Participative knowledge management to empower manufacturing workers

Abstract: Due to the rapid technologic change, we see the role of manufacturing workers continuously changing: the increasing automation of manufacturing processes has reduced the amount of manual work, whereas the increasing complexity of manufacturing systems requires workers to build-up broader and deeper skills. In this paper, we suggest a participative knowledge management approach to empower manufacturing workers. Starting from a comprehensive empirical analysis of the existing work practices in a manufacturing company, we have developed and validated a knowledge management system prototype. The prototype is aimed for training, problem solving, and facilitating the discovery, acquisition, and sharing of manufacturing knowledge. The conducted evaluation of the prototype indicates that workers' skills and level of work satisfaction will increase since the knowledge management system allows faster problem solving by finding better solutions for observed defects.

Keywords: Knowledge management, social factory, knowledge extraction, defect management

1. Introduction

In recent years a number of manufacturing companies have recognized the growing need for developing new approaches to increase workers' job satisfaction and workplace attractiveness. This challenge has been highlighted in the Factory of the Future agenda (EFFRA, 2014) promoted by the European Commission, which calls for proposals on new approaches for skill and competence development, and knowledge management. Through its ubiquity and openness the Web has become a major source of inspiration for new tools and approaches that enable the sharing of information and ideas (John, 2013). Web platforms like Wikipedia, YouTube, and Facebook have promoted new ways of information search, sharing, and social networking. Users do not only consume, but actively produce information and engage with the information produced by others in a participative way.

Implementing a collaborative approach from the Web into a factory is a challenge that traditional manufacturing companies face in order to remain an attractive employer for younger workers (EFFRA, 2014). While younger workers are adopters of such recent technologies, and also "expect" to work with those in their job, fit strategies to engage older workers must also be put in place to avoid creating a "digital divide" (Pick & Nishida, 2015). Moreover, the ageing of the workforce leads to a continuous loss of manual and practical competences that is hardly affordable for the company, which must implement fit strategies to assess and contrast this phenomena (Jennex, 2014).

A growing number of studies has shown how social and mobile technologies can help to capture and process knowledge and to empower knowledge workers at their office workplaces (Faraj, Jarvenpaa, & Majchrzak, 2011; Jennex, Smolnik, & Croasdell, 2014; Kukko, 2013; Majchrzak, Wagner, & Yates, 2013; Richter & Riemer, 2013; Von Krogh, 2012). The adoption of ICT technologies plays a major role in the transition to a knowledge economy that is focused on the transformation of human knowledge in decision support systems that could generate economic value (Brown & Duguid, 2001; Gold, Malhotra, & Segars, 2001). This transition is ongoing at a global level and it is driving innovations from the ICT as a by-product of the so-called Information Age (Dutta, 2012).

In many industrial domains, manufacturing workers are still mainly manual workers; the challenge for the above mentioned transition is to empower them to become knowledge workers. Their work should be facilitated through innovative and dedicated knowledge management approaches, inspired by the digital transformation within office environments. This requires implementing knowledge-based strategies into manufacturing work that acknowledge the central role of the manufacturing worker.

In this paper, we present a participative knowledge management approach to empower manufacturing workers in their work practices with the aim to improve their problem-solving capacities, eventually leading to an increasing attractiveness of their workplace. The developed solution is based on four key enablers of knowledge creation identified by Elliot and O'Dell (Elliott & O'Dell, 1999): culture, technology, infrastructure and measurement. We focus on the management of explicit manufacturing knowledge, which can be expressed in words (Nonaka, 1991). We have developed a prototype of a manufacturing knowledge management system (KMS) based on an extensive analysis of the existing work practices in an Original Equipment Manufacturer (OEM) in the automotive industry. The subsequent requirements were elicited in a design-research-based approach at an automotive supplier company. This KMS is intended to empower workers in one of the most difficult and stressful tasks in their job: finding an appropriate solution for manufacturing defects.

A preliminary evaluation of the developed prototype conducted together with future users has shown that the participative knowledge management approach proposed by the authors is well suited to be integrated in a streamlined manufacturing process. It is solving a real problem for manufacturing workers by allowing the sharing of useful and quality-relevant knowledge and ultimately empowering them. The KMS uses state-of-the-art technology to retrieve the knowledge within its repository, such as semantic search, and adopts standard and widespread human machine interfaces like tablets instead of traditional workstations. The basic idea of the KMS is to provide a continuous support to manufacturing workers who can then use knowledge acquired by their peers to solve the daily issues that arise during their shifts. Another advantage of the developed solution is the transformation of the shop floor into a social environment where all the peers can share their ideas, receive feedback and, in general, gain a higher motivation to collaborate together.

