People-Centred Production Design

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Abstract

This case reports on a worldwide operating SME producing floor cleaning machines. The SME distinguishes itself from its competitors by providing highly customizable high-quality products. Employees are one of the "most-valuable resources" to the management. However, the initial situation reveals significant improvement opportunities related to the employee involvement and empowerment concerning workplace re-design. The proposed subject-oriented solution aims to involve shop floor workers in workplace (re-)design by providing them structural empowerment means such as social media for suggestion proposals, discussions and negotiations. Furthermore, the newly introduced features are designed to allow for context-sensitive reporting of suggestions and errors. Context-sensitive elicitation provides the basis for analysing impacts of changes (e.g. the affected location or worker) and visualizing potential improvement areas within the shop floor. The generic suggestion and error handling process can be tailored to different organizations. The S-BPM process handling has been

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integrated with a semantic wiki allowing for context-sensitive workplace improvement elicitation and change propagation analysis. The evaluation reports on findings in developer workshops, focus groups and user tests conducted in parallel to the design and implementation to ensure a user-centred approach (formative part), and on findings related to the outcome of the case implementations at the given SME (summative part).

5.1 Elicitation and Analysis of the Initial Situation

The case described in this chapter captures an SME operating in the professional cleaning market with the focus on the production of floor cleaning machines on a worldwide level. The company, herein after called "Company B", has about 95 employees and a turnover of about 25 million Euros. It is a family-owned business, as many of the Italian SMEs.

The internationalized system of selling and purchasing enables the company to buy pieces all around the world, assemble cleaning machines, and sell them in more than 70 countries, while competing with large internationally structured companies. The majority of the company's customers are retailers in many different countries all around the globe.

5.1.1 Use Case Definition

The first step towards the elicitation of the requirements was the use case definition according to Leffingwell and Widrig (2003). A number of activities were carried out to define the use case, for instance factory visits and face-to-face workshops, characterized by brainstorming sessions and use case prioritization, definition of key terminologies, development of procedures, virtual and face-to-face workshops, discussions and interviews. Special emphasis was given to the involvement of all stakeholders, in order to capture the different perspectives—ranging from the workers' to researchers' and developers'—following the premises of a participatory people-centred case definition. Specifically, the use case definition was driven by brainstorming and discussion rounds including members of the middle and upper management to develop practices and tools for empowering workers, who were involved in later stages of the project.

In the following, the outcomes of these activities towards the definition of the use case are reported. Especially, the scope of the analysis, with a focus on the initial situation as perceived by the SME, as well as the first steps towards the to-be situation, i.e. purpose, goals and objectives of the use case, are reported. Finally, an initial sketch of the solution is presented in Sect. 5.1.1.

5.1.1.1 Initial Situation

Company B is very sensitive to the quality of its products and achieving high quality standards. These attempts are physically reflected in the factory layout itself. Company B implements a road to quality throughout the whole factory covering areas as the "quality checking—incoming goods area" and the "final check area". Due to the importance of product quality, the quality checking area is one of the most sensitive areas for the company. In this area, incoming goods are identified and the delivered products are quantitatively checked with respect to the due quantity. Quantity control is followed by a conformity check of the received goods with respect to the ones already in the warehouse. Finally, the goods are checked with respect to their quality.

The SME pays a lot of attention to quality issues and tries to foresee problems by carrying out rigorous checks in the receiving and quality checking area. Overseen errors at this stage can lead to problems in the assembly line at a later stage of production. If some pieces are damaged or do not meet the quality standards, they may impact the production process. However, it is time-consuming to check each component. To address this challenge, Company B aims at employees' participation in the suggestion and improvement process. They should make suggestions when reflecting on their actual task accomplishment, and come with proposals for improving their workplace design and the company's performance.

Currently, workers suggest workplace improvements in a completely unstructured way. Suggestions for improvement occur in two different ways:

- **Quality Circles**. Quality circles take place at Company B every week with the production manager and the quality manager. Workers are not directly included in the quality circle. Their suggestions and opinions are only recognized indirectly through one of the managers. These meetings result at least in five suggestions of technical nature at the end of every meeting
- **Face-to-Face Suggestions**. Workers pose suggestions directly (face-to-face) to the responsible manager (e.g.: Quality Manager). These suggestions are discussed by the managers during the quality circle meetings but are not documented or persisted in any form

Workers suggest improvements to the management face-to-face. Sometimes workers immediately receive feedback. Most of the times, however, workers do not know whether their suggestions are taken into account at all. In addition, suggestions could be lost, since they are not documented. The same happens with the process of feedback and rewarding: there is no transparency for workers whether their suggestions are taken into consideration, or why they are rejected.

With respect to the suggestion and improvement process in Company B, the current situation can be described as having no structured procedure processing suggestions, neither for the communication among production workers nor between departments.

5.1.1.2 Goal Definition

Focusing on functionality and efficiency often leads to neglecting a critical factor for sustainable organizational success, the human being. Company B considers humans as one of the most important assets of its operation by putting the worker at the centre of the workplace design. Management aims to engage workers in the (re) design of their work environment and processes. However, the participation of the employees in the workplace re-design is hindered by problems in communication and suggestion making.

Starting with these findings, the goals and the objectives of the use case have been defined in an iterative process involving different stakeholders. The refined and consolidated list of these goals and objectives is summarized in Table 5.1. The development team has identified the global goal as "subject-oriented re-design of production workplaces to empower workers and stimulate teamwork". The empowerment of workers to actively participate in the re-design of their workplace is the umbrella for three sub-goals addressed through the use case implementation at Company B. The first sub-goal is to improve the internal communication and collaboration considering the re-design of workplaces. To achieve this goal, four objectives addressing different aspects have been identified for the use case:

Table 5.1 Consolidated goals and objectives

Overall goal	Goal	Objective
Empower employees to actively participate in workplace re-design	Improve the internal communication and collaboration	Increasing traceability of information flow
		Increasing transparency of communication
		Facilitating meaningful information exchange on workplace improvements
		Application of methods and tools to support collaborative re-design and information exchange
	Increase understanding of relevant work context	Identification of relevant work context by workers
		Enabling workers to create and access context-relevant workplace information supporting context awareness in terms of potential improvements considering processes, communication, collaboration, and workplace designs
		Facilitating the analysis of the impact of changes
	Increase the traceability of suggestions considering error detection	Providing means to supporting access to and creation of context-relevant information for current work task/environment/place

- Increase traceability of information flow. In terms of empowerment this objective could be beneficial for the psychological empowerment dimensions (1) importance and (2) impact
- Increase transparency of communication. Transparency comprises the awareness of employees considering who made a suggestion, who evaluated a suggestion, why it has been implemented or not
- Facilitate meaningful information exchange on workplace improvements. Content needs to be meaningful for its stakeholders
- Application of methods and tools to support collaborative re-design and information exchange. Workplace re-design and proposed suggestions usually affect or could be of value for several employees and/or organizational units. Therefore, a collaborative approach to suggestion making and workplace improvement is necessary

The second sub-goal aims at an increased understanding of the relevant work context. Thereby, work context includes all aspects considering the workplace itself (e.g. temperature, time, conditions of illumination, etc.), as well as all facets regarding the situation of a specific work task (e.g. a worker interacts with others; a worker requires special skills/knowledge to accomplish a certain task, etc.). Accordingly, three objectives should be met:

- Identification of relevant work context by workers
- Enabling workers to identify, create and access context-relevant workplace information, supporting context awareness in terms of potential improvements considering processes, communication, collaboration and workplace designs
- Facilitating the analysis of the impact of changes

5.1.1.3 Sketching the Envisioned Solution

The solution proposed to achieve the objectives of the use case is based on extensions of the following base technologies:

- **Metasonic Suite**—a process management suite for subject-oriented (S-BPM) processes. The Metasonic Suite (https://www.metasonic.de/en) is used for modelling, validating and executing work processes applying the subject-oriented methodology (Fleischmann et al. 2012)
- **MoKi**—a wiki-based collaborative tool for the enterprise modelling. MoKi (Rospocher et al. 2008; Christl et al. 2008; Rospocher et al. 2009; Ghidini et al. 2012) has already been applied to a number of collaborative settings (Casagni et al. 2011; Dragoni et al. 2013), also in multilingual scenarios (Bosca et al. 2014; Dragoni et al. 2014a), and for the analysis of business processes (Dragoni et al. 2014b; Di Francescomarino et al. 2014). MoKi is used for analysing the propagation of workplace changes (including changes related to processes and non-procedural aspects), as well as for supporting discussions, notifications and approvals related to potential workplace improvements

Specifically, these technologies should empower workers in Company B's goods-receiving and quality-checking department by allowing them to:

- Provide access to shared knowledge, thus easing their understanding of procedures
- Improve their workplaces by autonomously suggesting changes, thus increasing their empowerment capabilities
- Exploit semantic knowledge of non-procedural aspects (i.e. "static" concepts or constraints) to analyse, e.g. the impact of changes on other stakeholders
- Provide suggestions, and feedback related to workplace changes, thus improving the internal communication of Company B workers
- Keep track of the provenance and rationale of workplace changes

A possible scenario of how this set of technologies and functionalities can be used in the goods-receiving and quality-check department is shown below (see Fig. 5.1). The "Quality Control" worker becomes aware of potential improvements and would like to propose them to the management. Examples of improvements include changing the temperature in the goods acceptance area, and changing the work procedure. In some cases, the change can be related to non-procedural aspects (technical and workplace modification); in other cases, the change is directly related to a process change (process modification). Moreover, a change analysis could be

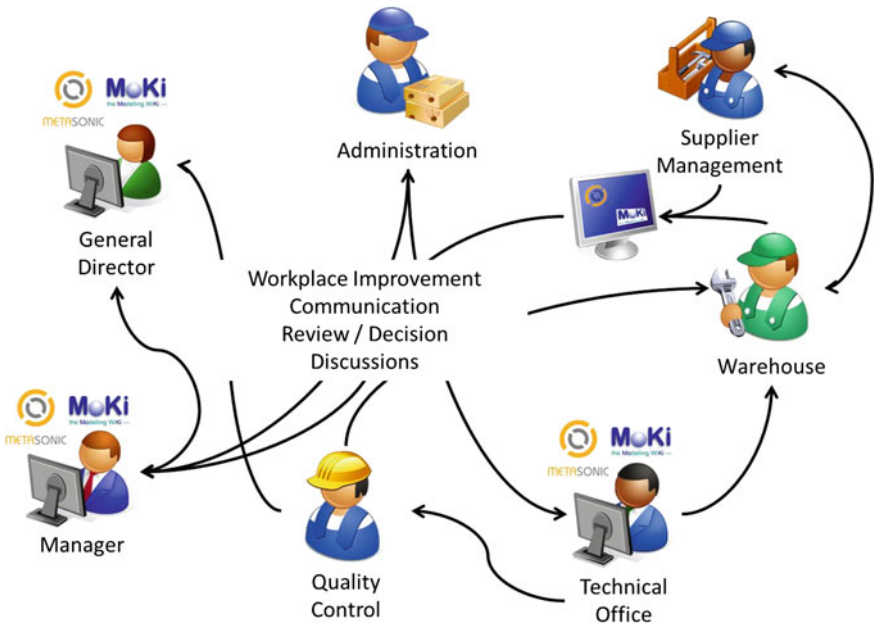

Fig. 5.1 Interactions among goods-receiving and quality-department workers

triggered which would lead to a propagation of the change. The co-workers can be notified and involved in discussions related to already suggested improvements. These discussions, as well as the authorization processes are carried out using the MoKi collaboration features, capturing a network of different stakeholders as shown in Fig. 5.1.

5.1.2 Requirements Elicitation and Analysis

Once the use case had been defined, the requirements elicitation and analysis was started. Based on the activities conducted at Company B to understand stakeholder needs and to define the scope of the use case, additional workshops were carried out to elicit and narrow down requirements within the defined use case. Beyond the functional requirements, a set of technical and organizational requirements have been defined in the requirements engineering process. The requirements engineering approach has been accompanied with setting up a technology acceptance framework.

5.1.2.1 Organizational Requirements

The organizational requirements for this use case are understood as a transition from the current situation ("as-is") to a desired situation ("to-be") at Company B.

The as-is process of making suggestions for workplace improvement at Company B is completely unstructured (see Sect. 5.1.1.1). Suggestions are made by workers directly to their supervisor in a face-to-face interaction, even though the supervisor is not the person in charge of that specific type of issue. In Company B, indeed, it is often the case that the same person is in charge of more than one responsibility (e.g. the person holding the role of Quality Manager also holds the one of Security Manager; the Administrative Manager also holds the role of Human Resource Manager), thus becoming the reference person to whom workers communicate every kind of problem, request and suggestion.

