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Smart Health Care Monitoring Technologies to Improve Employee Performance in Manufacturing

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Abstract

In today's economic context the input via productivity of highly skilled employees are crucial assets in manufacturing. The ageing of skilled workforce and unconducive work environment are some of the challenges that hold back competitiveness. Employee performance and productivity are influenced by a number of factors including satisfaction, health, safety, comfort, welfare. This paper emphasizes the human factor as a critical asset in the value chain and presents new approaches for motivating and safeguarding the employees. The collected data enables to design a human centric employee performance measurement system comprising of various indices. As a result management can make decisions based on quantitative information towards employee satisfaction, physical wellbeing and attract workforce to stay longer in the labour market. ICT tools are exploited to support the integration of different developments forming a framework that combines modules that monitor several health and well-being parameters and analysing how they affect employee performance.

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Keywords: ICT for Manufacturing and Logistics; Workplace Performance; Human Factor; Healthcare Monitoring; On-the-Job Fatigue

1. Introduction

Regarding the hard concurrence in the nowadays globalized markets, industries persistently have to improve their productivity. In current time costs of employee and value of skilled workforce are in high competition. Co-evolution of products and production systems is a critical issue to assure the dynamic and continuous progress of smart factories in a very constrained context [1]. To do this, managers pay great attention to how to exploit current technological innovations to improve the performance of their production processes and the quality of their

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products. In parallel strategic and tactical optimization actions are currently deployed to optimize the impact of resource on the final product cost.

Modern management strategies pay more attention to the role of human in the production system considered as a complex socio-technical system. According to several socio-organizational theories that focus on complex socio-technical systems, faulty conditions are considered to arise due to dysfunctional interactions among system's constituents (here in a broad sense considering human and non-human intra- and interactions both). Such view emerges as a direct consequence of the acknowledgement of the difficulty to comprehensively account at a design/planning stages for the overall interdependence that surrounds complex, large scale systems. In fact, many industries represent large scale, complex and highly dynamic socio-technical systems not infrequently pushed to operate beyond their original or desirable work boundaries to cope with demand and technological possibilities. The collected data enables to design a human centric employee performance measurement system comprising of various indices.

Under this perspective, any intervention toward work (re)arrangement should inevitably hold a multi-dimensional/disciplinary approach. A number of research communities such as engineering, cognitive psychology and organizational sociology have developed several complementary approaches towards organizational resilience and reliability, providing complementary perspectives and contributions on the understanding of errors etiology [2-7].

More generally, efficient human factor integration for competitiveness goal can be reached by applying different actions, including technical progress, managerial strategies and socio- cognitive approaches, which contribute to the factory attractiveness and the well-being feeling of the workers in the factory. Indeed, well-being of the worker, but also the work group, in the factory creates a collective motivation to develop strong and continuous efforts that contribute to value creation and maintain the success and the competitiveness of the company.

Well-being feeling of workers in their workshop can be obtained throughout the contribution of different individual and collective feelings. For instance, the feeling of safety and comfort in the work station can enhance the attraction of this workplace and improve the concentration of the worker in his work. Career evolution and gratitude of the worker effort can contribute to the motivation of the worker. In addition, mutual assistance and fraternity between workers contributes to the enhancing of the feeling of usefulness and responsibility of the worker regarding his work group, on one hand, and on his enterprise, on the other hand.

The aim of this research work is proposing ways via employee monitoring to improve performance and productivity. This is done by investigation of different innovations coming from various scientific and industrial fields in order to propose new methods and tools that help the enhancement of the well-being feeling in the smart factory. Modern factories mostly work 24/7 in many shifts, whereas both office and management personnel being not present in night shifts.

2. Advancement of Innovative Teaching Factory Approach

In Europe manufacturing accounts for more than 28% of the GDP [8]. The manufacturing activities including education are well specified by Manufuture platform [9]. New approaches for manufacturing education include aims to i) modernize the teaching process and bring it closer to the industrial practice ii) leverage industrial practice through new knowledge, iii) support the transition from the manual to the future knowledge workers and shorten the gap between resource-based manufacturing (labor and capital) and knowledge-based manufacturing (information and knowledge) and iv) establish and maintain a steady industrial growth [10]. The envisioned paradigm focuses on integrating industry and academia, through novel adaptations to the teaching / training curricula, achieved by the deployment of ICT-based delivery mechanisms [11]. Such a knowledge transfer environment development in Mektory Innovative Teaching Factory environment has been described at [12] in more detail. The first year of Mektory experience as 24/7 environment has led us to include health care monitoring into factory, supporting elaborated eHealth platform for e-prescribing at national level [13], whereas development towards involving modern public sensor systems is compared in Table 1.