After laying the theoretical background for our study (section 2), we describe our research approach, i.e. in gathering needs and eliciting requirements of industrial workers for empowerment (section 3). In Section 4 we introduce the adopted case study and describe the as-is situation and the challenges of the manufacturing workers to be taken on. In Section 5, we describe the KMS which has been developed according to the needs and requirements of the case study. The paper closes with a presentation of the results of our preliminary evaluation of the developed prototype in section 6 and a summary and outlook of future research in section 7.

2. Theoretical Background

2.1. Knowledge management in manufacturing companies

To have an optimal management of the workforce in a manufacturing company, it is fundamental to valorise the compromise and collaboration attitude of the employees (Wang & Ting, 2011). These two attitudes could be exploited simultaneously only if a formalization of the employees' knowledge is available: collaboration and compromise must be based on a common idea and understanding. Many authors studied how the use of a KMS can improve the organizational performance. Greco et al. (Greco, Grimaldi, & Hanandi, 2013) have developed a framework based on the Analytic Hierarchy Process approach. With this proposed approach, an ad-hoc hierarchical structure has been implemented, considering also second-order criteria. The KMS definition is also the base for supporting and promoting knowledge sharing among peers. However, many authors (Kukko, 2013) report that some barriers must be overcome to have an effective sharing system, that otherwise would lead to a knowledge mismanagement, responsible for unsatisfactory performance. Supporting knowledge sharing is one of the main driver for continuous improvement actions (Quesada-Pineda & Madrigal, 2013). It is one of the most useful approaches to cope with fast changing environments and contexts and requires a new organizational strategy (Jennex, Olfman, & Addo, 2003).

An important issue for the implementation of a KMS is the effectiveness related to the implementation of a KMS in a manufacturing company: this is related to the success of reusing knowledge to improve company organization thanks to the availability of shared knowledge when it is needed (Jennex & Olfman, 2006). Since this issue is quite important for the implementation of the KMS, many assessment frameworks have been developed to evaluate how the model meets the success criteria of the KMS and the KMS theoretical foundation; one of the most used models is the one proposed by Jennex and Olfman (Jennex & Olfman, 2005).

Due to the need of industrial enterprises to focus on the increase of short time productivity, most of them have invested in the creation of tools that limit the decision making of the workers, introducing systems that automatically detect problems and suggest solutions, like in the field of machining and die casting (Campatelli & Scippa, 2012; Grossi, Sallese, Scippa, & Campatelli, 2014; A. Scippa, Sallese, Grossi, & Campatelli, 2015; Antonio Scippa, Grossi, & Campatelli, 2014) among the most common manufacturing processes in manufacturing companies. The massive use of analytical models, simulations and experimental approaches simplified some problem-solving activities, but demotivated workers, who have then been sometimes “substituted” by automatic routines. An additional drawback is that such developments lead to the loss of problem solving creativity and crucial knowledge in the company, owned by experienced workers that could not be simply described using a process model (Pokhrel, Cruz, Ramirez, & Kraslawski, 2015).

Another important issue is the creation and formalization of knowledge. Social software can sustain the interest of customers and employees to dialogue and share ideas (Martini, Massa, & Test, 2012; Ngai & Chan, 2005), but this approach usually lacks a systematization of the data exchanged that could be transformed into knowledge.

2.2. Social software and user participation

In the last decade, many organizations started to use Web-2.0-tools ‘behind the firewall’ to support knowledge transfer, sharing, and collaboration; this is perceived as the new way of supporting employees (Kane, Alavi, Labianca, & Borgatti, 2014; Paroutis & Al Saleh, 2009). Most notably, social software facilitates user participation in creating content and allows for new ways of connecting, interacting and communicating with other people on the Web. For the people involved, this did not come without challenges – mostly related to the integration of organizational structures and processes. These go beyond the requirements of Web platforms, which are primarily characterized by informal structures and have to be taken into account in socio-technical tool design (Dimicco et al., 2008; Pei & Grace, 2009). Amongst others, researchers and practitioners have been continuously debating the impact of the adoption process on the success of social software (Buhse & Stamer, 2008; McAfee, 2009; Richter & Riemer, 2009; Richter, Stocker, Müller, & Avram, 2013). McKay and Donald (McKay & Ellis, 2015) proved that knowledge sharing is a crucial factor for high tech companies, like in the IT sector, where a lack of adequate knowledge sharing leads to intellectual capital loss, rework, skills deterioration, and repeated mistakes that increase project costs or failures.