The consequence of this single point of reference is, on the one hand, workers' frustration, lack of self-awareness and trust in the management; on the other hand, it has effects at the production level. For example, in the receiving and quality checking process, in case of goods damages, the Quality Manager has to make decisions on how to proceed. In case of serious damages on goods triggered by a contingent event, or of systematic problems on the same type of items, the Quality Manager is asked to involve other managers, e.g. the Supplier Manager, in the decision-making process. The lack of transparency and traceability of communication makes this process easily subject to delays and unattended requests, thus also potentially causing errors at the production level. No technological means are used for the internal communication at Company B, while an internal network and an ERP server are used for connecting all the partner companies and for managing the administrative and the warehouse department, respectively.

Initial To-Be Process

Figure 5.2 shows the envisioned suggestion making process at the SME. The displayed Subject Interaction Diagram depicts the interaction of the involved actors, namely Worker, QM Area manager, Warehouse manager, Purchase manager and Logistics manager. Additionally, for communication with external process participants, the external subject Supplier is included in this model.

The suggestion making process starts with a worker raising a suggestion and sending it to the quality area manager. The quality area manager first analyses the suggestion and provides promptly a first feedback on whether the suggestion will be further processed or not. In the latter case, the reason for not further following a

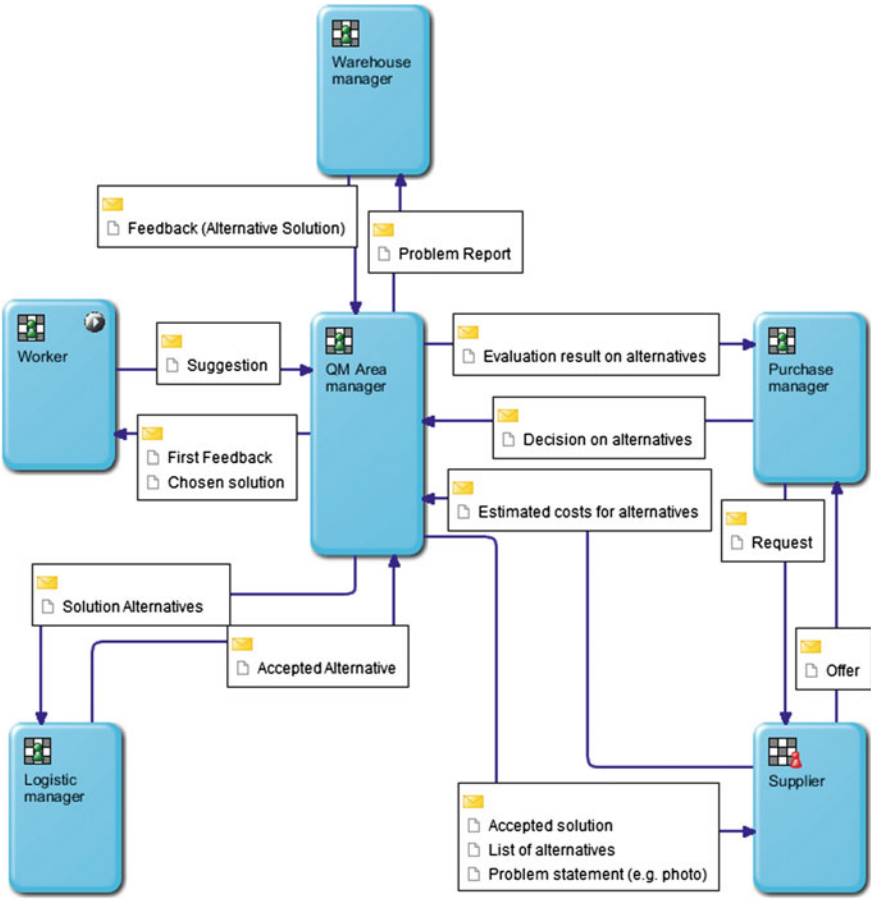

Fig. 5.2 To-be suggestion making process at Company B

suggestion has to be fed back. In case the suggestion is handled further, the quality area manager creates a problem report and sends it to the warehouse manager, who sends back feedback that may contain an alternative solution. The quality area manager also collects solution ideas from other shop floor areas and compiles them into a list of possible solutions. These are called solution alternatives and are subsequently sent to the logistics manager, who decides upon the alternatives. The accepted alternative is sent back to quality area manager. The process is split up in several branches at this stage, according to the concerned decision-makers. Finally, all decision branches are merged into one last action: the worker gets informed about the chosen solution.

5.1.2.2 Functional Requirements

For the elicitation of (functional) requirements user stories have been applied. A user story describes a usage scenario via simple natural language. User stories were defined in a "people-centred" two-stage process involving not only managers but also workers in specifying user stories. In an initial stage, workshops were conducted with the management of Company B, in which a first set of user stories were identified. In a second stage, these user stories were validated by the workers, through workshops in which workers were given the possibility to add, modify or remove (given) user stories. In addition to the user stories, prototypes of as-is and to-be process models were elicited by applying a paper card-based S-BPM modelling approach. These efforts were intended to elicit and validate system requirements engaging the actual stakeholders.

At the end of this process, a final list of consolidated (functional) requirements has been drafted. The requirements related to communication and collaboration can be summarized (from a workers' perspective) as follows:

Req. 1. Easy way to report context-sensitive issues/suggestions, and errors
Req. 2. Control over my suggestions (creation, update, deletion)
Req. 3. Feedback to my suggestion
Req. 4. Getting informed about suggestions that relate to me/my workplace
Req. 5. Receiving comments on suggestions or vote for them
Req. 6. Discussion of suggestions
Req. 7. Status checking of suggestion (approved, implemented, pending, etc.)

Moreover, few requirements related to the non-conformities report and change propagation were also identified. They can be summarized as follows:

Req. 8. Support of the analysis of what and who is how affected by a certain (process) change
Req. 9. Definition and application of rules and policies that can be triggered by a certain change
Req. 10. Reporting, analysis and visualization of non-conformities (e.g. errors for certain types of products).

5.1.2.3 Technical Requirements

A set of technical requirements was identified based on the specific IT environment at Company B and the defined usage of the base technologies (i.e. Metasonic Suite, and MoKi). Company B imposed the following requirements:

- For safety and privacy reasons all data recorded in the technologies to be developed needs to be stored on Company B servers
- A reuse of Company B's existing desktop computers on the shop floor is preferred for any IT solution to be developed

Requirements stemming from the Metasonic Suite relate to its multiple interlinked components. Depending on the desired usage, these components can be installed either on a single system or in a distributed environment. The individual components for the Web applications are available as packed applications (WAR files) to support straightforward deployment on different servlet containers (for example, Apache Tomcat). Typically, the Metasonic Suite requires a JDK (Java Development Kit), a MySQL database and an Apache Tomcat servlet container.

MoKi is developed on top of the MediaWiki[1] package that is based on a standard PHP/MySQL framework. MoKi requires a Web server environment supporting PHP and MySQL. Since MoKi is a Web-based application, it requires the availability of an internal network allowing the connection from a local workstation placed in the production line to the central server on which MoKi is installed. Furthermore, a Web browser needs to be available at the client workstation.

5.2 Process and Solution Design

An iterative approach has been taken in the design phase. The main milestones of this iterative approach can be summarized by the following two steps: (i) the design of a first prototype satisfying the users' requirements; (ii) the iterative refinement of such a prototype. Besides the goals and requirements collected in the requirement and elicitation analysis (Sect. 5.1.2), both steps have been accompanied by so-called formative evaluation activities.

In this section, we sketch the actions and the methodologies that were taken for formative evaluation (Sect. 5.2.1). We also detail the first prototype release (Sect. 5.2.2). Finally, we report on the refinements that have been applied to the prototype as a consequence of the feedback obtained from the formative evaluation, in order to develop a second prototype (Sects. 5.2.3 and 5.2.4).

[1] http://www.mediawiki.org.

5.2.1 Formative Evaluation Framework Guiding the Design

The formative evaluation framework has been designed and implemented according to the steps of Stufflebeam and Shinkfield (2011) for the Company B use case. Overall, multiple Skype meetings for aligning activities as well as a face-to-face meeting were conducted. In doing so, the evaluation team:

- Agreed on the formative evaluation framework along the six steps of Stufflebeam and Shinkfield (2011)
- Identified relevant stakeholders based on the use case
- Identified the key elements to be investigated
- Identified three overall (high level) evaluation dimensions (i.e. Usability, Usefulness, Social Acceptance)
- Identified an overall data collection approach (i.e. developer workshops, focus groups, user, prototype tests)

In the following, we detail the instantiation of the six steps of Stufflebeam and Shinkfield (2011) for the Company B use case. The **stakeholders** involved in the formative evaluation are:

- *Technology providers.* This group comprises technology developers as well as solution designers and providers
- *Users*. This stakeholder group includes end-users, i.e. the workers and the management at Company B
- *Evaluators*. Evaluators conduct the formative evaluations. They are responsible for planning, designing and analysing the surveys. Evaluation experts support the evaluators
- *Others.* The formative evaluation could also consider and incorporate other stakeholders if required, e.g. worker union, policy makers (e.g. regarding occupational safety, occupational health and safety practitioners for the involved factories)

The following three **key evaluation elements (KE)** have been identified to be evaluated in the formative evaluation activities at Company B:

- KE1: Change Analysis and Propagation Prototype
- KE2: Prototype for Supporting Re-Design with Collaborative Functionalities
- KE3: Contextual Work Models for S-BPM

The selection and definition of the **key evaluation questions** correspond to the issues raised in the requirements defined in Sect. 5.1.2.3. Thereby, the three dimensions—(1) Technical aspects, (2) Usefulness and Usability and (3) Social Acceptance—guided the definition of the key evaluation questions.

Different **data collection methods** were selected, prepared and used for the evaluation of the use case: the evaluation started with a developer workshop,

followed by one or more focus groups with the potential users. The results of these activities were then used to specify, plan and develop the user tests. Observations (e.g. task accomplishments, performance tests) and surveys (e.g. standardized and open questionnaires, interviews, discussions) were conducted and analysed in a qualitative and quantitative way.

5.2.2 The First Prototype Design

The goals and requirements collected in the requirements elicitation and analysis (Sect. 5.1.2) and the ones collected through the formative evaluation (see Sect. 5.2.1) were used to drive the development of the first release of the prototype developed for Company B, named the *Collaboration and change propagation prototype*.

The aim of the prototype was to support the achievement of the main goal of the use case: The empowerment and involvement of workers in the (re-)design of production workplaces. To do so, communication and collaboration among stakeholders (including workers and managers) need to be supported to foster sharing, discussing and negotiating ideas, suggestions or issues related to certain workplaces. The resulting communication and collaboration artefacts typically address specific dimensions of workplaces, such as tasks, tools for task accomplishment, social factors or environmental factors relevant for (re-)design. These dimensions characterize the context of the various statements provided by stakeholders (suggestion, error report, idea, etc.).

A prerequisite for change propagation analysis is the collaborative, (semi-) structured collection of workplace-related data as well as its semantic representation. Having a semantic representation of workplace-related data at hand, allows developing mechanisms to reason upon the collected data, e.g. localizing the impact of changes, performing statistical analyses of workplace-related data, and checking for the violation of rules and policies.

5.2.2.1 Prototype Description

The prototype described in this section applies the enabling technologies introduced in Sect. 5.1.1.3 to provide a means for supporting people-centred workplace re-design and for meeting the requirements identified at Company B. Thereby, it integrates different design-relevant workplace aspects, e.g. organizational procedures in terms of process models, errors within daily operations (process execution level), and relevant contextual dimensions (e.g. environmental, social, tool dimension).

The prototype is composed of two main modules: a module dedicated to the collaborative acquisition of knowledge and data (*Collaboration Module*) and a module devoted to assist users in the management of the acquired data (*Change Propagation and Analysis Module*). The *Collaboration Module* is composed of two submodules:

- A submodule that workers can use for reporting problems related to their workplace and suggestions for the workplace improvement, and
- A special instance of the suggestion module, i.e. a submodule to be used by workers to report errors/non-conformances related to the processes they carry out in their daily work (e.g. errors related to the incoming goods)

The *Change Propagation and Analysis Module* focuses on providing means for analysis as well as supporting the propagation of changes that are suggested by the workers or of changes, imposed by the actual behaviours of the system.

Figure 5.3 shows the conceptual architecture of the *Collaboration* submodules and the *Change Analysis and Propagation* module described above. The figure shows how the two *Collaboration* submodules, together with the *Re-design module*, provide the input for the *Change Analysis and Propagation Module.* Specifically, both, the S-BPM models used for describing the operational procedure, and the context information, are used for building the contextual domain knowledge. In turn, users' suggestions, change suggestions and other analysis output of the *Change Analysis and Propagation Module* act as input for the *Re-design module*.

The different modules and functionalities are accessible through simple interfaces, thus allowing workers with no IT background for quick and easy use of the prototype. In the following, each (sub-)module in terms of its functionality is be described in more detail.