Table 1. Health care monitoring devices comparison.

Parameter to be monitored	AiQ	Metria	Moticon	Basis Science	Balazs Botos	Fitbit
Pulse	1	1	-	1	1	-
Temperature	1	-	1	1	-	-
Blood pressure	-	-	-	-	1	-
ECG	-	1	-	-	-	-
Blood Sugar	-	-	-	-	-	1
Haemoglobin	-	-	-	-	-	1
Cholesterol	-	-	-	-	-	1
Breathing	1	1	-	-	-	-
Sweating	1	-	-	1	-	-
Activity	-	1	1	1	-	-
Comfort		0		0.5		0.5
Size		0		0.5	1	1
Wireless	1	1	1	1	1	1
Installation	1	1	1	1	1	0
Check frequency	1	1	1	1		1
Total	8	7	6	8	6	6.5

There are listed different smart devices: a) AiQ BioMan "smart shirt"; b) Metria "wearable sensor"; c) Moticon "insole"; d) Basic Science "wristwatch"; e) Balazc Botos "blood pressure gauge"; f) Fitbit "skin chip". Smart innovative factories give important means for observing the actions and results of the different processes, mostly based on strong knowledge, specific skills and quality requirements. A lot of data are collected and assessment indicators are used to help humans taking the right decision at the right time. But there is a real lack of connection and adapted configuration of a real digital assistance for each human in the factory, at operational level but also at management level. Smart interaction between humans and the whole knowledge cloud of the company is one important issue that this proposal aims to provide in order to increase well-being for workers.

Moreover, the tight integration of working, learning and knowledge aspects of workers in their respective workplace is a major topic that needs to be addressed. The aspects of work, learning and knowledge cannot be tackled in isolation.

Change management strategy is another aspect that should contribute to the good feeling of employees in their organization. It requires social development to successfully integrate new modifications of the process or organization, currently fulfilled to cope with the increasing competitiveness and market evolution. Taking into account the role of accompaniment of workers to adopt correctly this new change in their working environment can give serious advantages to obtain adhesion from different partners and their well-being, workplace development process is analyzed at Fig. 1. Theories and practical experiences with implementing quality management systems in different companies, we may declare that role and importance of every workplace performance plays more and more important role in effectiveness of manufacturing company, in addition to previous research [14] the health care dimension is added.