The greater awareness and willingness of users to participate in a system that formalizes and shares knowledge opens a lot of new possibilities - also in the industrial sector. The great advantage is that the users, i.e. the manufacturing workers, are encouraged to formalize their experiences and codify them into knowledge artefacts that could be shared with the other workers through KMS. This produces a benefit for the company but, most important of all, leads to an increased satisfaction of the workers themselves, thanks to their empowerment and their increased capability to exploit their potential in a collaborative environment that supports and prizes its willingness to share its idea to improve their job performances. The greater inclusion of the workers in decisions that could be taken at shop floor level has the advantage to motivate people and create a better working environment. Bloodgood (Bloodgood, 2015) proved that companies with a good knowledge management are also characterized by a higher dynamism, thanks to the greater motivation and involvement of people in the manufacturing processes.

2.3. Key enablers of knowledge creation

The introduction of a social software-based KMS in a manufacturing environment wants to put workers into the centre of the decision-making process, enabling them to take care of more complex and motivating tasks thanks to the knowledge support of their peers. The preliminary step for the introduction of a KMS is the creation and formalization of human knowledge by providing a correct context and proper knowledge creation tools. The four key enablers of knowledge creation identified by Elliot and O'Dell (Elliott & O'Dell, 1999), culture, technology, infrastructure and measurement, must be taken into account to design such a participative KMS. It is important to keep in mind that leadership also plays a major role in ensuring the effectiveness and shared efforts of the four enablers (Scovetta & Ellis, 2015). Furthermore, it is important to harmonize the commitment of the leadership for the implementation of the KMS with its Leadership Social Power (LSP), since it influences the success factors for the implementation of the system. These four key enablers have been considered in the development of the current strategy to formalize the workers' knowledge.

- **Culture**: The project aims to introduce a new culture into the company that will foster the empowering of workers and will create the motivation to collaborate and share ideas and knowledge, creating a new social environment in the manufacturing company.
- **Technology**: New technologies will be adopted to support the involvement of workers in a collaborative environment. The role of the software is fundamental in knowledge sharing, as highlighted by Marouf and Khalil (Marouf & Khalil, 2015), that put in the first place the IT as an enabler of sharing, together with individual characteristics of the peers involved.
- **Infrastructure**: The infrastructure redesign will include the definition of new organizational roles and responsibilities, in particular for leadership that have to promote the collaboration among workers, also with prizes and incentives.
- **Measurement**: To support the creation of usable technology, the system will be based on objective measures, that could be acquired and verified by the workers. The system will be connected to many real-time sensors that will send their data stream to the worker tablet. Moreover, the quality of the created knowledge will be measured and monitored thanks to a rating strategy.

3. Applied method for defining workers' needs for empowerment

To design a really useful solution for manufacturing workers, it is crucial to fully understand their daily tasks and challenges. Our general approach was inspired by well-known and widely accepted approaches, such as the ISO9241-210 standard for the human-centred design of interactive systems and Design Research's process model (Peffers, Tuunanen, Rothenberger A. Marcus, & Chatterjee, 2007). Both processes build on the assumption that "wicked problems" (Pries-Heje & Baskerville, 2008) cannot be solved in a linear process. Instead, an iterative and agile form of the subsequent (re)-development and evaluation of the requirement is needed. This approach accounts for the normally up-front, loosely specified goals and use contexts. Further, it assumes that the solution success depends heavily on complex interactions between the stakeholders and that proper solutions can only be achieved through a critical dependence on human cognitive and social abilities (Hevner, March, Park, & Ram, 2004). However, it must be considered that the above-mentioned process models are generic and lack concrete procedures for specific situations. To apply the approach to different manufacturing domains it is necessary to develop an agile solution that could be adapted to the manufacturing environment as the analysis of workers' needs progress.