Suggestion Management Submodule

The *Suggestion Managemen*t submodule is in charge of collecting and managing issues and suggestions by workers, according to a generic suggestion handling process. This process (involving the workers, the management and their communication) can be refined and instantiated according to the specific organization in

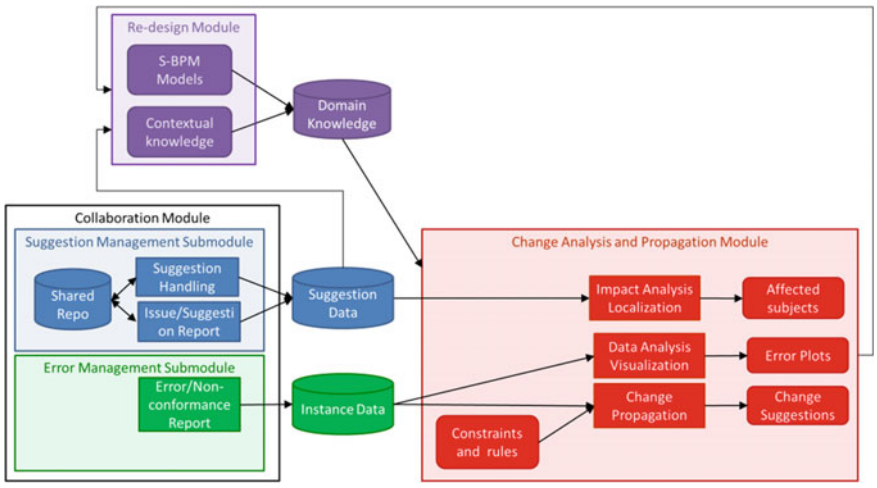

Fig. 5.3 Conceptual architecture of the prototype

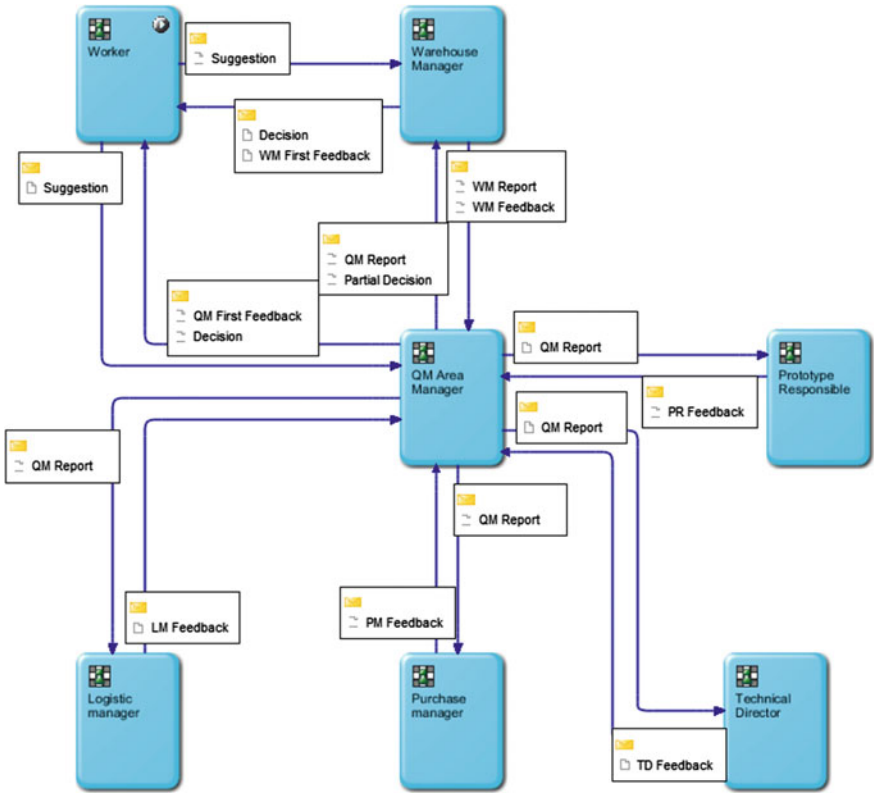

Fig. 5.4 Suggestion making process

which it is applied. The issue/suggestion to be handled is modelled as S-BPM business object that is incrementally enriched during process execution.

Figure 5.4 shows an instance of the generic *Suggestion Making* interaction diagram (using the S-BPM modelling notation) that has been specialized for the use case in Company B, according to the "to-be" S-BPM *Suggestion Making* process envisaged and reported in Sect. 5.1.

The issue/suggestion report is modelled as a business object that is incrementally enriched with feedback by the different involved actors until a final decision is made. The decisions or actions taken by the management are finally communicated to the worker. Besides the fields related to the issue/suggestion report, the business object contains three fields for each manager potentially involved. These fields are devoted to report the positive aspects of the suggestion, the negative aspects and a general feedback, e.g. suggestion variants or adaptations. Moreover, the business object allows for handling the *first feedback* to be provided to the worker, as well as the final decision (*decision* and *rationale*).

Handling suggestions requires seamless integration of the S-BPM workflow tool (in charge of dealing with the procedural knowledge) with the collaborative

instrument devoted to acquire context-sensitive issues and suggestions by workers (MoKi). The solution envisaged for achieving such an integration consists of a shared repository and a set of services built on top of the workflow tool enabling the communication between the two components. Both, the *Issue/Suggestion Report* component (MoKi-based interfaces), and the *S-BPM Workflow* component (Metasonic Flow), read and write information from/to the shared repository.

The *Suggestion* submodule provides users with two features: (i) the issue/suggestion management and (ii) the discussion management, which allows workers to discuss and share opinions, not only about proposed suggestions but also about other topics of interest. Specifically, concerning the issue/suggestion management, three main functionalities are provided: the suggestion creation, visualization and update. Workers can report their suggestions using the form reported in Fig. 5.5. Specifically, they can introduce a description of the issue/problem they

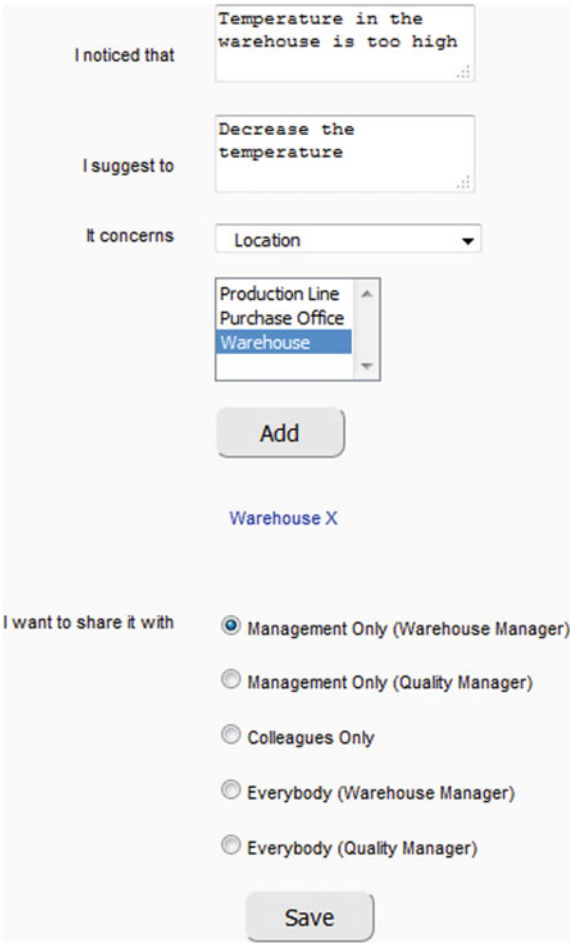

Fig. 5.5 New suggestion form

have observed or/and the suggestion proposed to solve the problem. Furthermore, workers can specify the category an issue or a suggestion refers to via a multi-selection list. The top context categories in the list correspond to the dimensions captured in the "work models" defined in the Contextual Design approach showing (cf. Beyer and Holtzblatt 1998; Holtzblatt and Beyer 2014). We took into account the following context dimensions and corresponding models:

1. Communication/information dimension of workplace context captured in the Flow model
2. Activity dimension of workplace context captured in the Sequence model
3. The environment dimension of workplace context captured in the Physical model
4. Tool/document dimension of workplace context captured in the Artefact model
5. Social/cultural dimension of workplace context captured in the Cultural model

These categories are further detailed. Whenever a (sub-)category is selected, a new list with the corresponding instances is provided to the users so that they can specify the detailed category for their issue/suggestion.

For instance, Fig. 5.5 shows an issue ("Temperature in the warehouse is too high") related to the environment category (context dimension) and, more specifically, to the place dimension. Whenever a category is selected among the ones in the drop-down list (cf. "It concerns: Place" in Fig. 5.5), an updated list containing a set of instances of that category is shown below.

Finally, workers can decide whether they want to share their issues and suggestions only with colleagues, only with management or both. Whenever they share a suggestion with colleagues, they can express their opinion about the proposed suggestion in two ways: (i) through a mechanism for supporting or taking position against a specific suggestion; (ii) and/or starting an open (i.e. free-text) discussion about the reported issue/suggestion. When a suggestion is shared with the management (i.e. in the "Management only" and in the "Everybody" case), workers can also choose with whom, either the Warehouse Manager or the Quality Manger, to initially share the issue/suggestion. According to the suggestion making process, workers can decide which one of the two managers has to be involved first.

Once a suggestion is saved, all users sharing it can read and discuss the suggestion. Specifically, each worker can access a table with the latest ten suggestions (the date and the time at which it was proposed, the proposer as well as the decision) shared with him/her. Moreover, an advanced search functionality allows users to retrieve reports according to elaborated criteria. A detailed-view function allows them to access the complete information related to the specific issue/suggestion in the corresponding row.

Besides the date, the proposer and the data inserted by the proposer (i.e. the issue, the suggestion, the categories and the sharing policy), the popup of the detailed-view function allows users to visualize the current status of the report (pending, accepted or rejected), the management's feedback (first feedback, final decision and rationale of the decision) and the number of colleagues supporting/non-supporting the report. A further detailed view about the status of the

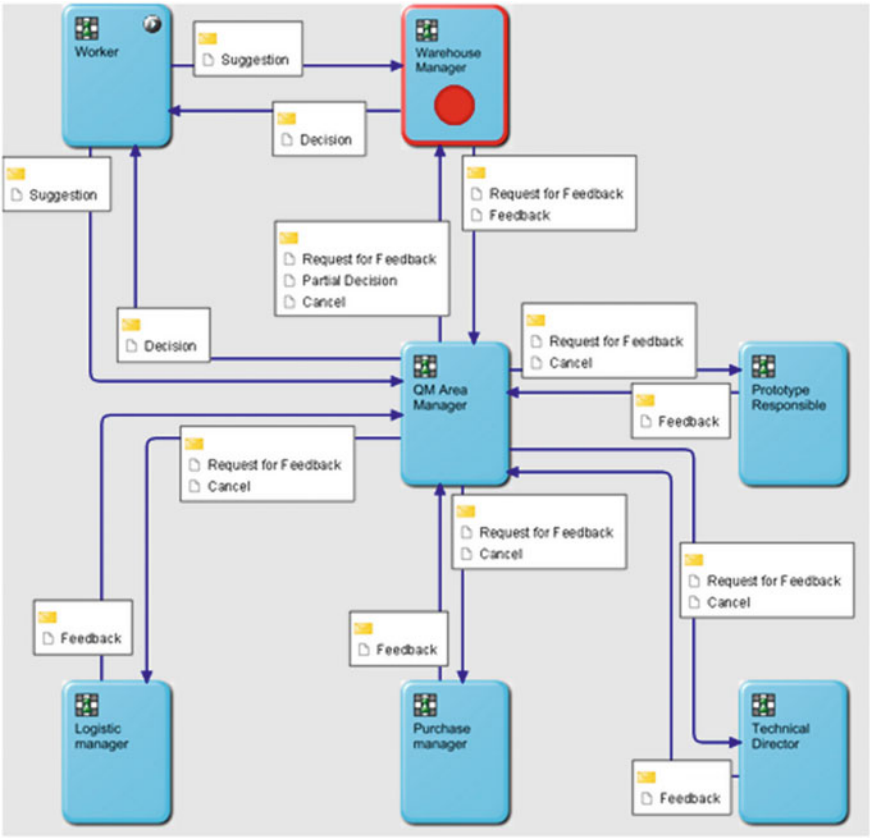

Fig. 5.6 Detailed view of the current status of the process

current suggestion is available when clicking on the "View Status" button (see Fig. 5.6): a red circle indicates the subject currently in an active state (in the Suggestion Management process it is the manager who is currently handling the suggestion). Finally, the popup provides the colleagues of the proposer with the possibility to rate the report through the "I like/I don't like" buttons, as well as to discuss about it ("Discussion" button). The rating buttons increase the counters of the supporters and the opponents for a specific issue, while the discussion button opens a new popup enabling to start or continue a discussion on a certain topic.

In case an issue/suggestion is not shared with the management, it can be updated by the proposer by clicking on the "Update" button in the suggestion menu. Subsequently, users may edit and update all the data related to the selected issue/suggestion or remove it.