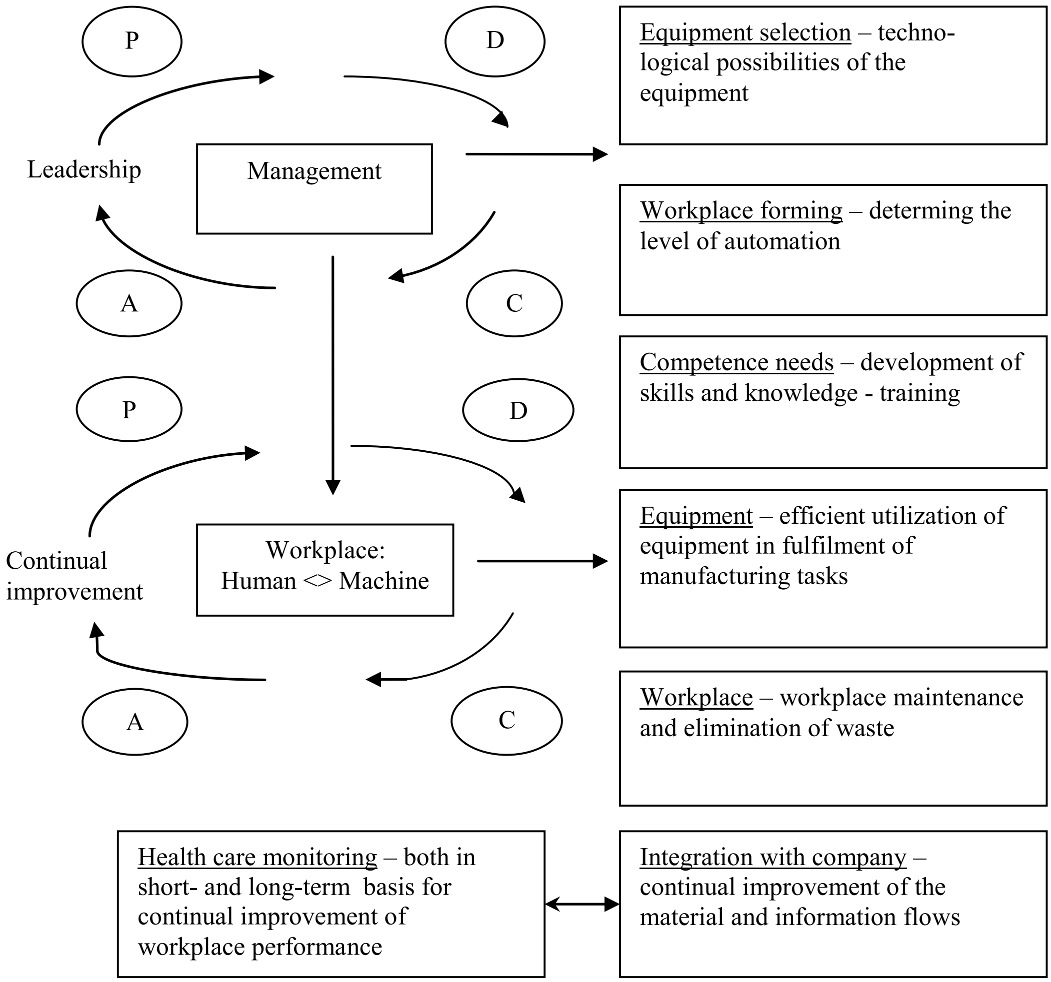

Fig. 1. Roles in workplace development.

One paramount factor that contributes to the well-being of the workers in the factory is their understanding of their activity's contribution to the value chain. Such understanding requires the integration of several socio-organizational aspects impacting work arrangements definition, like promoting positive interactions among workers on one hand, and between workers and their hierarchy, on the other hand, in the pursue of a collective alignment within the organization and favor the development of relations of trust. Such accomplishment requires the promotion of the individual and group (team) awareness regarding both the organization's health care related environment and the underlying technical competencies and information flows that concomitantly frame efficient and effective operational activity.

Particularly, one may emphasize the role of a context awareness integrated strategy in the workshop to enhance the support of change management related endeavors, as those in the realm of the implementation of new work arrangements, to cope with, e.g. worker's satisfaction, engagement and/or organization's competitiveness.

On the other hand, regarding the technology side, given its current state of the art, a number of technologies (e.g. rapid manufacturing, RFID, NFC) and end devices (e.g. embedded systems, mobile, IoT) rises the possibility of infrastructures enabling the specific affordances to be considered in awareness aid systems design and implementation, for instance, regarding information providing, communication support and operational work enactment assistance, considering different interaction modalities and channels.

Such paradigm supports to move the development of work assistance systems, as awareness enhancement aids, beyond the traditional boundaries that typical guide such developments framed on job/role requirements toward the consideration of the affordances specifically required/associated with the human operator performing the job/role, which are inherently complementary bounded by additional humans factors considering either her/his intrinsic abilities, experience and training.

The product quality is achieved through an accurate design of workplace and definition of assembly sequence. A good collaboration between production engineering, process planning and logistics areas will drive engineers to conceive the right tools or systems to support human operations, thus avoiding defects.

Rooted on the analysis results, the targeted models are intended to provide basis to support forecasts regarding as follows:

1) Recognize the need for the introduction of operator work-aid systems (in consideration with the process, workstation and operator (required) specific characteristics), taking into consideration also mental and physical health parameters and on-the-job fatigue,

2) Direct the type of aid system to be considered, including direct access to e-health systems,

3) Evaluate interventions (which may be extended to a broader scope comprehending not only the introduction of work-aids, but also changes in some of the factors/attributes of (according to the devised model) related dimensions). Consequently, a possible outcome from such models is the identification of specific, to some extent fine grain, training requirements. This way, the selection or specification of support systems or tools will be grounded on a comprehensible holistic model rather than on empiricism, best guess or trial and error.

4) Integration of Internet of Things (IoT)

The network of devices may be personalized and adapted to the workers' profile according to IP addresses to the context they are facing, in order to better support the operation.

3. Smart health care monitoring for industry

Tablets, laptops, mobile phones and other gadgets monitoring both machines and humans are being used in the shop floor. Digital devices are getting smaller, faster and more efficient, using Industrial Internet. This paradigm, supported also by initiatives like Industry 4.0 is strongly centered on the human aiming to provide the appropriate information and the right services to people in specific contexts, according to their needs. Mobile computing is a strong support for the ubiquitous computing vision, with mobile devices having the great potential to be its default physical interface due to their advanced capabilities.

So, advantage will be taken of mobile devices and sensors to capture environmental clues and frame the context toward making operation and training more personal and aligned with the user's context.