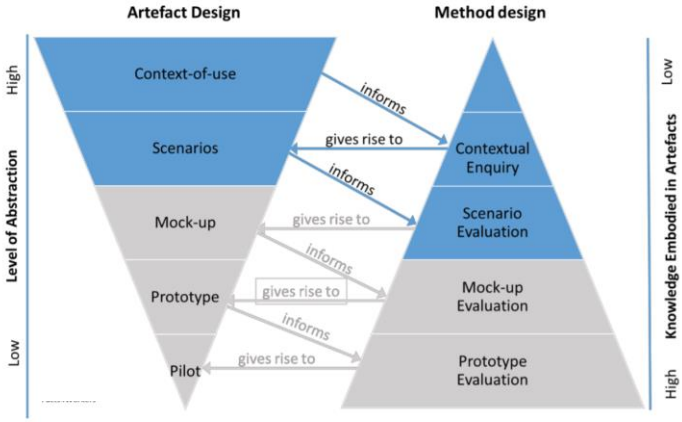

Fig. 1 - Artefacts design and method design interaction (Heinrich & Richter, 2015)

The used approach can provide a decreasing level of abstraction of the solution as far as the interview and focus groups are carried out (fig. 1, cf. Heinrich & Richter, 2015). On the highest level of abstraction (with the least knowledge available at the beginning of the analysis), we used textual descriptions of the rough context and vague solution ideas that we shared and discussed with the people involved in the survey. Based on this *context-of-use*, we planned the specific procedure of the contextual enquiry. This planning step could not be done previously, as both quantitative (i.e. how many subjects from each stakeholder group had to be included) and qualitative (i.e. specific methods of inquiry, e.g. semi-structured interviews, video-recording of work procedures) reasoning would not have been possible.

The information gained from the contextual enquiry was then aggregated into problem scenarios and into process models, which made the identified problems and technological solutions better comprehensible. Creating these scenarios is part of the scenario-based development (SDB) methodology (Rosson & Carroll, 2002). Instead of describing a future system only in terms of its pragmatic dimensions (i.e. its functions) SDB focuses on the perspective regarding how the system is and should be used by the relevant stakeholders (Rosson & Carroll, 2002). *Problem scenarios* are types of stories that describe how the relevant stakeholders act in the current situation. Later, *activity scenarios* are created that describe how the envisioned system is used in the specific context. These *scenarios* have been used to design the first mock-ups (i.e. clickable screen mocks). The procedure of alternating building/evaluating cycles was repeated till the final definition of a functional and workers' acceptable solution. The advantage of using such artefacts is that, unlike lists of requirements, they cannot be inconsistent among themselves. Of course, it is possible for a prototype not to incorporate all the information, or to incorporate information other than the scenarios, and therefore it is necessary to have a prior validation of the prototypes.

As soon as the final solution has been defined, an impact analysis has been carried out, considering the following impact dimensions (cf. Heinrich & Richter, 2015):

- Autonomy - the freedom of choice regarding what to do, when and the possibility to drive their own decisions without consulting various superiors or colleagues.
- Competence - the ability to make informed decisions, often required for problem-solving and innovation, with the possible support of peer collaboration.
- Relatedness – a measure of the workers' participation, involvement and awareness
- Variety - the diversity of the tasks during the employees' daily work.
- Protection - the reduction in stress levels and cognitive overload.

The first three dimensions can be aggregated into the psychological empowerment concept as expressed in the self-determination theory, which uses the exact same three dimensions (Deci, Connell, & Ryan, 1989). In the empowerment realm, the fourth category, variety, plays an especially important role in work contexts (Turner & Lawrence, 1965). Hence, the core directions of the impact are workers' empowerment and protection.

We have applied this approach and defined workers' needs for empowerment at an industrial partner to develop a KMS prototype for shop floor workers and validated its impacts in the dimensions from above.

4. Case study

The company that supported our study is a specialist in the field of thermoplastic injection moulding as well as the design and construction of the moulds, further called HOT. HOT's customer base ranges from Original Equipment Manufacturers (OEM) in the automotive industry (e.g. fittings for cars) to suppliers of end consumer products for supermarkets (e.g. thermos flasks). Most of the injection moulds are produced in-house. HOT is also responsible for the assembly of some injected parts to have a larger and more complex final product. HOT works closely with its customers, starting from the design activities up to the actual manufacture of moulds, their quality control and their shipping.

In the following, we will briefly summarize the various identified knowledge-based challenges posed for workers in the current manufacturing process:

Workers either manufacture work pieces or process/assembly/test work pieces delivered by external contractors. Depending on the product, specific knowledge is required for its manufacturing, assembly or testing. This knowledge is currently provided orally by colleagues or it is available on paper-based documents located near the workbench. If workers have specific problems, they must contact their team leader. If workers have ideas on how to improve the manufacturing process, they must rely on face to face communication with colleagues or superiors.