When, instead the issue/suggestion is shared with the management, the *Suggestion Making* process (reported above) is triggered and proposers cannot update it anymore. Regarding suggestion management, managers can access reports

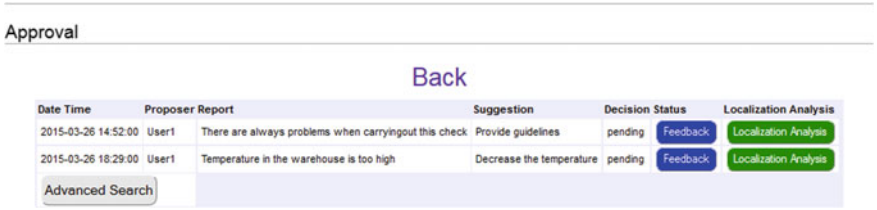

Fig. 5.7 Issue/suggestion approval

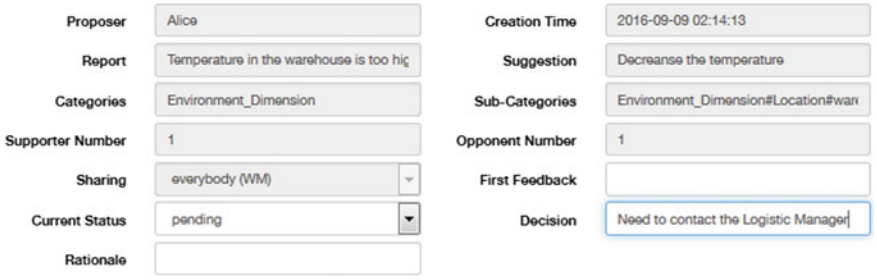

Fig. 5.8 Form for first feedback on a suggestions for the QM Area Manager

in the specific approval section, the issue/suggestion approval and two functionalities related to the data analysis. By clicking on the "Approval" button, managers are able to visualize the list of suggestions.

Whenever a manager is in charge of giving feedback about a given issue or suggestion, he/she can do it by exploiting the "Feedback" button (Fig. 5.7). The "Feedback" button will provide him/her an input form. For instance, Fig. 5.8 shows the input form for the quality manager when providing initial feedback to a suggestion. In this form the quality manager is able report his/her quick feedback about the suggestion, e.g. how long it could take to further process it, and why, or who needs to be involved.

The discussion-management feature, can be accessed both by starting a discussion associated to a specific report, and through a dedicated menu. The discussion menu offers the possibility to start a new discussion by providing a topic and related content, to visualize existing discussions, and to participate in a discussion already started. In addition, for discussions, the advanced search feature can be exploited to retrieve desired discussions.

Error Management Submodule

The error management submodule takes care of collecting the non-conformance reports by workers in their everyday work. Non-conformances can be discovered at different stages of the inspection process, and can be classified according to different criteria. The error management submodule enables workers

- To autonomously report these problems in the system in a simple and efficient way, thus giving them a more active role in the work, while decreasing the load of a single responsible of the error reporting
- To share problems and non-conformances with colleagues, thus making everybody aware of the problems and the issues already reported, and
- To track the non-conformances in a systematic way, thus providing useful data for further analysis

This submodule provides users, similarly to the suggestion management submodule, with three main functionalities: creation of a new error, error visualization and error update.

Workers can report observed errors using the form in Fig. 5.9. Specifically, a multi-selection drop-down list allows them to select the error reporter(s), and the type of error. During the inspection process, for instance, the incoming goods are subject to different checks (DDT[2] Check, package integrity check, quantity check, sample check and quality check). The radio buttons in the form allow workers to select in which of these checks (i.e. at which step of the inspection process) the non-conformance has been detected. Moreover, the interface allows for reporting the codes of the product and product supplier. This information can be read with a barcode reader in order to speed up the process and reduce errors occurring in manual data insertion. Filling in the other fields of the form depends on the type of check selected by the user. According to the type of check, the most common categories of non-conformances for that check are shown to the worker, thus enabling him/her to select the most appropriate. For instance, in the package integrity check case, the worker can provide a textual description and, if necessary, upload a picture proving the problem noticed in the packages (see Fig. 5.9).

Finally, the tool offers functionality allowing users to import special types of non-conformances from a csv file. The user can choose whether to manually insert a single error, or to load a number of new errors from a csv file.

The error visualization functionality makes it possible to visualize the last ten reported errors, by showing at a first glance, the date, the reporter, the error check type and the category(ies). Finally, the advanced search button allows users to search for a particular error by specifying advanced search criteria, as in the case of suggestions, and a view button for each error, allows workers to access the detailed content of the error report.

A popup enables workers to visualize the information reported at the creation of the error (reporter, error check type, description and categories, product, supplier and DDT barcodes, as well as a link to the picture associated to document the event), the date and a link to visualize the specific check phase in the corresponding S-BPM process diagram. Furthermore, the popup visualizing the details of each non-conformance provides an "Update" button allowing workers to immediately update a non-conformance report. In such a form, the worker can change each of

[2]DDT is an acronym for the Italian expression "documento di transporto" (English: transportation document).

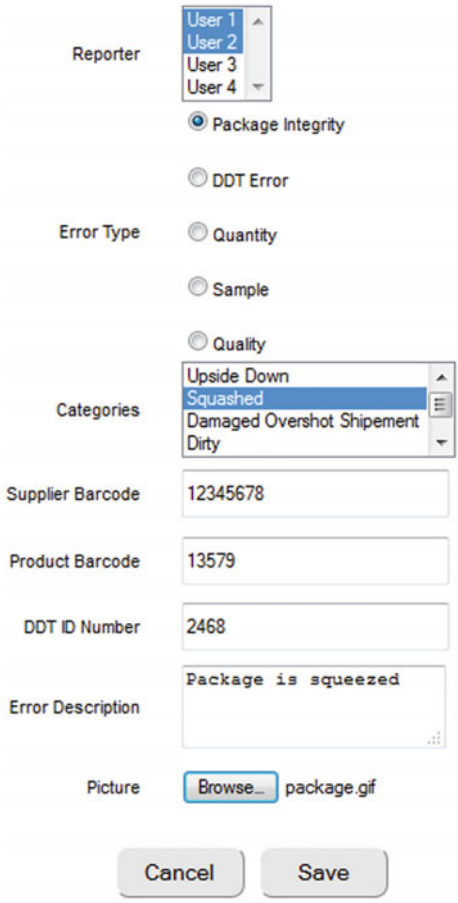

Fig. 5.9 New error—package integrity error

the fields she/he has inserted (including uploaded pictures for errors). Moreover, the form offers the possibility to completely remove the reported error. Such an update form is accessible not only through the "Update" button from the error visualization popup, but also through the "Update" button in the error menu. Such a button provides users with the classical table with the latest ten reported errors for the error update. If the non-conformance is not among those errors, the advanced search can be carried out by clicking on the corresponding button.

Change Analysis and Propagation Module

This section describes ways to analyse the impact and the propagation of changes based on the collection of workplace knowledge. *Impact analysis and change propagation* are concerned with identifying the potential consequences (side effects) of a potential local change for other areas of a system as well as for the system as a whole (Bohner and Arnold 1996). The *change analysis and propagation module* provides three main sets of analysis functions: data analysis visualization, impact analysis visualization and change propagation.

Fig. 5.10 Plot visualization

The purpose of data analysis visualization is to provide a visual representation of the instance data, e.g. related to non-conformances. Specifically, the functionality allows for the parallel visualization of two plots, each showing the trend of the instance data. The manager or the analyst can select, for each of the two plot areas, a specific type of plot, and configure the corresponding parameters. At this point, managers and analysts can visualize the desired trend in the plots. For instance, Fig. 5.10 shows the first plot reporting the number of errors per type of product, and a second one reporting the errors across the different error categories for the product with a specific code.

The impact analysis localization function aims at providing insights into the suggestions proposed by workers by showing which workers are potentially affected by the report. This function can be utilized by managers and analysts by clicking on the "Localization Analysis" button nearby each issue/suggestion in the approval form in Fig. 5.7, in order to understand which workers could be affected by the specific issue and/or suggestion. The *Localization Analysis* functionality relies on the categories defined by the workers and on the domain knowledge encoded in the system in order to understand which subject could be affected by the report. For instance, let us consider the suggestion related to the temperature decrease and the domain knowledge about the subjects that *work_in* the *warehouse* (e.g. the *warehouse_manager*, the *ddt_checker*, the *quantity_checker*, the *quantity_rechecker* and the *quality_checker*). The subjects affected by the suggestion will be the subjects that are related via a *work_in* relation to the warehouse. The concrete people affected by the suggestion report will be those who are assigned to perform the subject behaviour.

Finally, the change propagation function provides suggestions on how to propagate changes occurring on the instance level up to the model level. To this purpose, managers/analysts can select from a set of constraints and rules and customize it with the opportune parameters. Rules have the form "if HEAD then BODY", where HEAD usually represents the constraint/set of constraints that cannot be violated, while BODY is the possible action that has to be taken on model level if the (set of) constraint(s) is (are) violated. More than one rule can be specified, and, according to the type of rule, different parameters need to be provided. The result, provided in the form of change suggestions of the model, is the output of the inference engine in charge of propagating the rules on the real data.

5.2.3 Formative Evaluation Results and First Prototype Refinement

In parallel to the development phase, the formative evaluation has been carried out. In this section, we report the results related to the three formative evaluation activities together with the subsequent actions taken. Part of these results has been used for the definition of the first prototype and part for its refinements.

5.2.3.1 Developer Workshops

During the developer workshops some Critical **T**echnical **I**ssues (**TI**) related to KE1/2/3 have been discussed between developers and evaluators. They are reported in the following, and grouped according to the main prototype functionalities they refer to.

- Suggestion and Feedback Management (SFM)
  - TI_SFM1. User-friendly interfaces for the report and suggestion involvement of workers
  - TI_SFM2. MoKi/MC-Flow integration
- Error Management (EM)
  - TI_EM1. Quick and easy-to-use interface for the everyday use by workers.
- Change Analysis and Propagation (CAP)
  - TI_CAP1. Data acquisition from a proprietary ERP software. In Company B a proprietary ERP IT solution is used for collecting data related to everyday errors. Since these data represent the input for the Change Analysis and Propagation module, possible solutions have been discussed for the acquisition of the data

- Workplace Re-design (WR)
  - TI_WR1. MoKi/MC-Build integration

5.2.3.2 Focus Groups

Two focus groups—Focus Group I and Focus Group II—were conducted at Company B in order to investigate and collect feedback about KE1, KE2 and KE3:

1. *Suggestion and Feedback Management* mainly investigated during Focus Group I
2. *Error Management* mainly investigated during Focus Group I
3. *Workplace Re-design* mainly investigated during Focus Group II

Focus Group I has been conducted with 8 users, including both warehouse workers and managers. Focus Group II has been conducted one month later and involved the same 8 employees. In both cases, goals and purposes of the focus group were introduced to the users.

In Focus Group I, a prototype based on dynamic mock-ups was shown to the users in order to allow them to get an idea of the dynamics required for the collaborative reporting of ***issue and suggestions*** as well as of ***errors***. Focus Group II was conducted at Company B to collect and gather information and feedback to the context dimensions. The focus group was split into 2 sessions, one together with the workers and one with their superiors. The questions for the workers addressed the understanding of work context dimensions (see Sect. 5.2.2.1) and motivational aspects. The workers were asked to provide samples related to the defined work context dimensions "Tools", "Communication and Information", "Task and processes", "Environment" and "Cultural/Personal". We explored identical issues involving the management. Additionally some questions regarding re-design topics, e.g. the evaluation of work issues and related business analytics were discussed with the management. Based on their experience all workers were able to report several work issues for all the work context dimensions. The focus group showed that the general concept of the proposed workplace context dimensions is well understood, and thus applicable for the workers.

In the following the feedback gathered from the focus group participants is reported. Results are organized per prototype functionality according to **A**cceptance **I**ssues (**AI**), **U**sefulness **I**ssues (**UI**) and **D**esign **I**ssues (**DI**).

Suggestion and Feedback Management (SFM)

Acceptance of Suggestion and Feedback Management (AI_SFM)

Workers at Company B provided positive feedback with respect to means for communication and suggestion support through electronic instruments (rather than by means of face-to-face communication). Workers perceived this kind of tools as helpful to allow them to keep track of the reported issues and suggestions. However, they did not have a shared opinion about the possibility to report their issues directly to the

upper management [AI_SFM1]. Some of them would like, when it is the case, to directly communicate with the owner, while others do not feel that to be necessary.

The main concern workers have with respect to using the presented solution for reporting problems and suggestions is related to the possibility that their input is **neglected** by the management [AI_SFM2]. Management, on the other hand, is mainly afraid that workers could not **actively participate** in the project and that could limit their suggestions in the system to few instances. They are not convinced that receiving feedback would for sure motivate workers to make their proposals, also because not all the proposals can be implemented. A second concern is related to the **anonymity** issue. Few workers would prefer to have the possibility to make anonymous suggestions, while the others do not see the need to keep their suggestions and reports anonymous [AI_SFM3]. Last but not least, managers do not believe that the proposed technology-based solution can be fast and they do not want it to interfere with the workers' work [AI_SFM4].