Based on the analysis of principal well-being sources, the developments in this project are structured as an integrative approach covering various complementary disciplines: health care related, technical and organizational aspects by focusing on the interaction between organization, workforce, management and technology.

The design and management of manufacturing systems is a complex task entailing the need of taking decisions with a long time horizon impact and involving a major commitment from the financial point of view. The set of different decisions must take into consideration the products to be manufactured, the production technologies and processes, the production resources and the transportation system, all of them in a joint way.

One of the important challenges tackled is to investigate the broad domain of awareness related research and to propose a combined integration of the health care related and technical dimensions that surrounds the envisioned global perspective of awareness. Furthermore, society should contribute to inform socio-organizational practices, as well as, the development and deployment of ICT facilities that support awareness oriented aid systems. The lab concept is presented on Fig. 2.

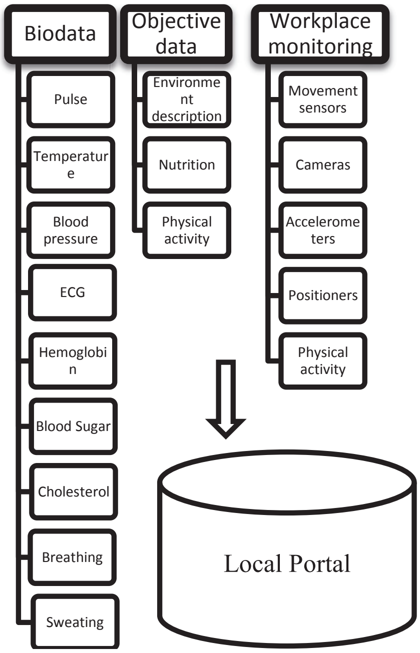

Fig. 2. Smart health care monitoring concept.

Moreover, further decisions must be tackled during the life cycle of a manufacturing system, i.e. managing the production, controlling the behavior of the production resources, defining proper maintenance policies and taking decisions related to possible reconfiguration of the plant. This is what is called co-evolution of product, process and system, i.e., the need of jointly considering the characteristics and constraints of product, process and system, together with their evolution in the time.

The proposed approach will tackle this set of problems taking into consideration the characteristics and the constraints of the human workers within the system. It includes several smart devices for workplace monitoring, discovering also large variety of bio data, which are subject of analysis based on objective data. The personalized bio data are sent directly to eHealth server, accessible by family doctor, thus avoiding access of personal health data by employer.

The concept realization focuses on the worker group and proposes contributions from health care related, education and knowledge management communities in the aim to enhance health care related conviviality in the work group and guarantee skills' evolution. The modern manufacturing is based upon technology, operated by humans. Even as due automation the direct influence of workers into manufacturing processes has been decreasing, there is increased demand for highly skilled both from blue- and white-collar staff members. Technological resource is defined by technological equipment (machine tool) on one side, and by corresponding skilled staff member (engineer, operator) on other side. While monitoring of technological equipment performance has improved a lot [15], using several performance indices [16], and qualification systems for engineers and workers are developing in most countries, the monitoring of employees' health at workplace has been rarely thought about in manufacturing industry. Rapid development of health care gadgets and mobile apps has made possible also for employer to monitor staff members' health condition.

In fact, work accomplishment is inherently rooted on the confluence of several factors characteristic of operator, technology, processes and organizational dimensions.

Human factor integration in such kind of complex socio-technical systems should be addressed throughout several leverages. Continuous improvement of workers' competencies and knowledge transfer in the wok group constitute one of most important one of them since the right competencies and level of experience of human operators are crucial to deal with the complexity of the development processes and assure the right quality of final product. It also contributes to increase the reactivity of the workers and their auto-adaptation regarding specific working situation in order to guarantee a high productivity level at any marketing request.

Conclusion

Modern management strategies pay an increasing attention to the role of human in the socio-technical production as the principal factor for success. Human operators are crucial to deal with the complexity of the product and production development processes and assure the right quality of final product. Even with all the technological advancements in the field of factory automation, we are still far from achieving a true "lights-out" production. A commonly used job quality indicators in the scope of the EU comprise of a set of 10 dimensions addressing health and safety at work, flexibility and security, work organization and lifelong learning. Such a health care emphasized industrial lab prototype is in development, targeted to use in future smart and innovative factories. As a novel feature, monitoring of human machine tool operators is included into workplace monitoring. A set of parameters gathered from medical and publicly available sensors and smartphones help to predict employee performance. The collected data also enables to design a human centric employee performance measurement system based on these indices. As a result management can make decisions based on quantitative information towards employee satisfaction, physical wellbeing and attract workforce to stay longer in the labor market.

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