Another task that manufacturing workers must carry out is the handling of data, mostly regarding the continuous quality assessment of produced work pieces. Even before they execute their own manufacturing step, workers must check incoming work pieces to verify if they are within specifications. Quality requirements are defined by quality managers in close cooperation with the customer. During each production run, data including throughput per hour, number of errors and types of errors are manually documented on a flip chart and periodically communicated to the team leader in a direct conversation. In case of a serious error, the entire production line must be stopped and re-adjusted. With respect to the quality control of the produced parts, the operator is loaded with a variety of manual checking procedures, e.g. a visual inspection of the product and comparison of some characteristics with the standards. This is a particularly monotonous task for a worker. If an observed deviation requests a readjustment of the production line, the team leader consults paper-based configuration instructions and documents conducted changes on paper to be used when a new production batch of the same product would be scheduled. The workers are not generally in the position of solving most of the problems autonomously. Hence they can only carry out prescribed steps of work without any sort of self-organization and decision competency, affecting their job satisfaction.

5. Defect management support for shop floor workers

The KMS of this study has been developed to provide a solution for empowering workers in their daily tasks and support their greater autonomy and self-organization. As preliminary step, HOT has developed an IT infrastructure for accessing the real-time data generated by the process, including both the data feed from the machines than the data available on the company's ERP (e.g. production order, batch dimension, percentage of error, production rate, machine setup). The connection of the developed system with the existing IT framework of the hosting company is mandatory to create an environment where all the data regarding the manufacturing process are accessible to provide in-depth analysis and cross references for problem-solving suggestions. The manufacturing process generated data have been stored in a MySQL database, accessible for the workers and external applications like the KMS.

One interesting feature of the developed KMS is that it provides a smart and agile approach to let the workers access the manufacturing data thanks to a high usability device: a tablet. The basic principle used during the development of the system has been that the information must be easily accessible and understandable, and therefore must be presented with an user-friendly and accessible tool, in a simple format, possibly after some pre-processing and analysis to improve its readability. This is a major challenge since the information collected during the process is usually intended for later post processing and not for a fast understanding finalized to defect solving since it consists of huge amount of data, often not correlated. It is important to consider that the availability of this information is crucial to provide a solid background for the decision-making process of the worker. In this case the knowledge that the workers are interested in is the definition of the optimal solution for an arising issue. The KMS is able to track and comment any decisions and actions within the process: the workers is able to describe the problems and the actions carried out creating multimedia content like video, photo and audio. This allows to provide a usable description of the activities based more on image - or video - than on text. The KMS has been programmed to provide an easy and intelligent (based on semantic search) search engine of the data that allows the workers to navigate easily the whole database. It is important to remind that the explicit knowledge that the KMS is trying to elicit is the relation among the arising problems and the related solutions; the database is structured to expose this link to the workers.

Regarding the design of the interface of the system with the worker, we considered that to have a functional exchange of knowledge, it is necessary to have it available in an explicit form. This issue has been exploited by many authors, like Vera et al. (Vera-Baquero, Colomo-Palacios, & Molloy, 2016) who recognized that knowledge required in a manufacturing environment is usually in the form problem/defect->solution. Knowledge workers require the information about the corrective action (solution) to be deployed when an event (problem/defect) occurs. The developed approach has been called "Defects&Solutions" where the adopted definition for "Defects" is quite general: a defect is both a non-conformity of the product but also an abnormality of the manufacturing process that are not responsible for a bad quality of the product but affect only the process efficiency. The general concept used for the implementation of the KMS is to consider a defect a general problem that the worker must solve. The KMS want to become the tool that every worker would use when encountering a defect to have a proper suggestion about the required solution but also to comment the results of an adopted action on the process performance to create a shared and easily accessible knowledge database, useful for all the workers.

In general, multiple solutions to solve a similar issue could be available in the repository of the user generated content. To cope with this issue, the developed KMS applies the concept of solution ranking. Ranking is a measure of how adequate a solution is for a specific defect. General solutions (e.g. 'clean the device') could be applicable to a large variety of observed defects, but may have a poor effectiveness in a more complex case. Knowledge must be highly contextualized and the worker can provide feedbacks and validate the effectiveness of an applied solution for a very specific defect.