Perceived Usefulness of Suggestion and Feedback Management (UI_SFM)

The main expectation workers have with respect to the use of electronic support for communication is getting feedback from the management [UI_SFM1]. They hope this feature could allow them to work better and to find actual solutions for their problems. Moreover, both workers and managers believe that introducing electronic means for reporting issues and suggestions would be useful for traceability purposes. Managers hope that workers can be actually active in providing solutions and that the system could help in improving the company process and climate, fostering the workers' understanding.

Design of Suggestion and Feedback Management (DI_SFM)

Workers would like to have the possibility to provide feedback to colleagues' suggestions [DI_SFM1]. Managers, on their side, would like to support the electronic answer also with the verbal communication in order not to neglect the human dimension. Moreover, for security and external access reasons, managers do not like the idea of using electronic devices outside of the workplace [DI_SFM2].

Workplace Re-design (WR)

Acceptance of Workplace Re-design (AI_WR)

Workers do not have particular concerns about collecting issues and suggestions together with the contextual dimension(s) they belong to (see Sect. 5.2.2.1). On the other hand, management believes that being aware of the work context and acquiring information is in general important to better organize the work.

Design of Workplace Re-design (DI_WR)

Workers believe the most important aspects for (the improvement of) their workplace relate to the communication/relationship dimension and to the procedural one. The view is only partially shared by some of the managers, who believe that company's procedures have already been optimized at the best and that special care has already been given by the company to the communication. Moreover, workers

and managers also identified concrete examples of workplace issues/suggestions referring to the tool, environment, as well as the cultural social environment category [DI_WR1].

5.2.3.3 User Tests

Two user tests—User Test I and User Test II—were conducted at Company B in order to investigate and collect feedback about the following main components of KE1/2/3:

1. Suggestion and Feedback Management during User test II
2. *Error Management* during User test I
3. Change Analysis and Propagation during User test II

User test I was conducted with 7 users, while User Test II was conducted few months later and involved 5 warehouse workers and 1 manager. In both cases an introduction about the purpose and the goal of the user tests were provided to the participants. Later on, a demo about the prototype functionalities to be investigated in the specific user test was shown to the users.

Specifically, in User test I, the functionalities of the *Error Management* component were shown to the users. In User test II, first the *Suggestion and Feedback Management* component was demonstrated to workers, and in the second phase, it was presented to the managers by showing them how to provide feedback to the workers. Finally, in the third phase, the *Change Analysis and Propagation* module was presented to the manager, who is responsible for this type of analysis. After each presentation session, users have been observed by at least an observer while accomplishing simple tasks exercising the different functionalities to be evaluated. For instance, workers were asked to simulate a situation in which they need to report an issue, using the functionality for the creation of a new issue of the *Suggestion and Feedback Management* component.

Finally, after users had experienced the components, they were asked to fill in a questionnaire (inspired by the ISONORM 9241/10), in order to capture their perception about ease of use, efficiency, ease of understanding, usefulness, and overall impressions and suggestions about the system. The items were mostly questions on a 5-point Likert scale (where 1 = *I strongly agree* and 5 = *I strongly disagree*).

Suggestion and Feedback Management

The following **F**unctionalities (**F**) have been investigated for the *Suggestion and Feedback Management* (**SFM**) during the user tests:

F1_SFM. Creation of a new issue and suggestion report
F2_SFM. Retrieval and visualization of a suggestion report
F3_SFM. Suggestion discussion reply
F4_SFM. Suggestion voting
F5_SFM. Suggestion status
F6_SFM. Retrieval and update of a suggestion report
F7_SFM. Advanced search of a suggestion report

F8_SFM. Discussion creation
F9_SFM. Suggestion feedback by managers

The findings related to the functionalities are described in the following. Findings are reported as **US**ability **I**ssues (**USI**) related to the **S**uggestion and **F**eedback **M**anagement (**USI_SFM**):

- Issues related to the capability to describe itself:
  - Some labels containing terms not translated from English to Italian (because terms sometimes used in Italian) were not clear for the users [USI_SFM1]
  - Some labels were not clear for users who did not understand the meaning of the corresponding field or button [USI_SFM2]
- The labels of some of the buttons are difficult to read [USI_SFM3]:
  - Sometimes users were a bit confused about which context dimension (among the proposed ones) to associate to the suggestions [USI_SFM4]
- Issues related to the navigability of the system:
  - When the number of items in lists is too high, users found it difficult to use the advanced search in order to be able to visualize older items [USI_SFM5]
  - Sometimes, after a save or an update action, the interface is redirected to the main menu, thus making users confused about the action carried out [USI_SFM6]
- Issues related to its capability to fit the user needs:
  - Managers asked about the possibility to receive e-mail notifications [USI_SFM7]
  - Managers asked about the possibility to refine the designed suggestion process [USI_SFM8]
  - Managers asked about the possibility to export the stored suggestions [USI_SMF9]
- Issues related to its efficiency:
  - The tool was slow [USI_SFM10]

User test questionnaire results—Suggestion and Feedback Management
After each user test, the users filled in a questionnaire. The results related to the main items can be summarized as follows:

- *Perceived Ease of use.* All users (absolutely) agree on the ease of learning to handle the module. Only one out of 6 users declared to be not sure about the

overall ease of use of the module. Overall, however, users agreed on the ease of use of the module

- *Perceived Efficiency.* Overall, users do not have a homogeneous perception of the extra time required for using the module. However, in general they disagree about the fact that using the suggestion module would require a huge quantity of extra time. They rather perceive they have enough knowledge and resources
- *Perceived Usefulness.* Concerning the capability of the module to improve the accomplishment of personal tasks, users showed some doubts, though still overall resulting in a positive evaluation. However, overall, users totally agree about the positive effect on introducing the module in their working environment
- *Positive Aspects.* Among the most appreciated benefits the users expect from this specific module, is the improvement of the collaboration between workers and managers, as well as the workers' empowerment

Error Management

The following **F**unctionalities (**F**) of the **E**rror **M**anagement (**EM**) module have been investigated:

F1_EM. Creation of a new error report and picture upload
F2_EM. Retrieval and visualization of an error report
F3_EM. Retrieval and update of an error report
F4_EM. Advanced search of an error report

The findings related to the functionalities are described in the following as **U**sability **I**ssues of the **E**rror **M**anagement (**USI_EM**):

- Issues related to its capability to describe itself:
  - Some labels were not clear for the users, who did not understand how to use the corresponding field or button [USI_EM1]
  - For some inputs it was not clear to users whether the input is compulsory or not [USI_EM2]
- Issues related to the navigation elements of the system:
  - Some of the buttons in the interface are not easy to find [USI_EM3]. For instance, they found it difficult to find the "Back" button in the interface
  - Some functionalities in the system cannot be accomplished in an efficient way [USI_EM4]. For instance, they found it inefficient to update an error when they visualize it. Indeed this would require users to close the current visualization popup (see Fig. 5.15), go back to the error management menu, and press the update button rather than having the possibility to directly update the visualized error

  - Interfaces had a resolution not fitting the use of monitors at the shop floor in Company B, thus demanding users a lot of effort with the scrolling bars [USI_EM5]

- Issues related to its capability to fit the user needs:

  - Users asked about the possibility of using different devices [USI_EM6]. For instance, they proposed the use of tablet or smartphones for the creation of suggestion reports

- Issues related to its efficiency:

  - The tool was slow [USI_EM5]

User test questionnaire results—Error Management
After each user test, the users filled in a questionnaire. The results related to the main items can be summarized as follows:

- *Perceived Ease of Use.* Overall users *agree* about the ease of use of the module. Specifically, they all (absolutely) *agree* about the ease of use when learning to use the tool and the ease of using it as they want
- *Perceived Efficiency.* All users (absolutely) *agree* about the fact that they have the needed resources to use the module and only one *has doubts* about having the required knowledge to use the system. They overall *do not know* whether using the module would require extra time. However, overall, users *agree* about the efficiency of the module
- *Perceived Usefulness.* All users (absolutely) *agree* about the usefulness of the module not only for a more efficient accomplishment of the personal tasks, but also for the company. Moreover they all believe that using the module in actual operation is a good idea
- *Negative Aspects.* Among the main drawbacks of the module, the users listed the fact that the module is not integrated with their ERP system
- *Positive Aspects.* Workers reported about several benefits that they perceive the system could provide to them: The possibility to report errors quickly, to track errors, and to make available statistics about errors per supplier, thus improving the relationship with suppliers

Change Analysis and Propagation

The following **F**unctionalities (**F**) of the **C**hange **A**nalysis and **P**ropagation (**CAP**) component have been investigated:

F1_CAP. Impact Localization
F2_CAP. Error Analysis Plot Definition and Visualization
F3_CAP. Change Propagation Rule Definition and Application

The findings related to the functionalities are described in the following. Findings are reported as **US**ability **I**ssues (**USI**) related to the **C**hange **A**nalysis and **P**ropagation (**USI_CAP**):

- Issues related to the capability to describe itself:
  - The labels used for specifying the input required in the analysis plot definition are difficult to understand [USI_CAP1]
  - The labels shown in the result visualization are difficult to read [USI_CAP2]
- Issues related to its capability to fit the user needs:
  - Managers asked about the possibility to persistently store the defined rules [USI_CAP3]

User test questionnaire results—Change Analysis and Propagation
The questionnaire related to the *Change Analysis and Propagation* component was filled in by a single user—the Quality Manager. Hence, the results cannot be considered as significant like the other ones. Overall, the user has a neutral position concerning the perceived ease of use and efficiency of the module, and he *agrees* about the usefulness of the *Change Analysis and Propagation* module for improving the performance of the team and about its benefit when introducing it into the work environment.

5.2.3.4 Consequences and Measures

The discussion of the criticalities identified during the developer workshops, focus groups and users tests, led to the adoption of some changes, both on the use case and on the system level. In some cases, the same functionality has been iteratively refined during the three formative evaluation activities. In the following, we report for each of the prototype components the actions taken as a consequence of the formative evaluation.

Suggestion and Feedback Management

The feedback gathered during the developer workshops [TI_SFM1, TI_SFM2] inspired the implementation of the *Suggestion and Feedback Management* component (see Sect. 5.2.2). The focus group confirmed the acceptance and usefulness of the easy-to-use interfaces developed for the system [AI_SFM2]. Furthermore, the focus group influenced design choices specific to the use case (e.g. not allowing the use of the system from alternative devices [DI_SFM2]) and inspired enhancing the existing prototype with certain functionalities, such as the suggestion voting [DI_SFM1]. Finally, user tests supported further refinements of the user interface components. In the following, we exemplify some of the improvements:

- Labels have been translated [USI_SFM1] and reworded [USI_SFM2] (e.g. see screenshot in Italian in Fig. 5.11)

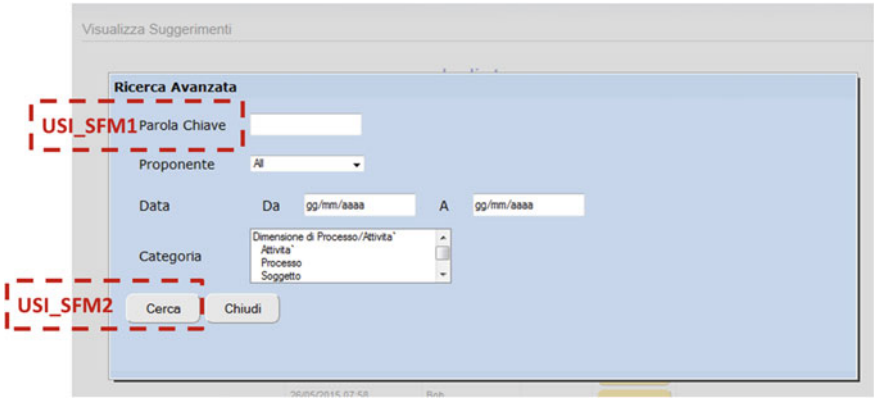

Fig. 5.11 Suggestion advanced search—translated and reworded labels (USI_SFM1 and USI_SFM2)

