batista Jr.; Lourieiro, 2010b) while others emerged from data. All factors were purposefully named as close as possible to factors discussed in the literature review section. They refer to practices related to operation management techniques, especially those related to lean manufacturing and Toyota Production System (TPS), namely for its flexibility and drive towards participative problem solving. Data shows that structured operations methods and practices help and support knowledge creation and sharing. To operators, structured and apparently restrictive practices as standard operating procedures and job description help to disseminate knowledge. It seems that blue collars need a more "bounded" environment as a starting point to process knowledge. In the same token, structured participative practices as problem solving and housekeeping (5S) also encourage knowledge creation and dissemination. Technically oriented practices as error proofing (poka yoke) and quick changeover were also found as conducive to a proper environment where knowledge is created.

Managerial action is also key to develop a supportive environment. Shared goals were indicated as a factor, and it has to be discussed from the top of the hierarchy. Availability of material resources were also indicated as an important factor, resembling Maslow's hierarchy of needs: basic needs have to be fulfilled to higher order issues to be dealt with. As it would be expected, human resource management practices, as training and incentives, emerged as factors. Training refers not only to formal classes (which the company provides), but also to on the job training. Personal characteristics play an important role, as in some cases, knowledge sharing happens as a personal initiative. This reinforces the concept that knowledge creation and sharing need conductive context to take place. Individuals engage in autonomous action as they feel confident to do so. In the same way, personal relationship, i.e., social networks were indicated as factors.

Table 2: Work and Production Factors

Factor	
Work Organization	**Production Organization**
Objective	Problem Solving Method (PSM)
Material Resources	Standard Operating Procedure
Job Description	Housekeeping (5S)
Communication	Error proofing (*Poka Yoke)*
Training	Quick Change Over
Incentives	
Personal Characteristics	
Relationship	

Interviews suggest no factor works in isolation, as they usually were not cited alone in answers. That can be viewed as their presence and interplay bring proper environment to knowledge sharing. For instance, formal and on the job training, good communication channels and personal relationship and social networks together create knowledge sharing. As one interviewee said:

> *You gotta talk to workers to share experience. Each one has her opinion; talking to everyone you get the best. (1st. Shift Operator)*

> *I'm working on my machine and a colleague calls me to solve a problem on his machine and vice versa, in those situations we exchange knowledge to overcome the difficulty. (2nd. Shift Operator)*

All Factors were found in operators, production supervisors and production leaders. It is interesting to note that production workers answers were richer, containing more factors in the same answer, suggesting they have perception and understand the importance of the interplay between factors.

As already pointed out, basic operations management and human resource management practices, as availability of material resources, standard operational procedures and clear job description are needs and work together. As Nonaka and Takeuchi's process has already noted, individual tacit knowledge comes from internalizing explicit knowledge contained in operations hardware and formal practices. It is on that foundation that individual action is taken and social relationships are developed. These findings were not foreseen in the literature review, and represent a contribution to what is known. Blue collars tacit knowledge is developed at the interaction man-machine.

5. A GROUNDED FRAMEWORK FOR KNOWLEDGE CREATION AND SHARING ON THE SHOP FLOOR

From the factors that emerged from the study, a grounded framework (Table 3) can be created, highlighting the main factors found in the field research. The framework has a important practical use, it can help managers to set practices to foster knowledge creation and dissemination. While some of the framework elements are well known and could be drawn from the literature, data just confirmed their importance, others are new.

Table 3: Grounded Framework

Knowledge creation and dissemination factors	
Structured practices	problem solving, 5S, quick changeover, poka yoke
Managerial action	Standard operational procedures, shared goals
HR management practices	Job description, incentives
Individual action	
Social networks	

The formal and structured practices as problem solving; standard operating procedure; 5S; error proofing and quick changeover contribute for the establishment and improvement of the daily activities of production workers.

Factors as goal sharing, structure, communication channels, formal and on the job training, incentives and personal characteristics support the interaction between the workers and the organization. They enhance personal involvement in order to get workers and organization's objectives, systematically, by the creation, retrieving, sharing and use of knowledge.

6. CONCLUSIONS

Factors promote a favourable context for knowledge sharing and results achievement at shop floor. Factors were confirmed as important by data collected during field work. Data also showed that no factor works in isolation, rather, there is interplay and synergy between them. Previous work from authors on automotive plants (Muniz Jr.; Batista Jr.; Loureiro, 2010a) has already showed the same result. But, while in assembly lines work tend to be more structured and individual action more restrained, in semi-automated molded glass lines, productivity depends on individuals and their tacit knowledge. Ongoing research conducted by the authors in the automotive, electronics and glass industries further support findings.

The framework has practical implications, since it clarifies the scope of manager's actions over blue collar knowledge creation and sharing. While it has already been suggested that good communication channels and goal sharing are important practices, here it is stressed the importance of “the basics”: managers should do their homework if they expect workers to engage in autonomous knowledge creation. Results were presented and discussed with managers, who agreed with conclusions.

It is also interesting to note that results indicate that blue collars, especially those from low educational background, as is the case here, do need a defined and relatively constrained starting point to their knowledge creation and sharing path. Standard operational procedures, job description, structured practices create a foundation for individual action. While white collar and highly educated analysts may discuss, argue and demand what they need to enhance their productivity, blue collars may not be as vocal. Many of them feel do not feel confident and prepared to express their opinions and some may even think poorly about themselves, as lower educated people. Workers need clear direction, feel themselves as capable operators, to them engage in knowledge exchange. As they feel confident, they start taking the lead and share knowledge. They talk to next shift operators, step forward to call managers’ attention to problems, suggest and demand improvement.

Thus, factors affect tacit knowledge creation and socialization within the organizations, support organization improvement and provide guidelines on how the manager can encourage knowledge conversion processes within groups in the organization.

Operations management models have two dimensions, a human or social (Work Organization), and a technical dimension (Production Organization) both capture, essentially, the explicit structure and behaviour of the operations management system. Findings of this research show how they also help to convert explicit into tacit knowledge at the shop floor.

Factors help to create a work environment were socially built knowledge is supported by cooperation and teamwork, and how individual tacit knowledge ted. It also stimulate learning by doing. The literature indicates that knowledge creation may not be separated from the context in which it is created, and the framework delivers actions to create that context. I such a context tacit knowledge sharing and social integration happens the framework allows managers to improve their action, as it integrates knowledge management with operation management and human resource and management practices.

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Appendix: Semi Structured Questionnaire

Dimension	Question
Work	Which factors are considered important for the work of the operators on the shopfloor?
	What helps to improve, to create synergy and pro-activity in the group of the operators on the shop floor?
Production	Which factors are considered to be relevant in the productive process?
	Which factors are considered significant in the improvement of the productive process in its organization?
Work and Production	Which factors contribute most in the integration between operators and the productive process? How to deal with such factors?
	What abilities and knowledge are important for the involvement and contribution of the operators in the production?
	What does motivate the operators in the continuous improvement of the production?
	Which practices promote the integration between operators and the production?
	Which difficulties do exist for the integration between operators and production?
	Which factors contribute most in the integration between operators and the productive process? How to deal with such factors?