The system formalizes the knowledge as the possibility for a solution to solve effectively a known defect, based on the feedback of the workers. To cope with new defects that could arise, KMS integrate a Semantic Search Engine (SSE), too. The SSE is intended to propose the best solution for the current defect, searching for solutions that have been positively applied for similar defects. The algorithm uses a natural language processing approach to extract information from the defect and solution description, as inserted by operators using "their" language and not a structured and formalized format. The algorithm is based on the popular semantic search engine ElasticSearch (Ittoo, Nguyen, & van den Bosch, 2016). The KMS could be used also to track the solutions deployed by the different workers, in order to assess their past experience and suggest solutions that are affordable for the specific workers. In case the defect could be solved only with a solution not compatible with the skills of a specific operator, the system calls automatically the worker supervisor - Team Leader – that will be able to train the worker for the required operation. The user profiling based on experience is a fundamental approach to provide the correct, adequate, and action-relevant information to a worker. Some information may not be useful or sometimes misleading for workers that did not have enough training to correctly understand and apply it in practice. The basic scheme of the KMS is presented in Fig. 2.

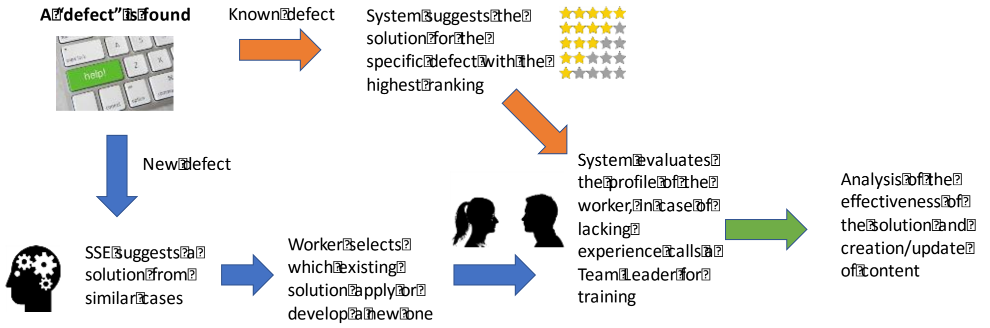

Fig. 2 – Scheme of the developed KMS

Knowledge is generated by the workers thanks to a visual approach that allows to insert easily the linked information (defect->solution) into the KMS. The chosen HMI is a tablet, characterized by an higher usability and acceptance respect to a workstation (Lai, Kuo, & Chuang, 2015). For the description of the defects and solutions it will be possible to use the tablet to acquire multimedia files like pictures, videos and audio tracks. A mock-up of the user interface for knowledge generation is presented in the Fig.3.

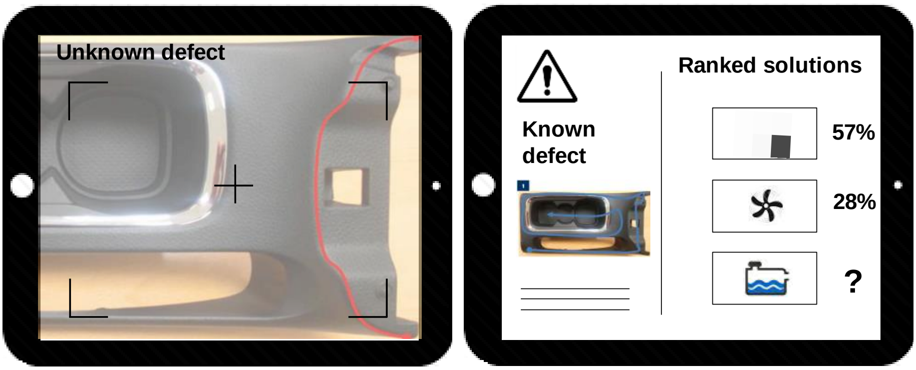

Fig. 3 - Mock-up

The ranking of a potential solution to a defect is calculated through the feedback of the workers, which is provided after a successful or failed application of a specific solution. This is an indicator about the success rate of a proposed solution, to be used when a choice among alternatives possibility is required.

6. Evaluation of the prototype

In our agile and iterative design process, mock-ups of the proposed KMS have been presented to the workers in specific focus groups and during personal interviews. A representative group of 14 out of 40 workers, that will use the KMS at the end of the project, have participated. The objective was to gain additional feedback for increasing the maturity of the KMS to fit the challenges of workers in the industrial case by using two levels of abstraction.