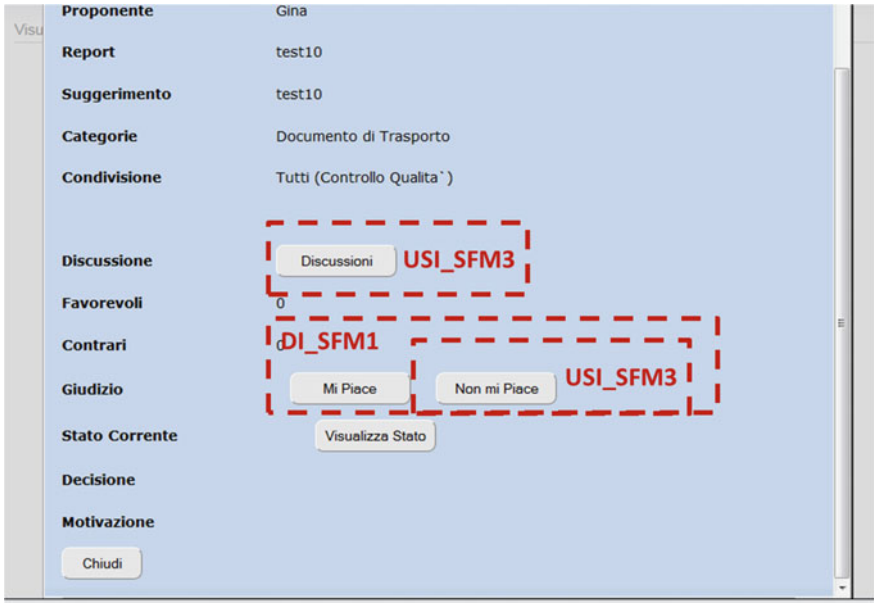

Fig. 5.12 Suggestion view—increased button size and voting functionality (USI_SFM3 and DI_SFM1)

- The size of buttons has been increased in order to make labels readable [USI_SFM3] (see screenshot in Italian in Fig. 5.12)
- Buttons Previous and Next to navigate among suggestions have been added [USI_SFM5] (see screenshot in Italian in Fig. 5.13)

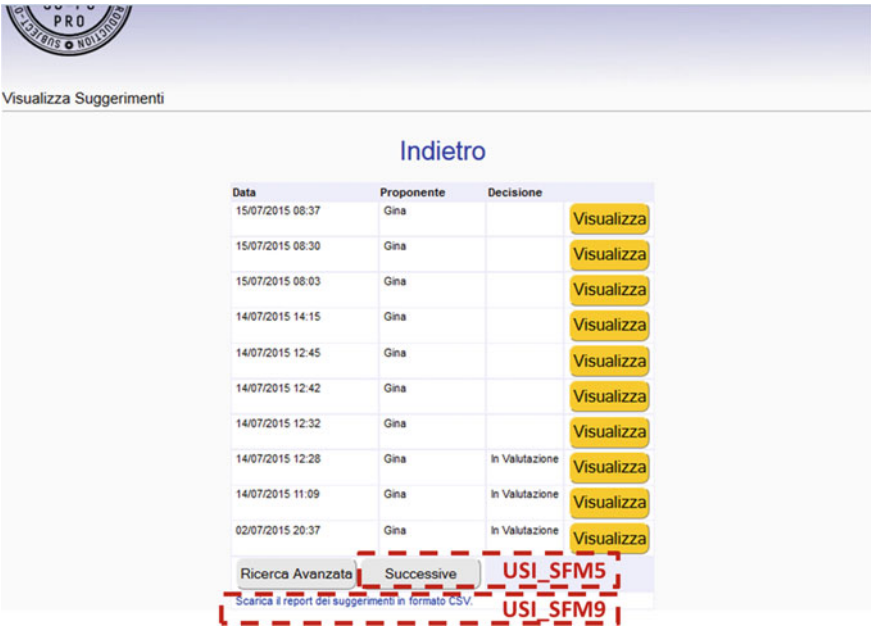

Fig. 5.13 Suggestion visualization—added previous and next buttons (USI_SFM5) and CSV export functionality (USI_SFM9)

- Redirection after approval of a suggestion to the main menu rather than to the pending suggestion list has been introduced [USI_SFM6].
- Export functionality in csv has been introduced [USI_SMF9] (see screenshot in Italian in Fig. 5.13)

Error Management

As a consequence of the developer workshops and of the focus groups [TI_EM1], a first prototype for the *Error Management* has been implemented (see Sect. 5.2.2). User tests allowed for further refinements of the *Error Management* component of the prototype:

- The "Back" button has been moved on top of the page and its size has been increased [USI_EM3] (see Fig. 5.14)
- A functionality for directly moving from the error visualization to the error update has been introduced [USI_EM4] (see Fig. 5.15)
- Problems with scrollbars have been fixed [USI_EM5]

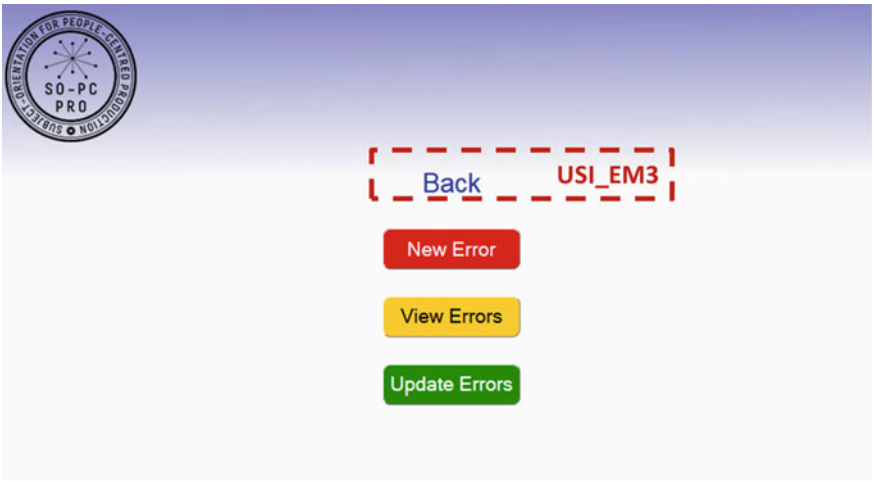

Fig. 5.14 Error management menu—Back button (USI_EM3)

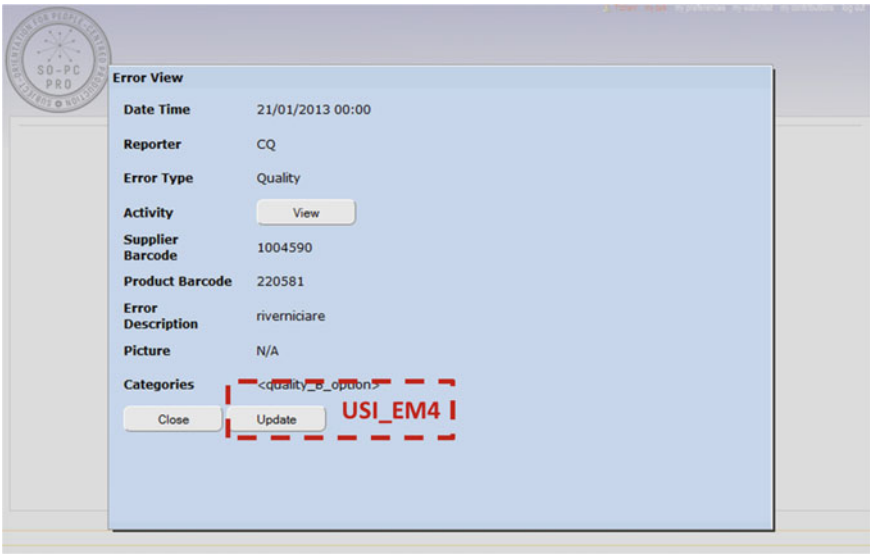

Fig. 5.15 Error view—functionality for the direct navigation from the error view to its update (USI_EM4)

Change Analysis and Propagation

As a consequence of the developer workshops and of the focus group [TI_CAP1], a first prototype for the *Change Analysis and Propagation* has been implemented (see Sect. 5.2.2). User tests allowed for further refinements of the *Change Analysis and Propagation* component of the prototype, such as the space size of the labels in the plot has been increased [USI_CAP2].

Moreover, the feedback provided by users revealed further improvement opportunities for the *Change Analysis and Propagation* module, such as the possibility of introducing the persistent storing of the defined change propagation rules [USI_CAP3].

5.2.4 The Second Prototype Design

This subsection reports the refinements applied to the *Change Propagation and Collaboration* prototype as a consequence of the requirements provided by the users after the formative evaluation.

5.2.4.1 Suggestion and Feedback Management

The following **N**ew **F**unctionalities for the ***S**uggestion and **F**eedback **M**anagement* modules (**NF_SFM**) were introduced concerning to the second prototype:

- NF_SFM10: the suggestion process enactment has been enriched with a mechanism that enables the involved managers not only to visualize the new suggestions in the prototype but also to be notified via e-mail when a new feedback is requested from their side
- NF_SFM11: an exception handling mechanism has been added to the Suggestion Process in order to avoid dead ends of the process. In case involved managers do not respond to a request for feedback, the flow of the process can be recovered

5.2.4.2 Error Management

The following new functionalities for the Error Management module (NF_EM) were introduced concerning the second prototype:

- NF_EM5: a new functionality for uploading data from CSV files exported from other systems has been implemented. For instance, Fig. 5.16 shows screenshots of the two import interfaces for quality errors and for new batches, respectively. Data in the first group are errors (and as such the upload functionality has been added to the error page) already tracked in another system, while data in the second group are incoming batches used in the analysis phase. A new utility functionality controlling the format of the csv files to be imported has also been implemented. For instance, Fig. 5.17 shows the messages printed out when the csv import procedure succeeds or fails, respectively
- NF_EM6: a new functionality carrying out checks on the format of (some of) the data (e.g. product or supplier codes) inserted in the system has been implemented. For instance, Fig. 5.18 shows alert messages (in Italian) popping up in case the product barcode and the supplier barcode are not in the correct format, or the description has not been inserted into the error form

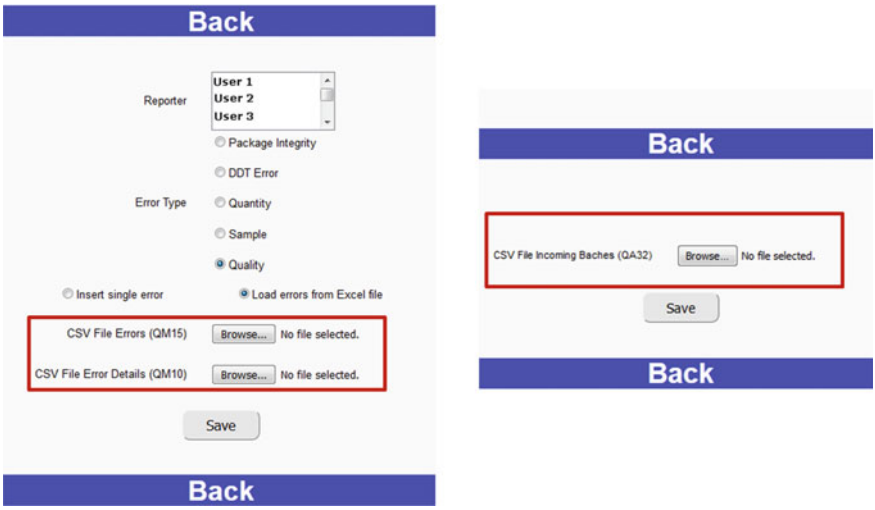

Fig. 5.16 New csv data import functionality (EM5)

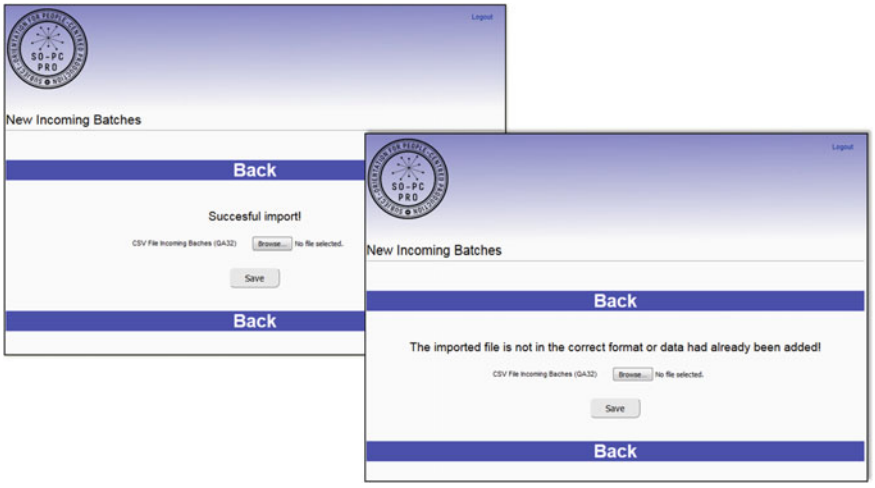

Fig. 5.17 New csv import check utility functionality (EM5)