As first step, we have presented the *context of use* of the intended solution to workers to define and refine the possible advantages for them and for the overall management of the process. As a part of this approach comics have been used to depict both the initial situation (problem scenario) and the improved situation (activity scenario) to the workers. The idea of using a comic has been elaborated to represent in a simple way the *context of use* to its core aspects, highlighting only those details that workers must consider for a comparative evaluation of the developed solution (Denner, Richter, & Heinrich, 2015). By using comics, the information regarding the future solution is comprehensible to all interested persons. Comics have proven to be useful in evaluating also a common understanding of the *context of use*. The feedback received upon showing the comics to the workers has been very positive, since the workers understood the future scenario and the benefits of a KMS to find solutions for defects, including the advantages for their future job.

Fig. 4- Comic representation of problem scenario: Fixing the manufacturing of faulty parts (Denner et al., 2015)

Fig. 5 - Comic representation of activity scenario: KMS simplifying decision making (Denner et al., 2015)

The feedback collected at this level of presentation has been used to refine the software architecture of the KMS and to review its required functions. An example of the current state (problem *scenario*) and the future activity approach are reported respectively (see Fig.4 and Fig.5).

In a second step a functional prototype of the KMS was shown to 10 workers during personal interviews. The KMS contained dummy data created to provide the solutions with multimedia data for a limited set of known manufacturing defects. This second evaluation has been used to highlight which content was more appreciated and useful for the workers' problem-solving. Also the satisfaction about the use of the software (usability check) and their feedback about its functionality have been collected (e.g. reducing of time and stress level to solve a current problem). The KMS was installed on an industrial tablet, in order to improve its usability and have a smart tool, which can be easily used by non-IT experts, too. This solution has the advantages that tablets are already-known and intuitive human machine interfaces and benefit from the "appealing" factor that immediately creates an interest to use the KMS.

Our preliminary evaluation of this developed prototype has yielded positive results. The constructive worker feedback has been used to further improve software functions as well as the graphical organization of the knowledge on the tablet screen. All workers involved in the test of the prototype declared their satisfaction about the functionality and potential support that the KMS could provide. During this preliminary evaluation, we received some feedback about the organization of the provided content, avoiding to report information with low interest for the workers and, in general, avoid distractions or time losing operations. During these tests the functionalities of the software have been presented also to the management of the company. Some appreciated features are that the system is as less intrusive as possible, and it requires very low IT expertise to be operated. The expected results for this implementation is not the reduction of defect rate but an increased capability of the workers to solve autonomously the problems/defects that could arise during their daily tasks, with positive effects in production rate (reduced time of the machines) and increased autonomy of the workers that lead to their empowerment and satisfaction.

7. Conclusions and Outlook

As a result of the rapid technological chance, the role of manufacturing workers is continuously changing. While manual work is replaced by automation, the increasing complexity of the remaining manufacturing work forces shops floor workers to build up cognitive skills. Applying practices and technologies from knowledge management can be a feasible approach to cope with this challenge.

In this study we suggest a participative knowledge management approach to empower manufacturing workers. We have proposed and applied a user-centred approach for eliciting and defining worker's needs at an industrial case partner to design a worker-centric KMS, which facilitates finding solutions for observed defects and allows the provision of worker-feedback on a solution's helpfulness.

The prototype of the developed KMS has been designed, tested, refined and validated according to the principles of user-centred design. Our approach starts from a high level of problem abstraction using comics to better outline the context of use, the as is situation, and the solution scenario. We then increased contextualization with mock-ups and finally defined the knowledge required by the workers, to be visualized on a mobile tablet computer.

Taken such a strategy has established a very good comprehension on the defect-solution process and an even better base for focus group discussions. Our participative knowledge management approach has been tested within the industrial context of one manufacturing company. All study participants have indicated their satisfaction about the functionality and the support of the developed KMS. This preliminary evaluation has indicated that using the proposed solution can increase problem solving skills and the autonomy and self-organization of workers. Sharing defect and solution knowledge with the developed KMS provides a solid background for the decision making process of the worker. Using the KMS is intended to increase the capability of shop floor workers on how to cope with defect and solutions challenges on the shop floor with positive effects on production rate, defect rate, and – most importantly – increased autonomy of workers that will lead to their empowerment and job satisfaction.

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