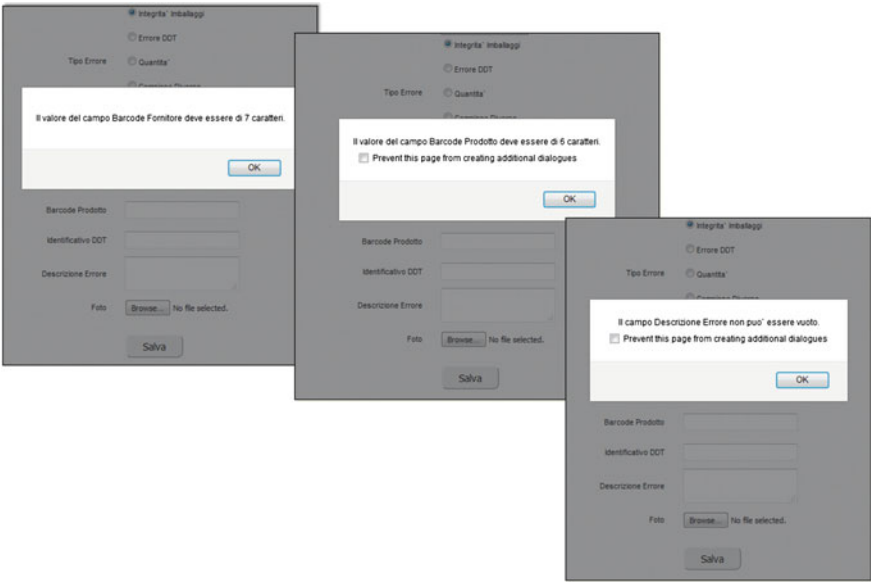

Fig. 5.18 New error data check (EM6)

5.2.4.3 Change Analysis and Propagation

The following new functionalities for the Change Analysis and Propagation module (NF_CAP) were introduced concerning the second prototype:

- NF_CAP3: a new functionality for persistently storing instantiated rule templates has been developed. Specifically, the functionality allows for grouping instantiated rule templates into configurations and for using these off-the-shelf rule configurations when needed. Figure 5.20 shows an example of a rule configuration that can be immediately used for propagating changes (button "Propagate Changes"), or just to store, in order to be used later on for the change propagation (button "Save Configuration"). The Change Propagation and Collaboration prototype offers the possibility not only to create new rule configurations (in order to store or to propagate them), but also to retrieve a specific configuration, as well as to (retrieve and) update existing rule configurations (Fig. 5.19)
- NF_CAP4: a functionality for the automatic check of the active rule set configuration has been implemented. This functionality allows for the execution of change propagations of a single rule set configuration (the only one marked as the active configuration in the system) with regular frequency (e.g. every day), and for the e-mail notification of the results of such an execution

Fig. 5.19 Refined requirements CAP1 and CAP2 (*top screenshot*), and changes performed (*lower part screenshots*)

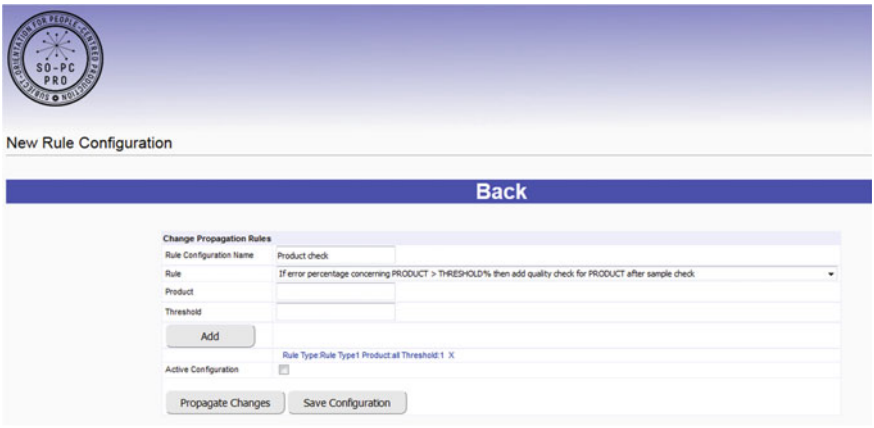

Fig. 5.20 Definition of a new rule set configuration (CAP3)

5.3 Case Implementation

This section describes the implementation steps carried out in Company B, both on the organizational (Sect. 5.3.1) and the technical level (Sect. 5.3.2).

5.3.1 Organizational Implementation

The organizational level is crucial for every type of project in SMEs. Within these companies it is important to value each individual as a professional, capable of autonomously taking his/her own responsibility and, at the same time, as part of a group to which a valuable contribution is made (Cesaro 2016). In order to allow all people involved to feel part of the project and be active on what it is evolving within the company, from the management to the workers, including directors and owners, different steps need to be performed. The Company B case was such a case, since the people-centredness was the core focus of the intervention.

The first step was an analysis of the company's as-is situation concerning both, technology and organization, together with the use case definition (see Sect. 5.1). In order to maximize people's acceptance, Company B's employees have been involved since the initial phases. Specifically, top management (the purchase manager and the logistic manager), middle management (the quality manager and the warehouse manager) and workers from the shop floor of the goods-incoming area (5 workers different for ethnicity, gender and age-class) were involved personally in this process. Thereby, they were asked to contribute according to their perception inputs about the workplace and their specific needs and expectations.

The next step was the definition of the requirements for both workers and managers. To this aim, based on the defined use case, user stories were formulated by workers, management and requirement experts, defining functional requirements (see Sect. 5.1.2.2). A two-phase approach was implemented for the user story collection in the company. First, a set of user stories has been defined by management and, subsequently, the set has been validated and edited by workers. Specifically, workers were encouraged to add, change, prioritize and even remove user stories. Moreover, different focus groups were held in Company B, aiming for feedback and inputs from workers as well as management.

After requirements elicitation, the first software mock-ups were built. These mock-ups have been presented and collaboratively refined in the course of focus groups carried out in the context of the formative evaluation (see Sect. 5.2.1). The focus groups offered also the opportunity to update all the people involved in the company about the different steps carried out, and to collect direct feedback in an open format. Different sessions were put into place with the workers, with the managers and with the whole group (workers + managers). The different sessions supported the analysis of the needs of different subjects in the process, and allowed to merge the results and feedbacks from different point of views.

Based on the results from the focus group sessions, a first software release was created and tested with employees in Company B. In dedicated user tests (see Sect. 5.2.1), employees were able to explore different features and provide immediate feedback on positive/negative aspects and potential improvements. In advance to the actual user tests, two different training sessions were conducted, a session with the management and another one with the workers. During these sessions, the software features were explained and the people involved could directly try them out and ask for clarifications when needed. In each of the two user-test sessions, users have been asked to use the system and have been observed in their interaction with the system, while exercising its different functionalities. Finally, they have filled in a questionnaire (inspired by the ISONORM 9241/10), aiming at capturing their perception about the ease of use, efficiency, ease of understanding, usefulness and overall impressions and suggestions about the system. The outcome of the user tests was considered as input to the successive development steps.

The developments at Company B aimed to empower people to contribute to workplace re-design and improvement. In the literature, two complementary views on empowerment at work and employee involvement have emerged: a socio-structural and psychological perspective (Liden et al. 2000; Spreitzer 2007). The socio-structural perspective focuses on "conditions that enable empowerment in the work-place" whereas the psychological perspective focuses "on the psychological experience of empowerment at work" (Spreitzer 2007, p. 54). In general, socio-structural empowerment can be subsumed as the sharing of decision-making power between superiors and subordinates (Liden et al. 2000; Spreitzer 2007). Empowering employees to take part in innovation and improvement processes requires organizational structures facilitating employee involvement as well as adequate tools supporting employee commitment (Fairbank and Williams 2001). In line with (Fairbank and Williams 2001), the developments at Company B targeted such organizational procedures and adequate tool support for empowering workers and management.

We conducted semi-structured interviews with workers and managers of the two company's departments involved. The main purpose of the semi-structured interviews was looking at the workers' and managers' perception of the objective achievement. Moreover, some of the defined questions were also devoted to investigate the users' perception about the usability and usefulness of the provided instruments. Among the different aspects investigated with the semi-structured interviews (see Sect. 5.4), the empowerment has been thoroughly inspected by taking into account the different dimensions described by Spreitzer (1995). All workers declared to feel deeper involved in the workplace improvement process than before, as well as to be motivated on keeping suggesting new ideas, since they can clearly see the path of their suggestions. They also stated receiving a feedback even if the suggestion was refused was a sufficient driver to keep them motivated to insert new suggestions. At the same time, the opportunity to give a suggestion and receive feedback or report an error, increased their perceived ability of making meaningful actions, in order to improve the workplace. Moreover, the fact of being taken into consideration helped some of them, especially the youngest workers, to

ask for more responsibilities and power for actively participating to workplace re-design. Managers shared that perception, although some of them agreed workers could have been further motivated by offering them other forms of incentives.

5.3.2 Technical Implementation

Concerning the technical implementation, the developments carried out had to be adapted for the hardware and software support already existing in the company. Data in Company B are stored in a central database. The server can be accessed through a number of devices located within the factory. Three main company areas are involved in the use case: (i) the incoming goods area; (ii) the office of the acceptance area; (iii) the quality manager's office. Each of these three areas is equipped with a PC for communicating with the server and tracking the arrival of incoming goods, reporting quality errors, deciding on whether to move the incoming goods to the warehouse or to the production line. Specifically, the acceptance area is equipped with a PC shared by the workers in charge of dealing with the incoming goods. The office in the acceptance area is equipped with four PCs and the quality manager's office with another one.

Moreover, in the incoming goods area, workers are provided with barcode scanners to simplify data input. Due to security reasons, a solution based on existing PCs has been preferred. However, the components of the IT solution are built in order to be easily adapted to other devices such as tablets or smartphones. IT components are installed on a server in Company B and can be accessed by workers through the PCs in the incoming goods area, in the office of the incoming goods area and the project manager office.

With respect to software components, the implementation of the software modules installed at Company B required the integration of two main base technologies: The Metasonic Suite and the MoKi-based collaboration environment. Metasonic Suite, by exploiting a proprietary database (*Metasonic Suite DB*) enables the execution of S-BPM process models (e.g. the suggestion handling process model) through simple and portable user interfaces, *FlowNG interfaces*, which are automatically built starting from the business objects of the S-BPM process models. Although these interfaces can in principle be adapted to different devices, Company B preferred to use these interfaces only from company internal. MoKi offers a collaborative environment for issue and suggestion reporting enriched with reasoning capabilities for analysis utilities (e.g. rule-based propagation of data changes). The interaction between Metasonic Flow and MoKi is mediated via a shared repository, which guarantees the communication and the synchronization between the two system components and their corresponding repositories.

5.4 Case Evaluation

This section describes the case study evaluation carried out at Company B in order to investigate the achievement of the use case goals and objectives as defined in Sect. 5.1.1. In the following, the evaluation framework (Sect. 5.4.1) and the results are presented (Sect. 5.4.2).

5.4.1 Summative Evaluation Framework

Figure 5.21 depicts the case evaluation framework adopted for the Company B use case. The basis of the framework contains three pillars: the case evaluation elements, the evaluation methods and the evaluation dimensions. The case evaluation elements represent important realized case components (e.g. prototypes, methods) to be evaluated. The evaluation methods are the methods that are used for the evaluation. Finally, the evaluation dimensions are the high-level perspectives that we are interested in to evaluate each case evaluation element. We detail each of these pillars for the current case subsequently.

The following four case evaluation elements (CEEs) have been defined during the case evaluation design for the "Empowered Workplace Improvement" case:

- CEE1. Improvement of the internal communication and collaboration
- CEE2. Facilitation of context-sensitive error reporting
- CEE3. Facilitation of change and error analysis
- CEE4. People-Centredness

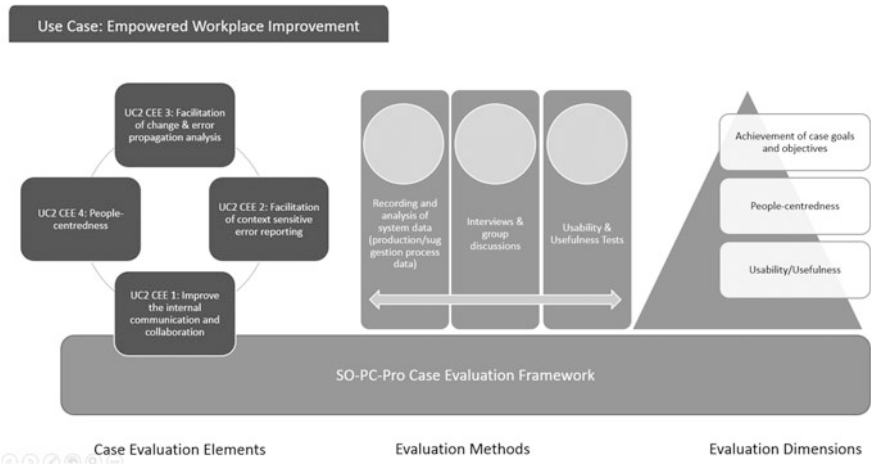

Fig. 5.21 Case evaluation framework instantiated for the Company B case, i.e. the "Empowered Workplace Improvement" case

Three **evaluation dimensions** have been investigated:

- *Achievement of goals and objectives*: this dimension focuses on the achievement of the use case goals and objectives defined in Sect. 5.1.1. It aims at evaluating the achievement of the use case goals
- *People-centredness*: this dimension focuses on the overall objective to providing adequate instruments supporting the involvement and the participation of factory workers. Empowering people to participate in the improvement of their workplace requires both organizational structures facilitating employee involvement as well as adequate tools supporting employee commitment (Fairbank and Williams 2001)
- *Usability and Usefulness*: this dimension focuses on the IT system provided to support the workers in the achievement of the goals. Specifically, it aims at evaluating the ease of use of the proposed solutions, their efficiency in the economy of the everyday work, as well as their usefulness to achieve the main objectives

As for the data collection and analysis, both quantitative and qualitative evaluation methods have been used. Specifically, semi-structured interviews have been designed and conducted, paper-and-pencil questionnaires have been prepared and provided to users, and system data has been collected and analysed.

According to the summative evaluation framework, a number of tasks have been performed when evaluating the case. We report the details about the instantiation of the summative evaluation framework for the Company B case in the following.

The case refers to the material check in the acceptance area and the quality management in Company B. Workers and managers belonging to two departments have been involved in the evaluation: the incoming goods area and the quality check department.

Three main groups of **stakeholders** were involved:

- Technology Providers, i.e. the technology providers involved in the implementation of the IT solutions as well as in the training of the system
- Users. Company B workers and management of the two departments described above. Specifically, 8 persons have been asked to participate in the summative evaluation: 5 of them belong to the category of workers, 2 of them to the category of management and, finally, one of them, who belongs to the middle management, actually holding the role of both, worker and manager. The age of the involved users is well distributed across different ranges, thus allowing us to receive different feedbacks on the basis of the age of the person involved. Specifically, the age of the workers encompasses four different age categories: one worker is under 20-years old, one is in the range 20–30, one worker over 50-years old, and all the others are between 30 and 40 years old. The managers are all in the range 40–50. Finally, concerning the gender distribution, one out of eight persons is female, while the remaining seven are males
- Evaluators. A team of different experts has been appointed to prepare and carry out the evaluation

For each of the four CEEs, a set of detailed objectives has been carefully designed and, in turn, for each of the objectives, a set of questions and methods to investigate their achievement and to evaluate usability and usefulness of the system provided to support the users has also been prepared.

Three different types of data collection methods have been designed and implemented: (i) semi-structured interviews; (ii) paper-and-pencil questionnaires; (iii) system data. Semi-structured interviews have been mainly used to evaluate the dimensions related to the achievement of goals and objectives, and people-centredness. On the other hand, the paper-and-pencil questionnaires provided a means for evaluating mainly the usability and the usefulness of the system supporting the workers. Finally, analysing the data collected from the system facilitated to investigate more than one dimension. They reveal the workers' involvement and engagement (people-centredness dimension), the achievement of goals and objectives, such as the communication improvements (achievement of goals and objectives dimension), as well as, in part, the ease to use the tool. All the three methods involved the same group of users. In the following, each of the data collection methods is detailed, in terms of aim and research design.

5.4.1.1 Semi-structured Interviews

The main aim of the semi-structured interviews is evaluating the users' perceived involvement in the project activities and in the workplace re-design, as well as their perception about the achievement of the case evaluation elements objectives. The interviews have been collaboratively designed by the evaluators. Specifically, a set of objectives has been defined for each case evaluation element. In order to investigate the achievement of each of these case evaluation elements, a set of items has been defined. In the following, the objectives for each of the case evaluation elements are listed:

- CEE1. Improve the internal communication and collaboration
  - Increase traceability of (suggestion and feedback related) information flow
  - Increase transparency of communication (related to workplace improvements)
  - Facilitate meaningful information exchange of workplace improvements
  - Application of methods and tools to support collaborative re-design and information exchange
- CEE2. Facilitate context-sensitive error reporting
  - Error description
  - Error classification
  - Error display and search

- CEE3. Facilitate change and error analysis
  - Facilitate error analysis
  - Facilitate automatic proposal of error-related improvements
  - Facilitate subject impact localization regarding suggestions
- CEE4. Ensure people-centredness
  - Investigation of worker involvement/participation in workplace design
  - Investigation of worker empowerment

5.4.1.2 Paper-and-Pencil Questionnaires

The aim of the paper-and-pencil questionnaires is evaluating the perceived usability and usefulness of the IT system supporting the users in order to achieve the main goal and objectives of the case evaluation elements. Three paper-and-pencil questionnaires have been designed, in order to evaluate the IS support for the case evaluation elements CEE1, CEE2 and CEE3. Specifically, the following main mapping between case evaluation elements and the IT system components for the users' support can be devised:

- CEE1. Improve the internal communication and collaboration → Suggestion and Feedback Management component
- CEE2. Facilitation of context-sensitive error reporting → Error Management component
- CEE3. Facilitation of change and error analysis → Change Analysis and Propagation component
- CEE4. People-Centredness → no direct IS support exists for this case evaluation element, which is orthogonal to the other CEEs

Each questionnaire, inspired by the ISONORM 9241/10, has been designed to investigate the following aspects for each case evaluation element:

- Perceived ease-of-use
- Perceived efficiency
- Perceived usefulness
- Willingness to use the system

5.4.1.3 System Data

Finally, system data has been collected with the aim to get a clear and objective assessment of the usage of the technical solutions provided to the users, and to directly or indirectly evaluate the achievement of some of the objectives. The selection of the system data to be collected has been designed, in order to overall evaluate the actual usage of the technical components as well as to investigate some of the specific

objectives defined for each case evaluation element. In detail, the following main metrics have been collected for the different case evaluation elements:

- CEE1. Improve the internal communication and collaboration
  - number of workers' suggestions, number of suggestions per user, number of accepted suggestions, quality of the suggestions, number of involved managers per suggestion, number of suggestions per affected workplace context, number of discussions, number of supporters and opponents per suggestion
- CEE2. Facilitation of context-sensitive error reporting
  - number of errors, number of errors per error category
- CEE3. Facilitation of change and error analysis
  - number of rule configuration instantiation for the change propagation

Quantitative as well as qualitative (content) data analysis methods have been used for analysing the collected data. Specifically, quantitative methods have been used to analyse most of the paper-and-pencil questionnaires and the system data, while qualitative data have been used for the analysis of the semi-structured interviews. Both, Company B workers and managers have been interviewed and asked to fill the paper-and-pencil questionnaires. The interviews have been carried out in a one-day evaluation workshop at Company B. Each respondent has been interviewed for about half an hour, and his/her answers were recorded. After the interview, respondents have also been asked to fill in the questionnaires. After collecting the data, they have been processed, analysed, interpreted and translated to English.

5.4.2 Summative Evaluation Results

In this subsection, the results of the evaluation carried out for each case evaluation element were used. The semi-structured interviews concerned each defined CEE. The paper-and-pencil questionnaires and system data were used to evaluate those CEEs demanding information system support, i.e. CEE1, CEE2 and CEE3.

5.4.2.1 Semi-structured Interview Results

Subsequently, we report the findings per case evaluation element and per objective. Moreover, some of the defined items were also devoted to investigate the users' perception about the usability and usefulness of the provided instruments. Some of the case elements (i.e. CEE1 and CEE4) can be seen both from the workers' and the managers' perspective. Consequently, different sets of items, looking at the same

objective from two different perspectives, have been designed for the two categories. The others, instead, are relevant for only one of the two categories.

CEE 1: Improve internal communication and collaboration

This case evaluation element has been evaluated by taking into account both the managers' and the workers' perspective.

Increase traceability of (suggestion and feedback related) information flow
The answers provided to this set of items reveal that all the involved workers participated in the suggestion making process and found it easy and useful to track the status of their suggestion(s), though some of them preferred to use the instrument in collaboration with their colleagues (both, for making suggestions, and for tracking the feedback). Similarly, all the managers participated in the management of at least one suggestion either alone or together with their colleagues. The managers' opinions about the traceability and the formalization of the information flow are discordant. While part of the management perceives the importance and the need to trace the information flow, another part of the top management feels it is not necessary due to the minimal context of the use case.

Facilitate meaningful information exchange on workplace improvements
The results of these items show that categorizing issues and suggestions within predefined categories is not always easy to achieve, especially in a dynamic environment of a factory. Among the possible impediments for some of the workers, the fear of discussing ideas with the management has been mentioned. Moreover, all the workers would really like to extend the usage of the system to other departments.

Application of methods and tools to support collaborative re-design and information exchange
The workers' answers related to this set of items highlight that, although they do not always use the system for voting about colleagues' suggestions, the fact of inserting a suggestion into the system stimulates the discussion in person. Although many of the respondents (both workers and managers) prefer to discuss face-to-face, most of them believe that it is of utmost importance to have the possibility to track a suggestion in the system because this encourages the management to provide an answer. Finally, both workers and (most of the) managers believe that the introduction of the suggestion and discussion management has had an impact on the workplace improvement, either in terms of implementing a suggestion, or improving the discussion.

CEE 2: Facilitate context-sensitive error reporting

This case evaluation element has been evaluated by taking into account only the workers' (authors of the errors) perspective.

Error description
Although not all the workers have directly reported an error in the system, all agree that it is easy to do so. They all agree that the instruments they can use for reporting errors, i.e. the textual description and the possibility to upload pictures, are sufficient for their purposes. Many of them have noticed an overall improvement in the behaviour of some of the suppliers.

Error classification
Overall, all the workers are satisfied with the five error categories the technical support currently provides them to classify the errors. Moreover, all the workers who have reported errors in the system have noticed that some of the error categories are more "important" than others, indicating with this statement that some errors (e.g. quantity errors) affect the daily activities of more than one worker, thus resulting in a loss of time for some of the workers. Before introducing the system, these errors were not recorded, and the management could not see their frequency and the actual impact on workers, neither in terms of taking actions per se nor towards suppliers in order to solve them.

Error visualization and search
All workers highlighted that they only searched errors that have been reported by themselves, and left any type of error analysis to the management.
CEE 3: Facilitate change and error analysis
This element was investigated only from a management point of view.

Facilitate error analysis
As for the workers (see CEE 2) also the managers agreed on the correctness and completeness of the error categories available so far for characterizing the occurring errors. Moreover, the management declared that the plots provided by the error analysis functionality are easy and clear, but they would also like to add further features, in order to be able to create and modify the plot, according to their needs.

Facilitate automatic proposal of error-related improvements
Concerning the change propagation functionality (providing managers with proposals of improvements and changes to apply), all the managers asserted that the rule templates that can be instantiated for the change propagation are well designed, and that they are able to instantiate them for their specific needs. They also assessed that they have never had the need to create new rules or modify existing ones so far. Finally, they also highlighted the usefulness of the e-mail notification mechanism for the change propagation results.

Facilitate subject impact localization regarding suggestions
According to the top management, it could be useful to extend the functionality to the workers, in order to enable them to understand who and which department are involved in a specific suggestion. As top management, being in charge of designing the process they are already aware of the involved people.

CEE 4: Ensure people-centredness

The CEE 4 aims at investigating workers' perceived change, involvement and empowerment. The items have been presented to both, workers and managers and related to workers' experience, expectations and point of view.

Investigation of worker involvement/participation in workplace re-design
All workers declared that a clear improvement has occurred especially with respect to the communication among the different departments. In general, all workers perceived an improvement of the workplace design as a whole: on-line suggestions and discussions have led to face-to-face discussions and vice versa. In addition, sharing ideas before entering a suggestion helped to increase the quality and frequency of communication among people. Moreover, both workers and managers assessed that suggestions and discussions are supported and fostered by the management.

Both workers and management noticed an increase in the workers' involvement. Workers feel involved in participating in workplace re-design, not only by inserting suggestions, but also sharing suggestions on how to improve their environment. For instance, an important issue shared and discussed by everyone was the one related to safety. Overall, workers feel that the value of their suggestions is taken into account by both management and colleagues.

The opinions of the managers, instead, are slightly different. Most of them agree with the workers in assessing that workers feel to be taken into account and empowered, while some of them believe that this is not the case for all the workers, only for those that already have a relationship with the management, i.e. the oldest ones.

Concerning the possible drawbacks and obstacles in the usage of the system, many workers, especially the youngest ones, pointed out the rigidity of the usage of the personal computers. Hence, they suggested to create a specific app in order to be able to make suggestions directly from a smartphone, even when they are not at work. Another suggestion consists of embedding the system functionalities in their current ERP system. According to the workers, among the possible obstacles to the usage of the system, there is the impossibility of making anonymous suggestions. This aspect, that had already been taken into consideration during the user-requirements elicitation, and had been excluded based on a shared decision involving workers as well, popped up again. This could mean that some suggestions, eventually about relationship issues, have not been reported in the system.

Investigation of worker empowerment
All workers declared to feel more involved in the workplace improvement process, as well as to be motivated on keep suggesting new things, since they can clearly see the suggestion path. They also stated that receiving feedback even when the suggestion was refused, was sufficient to keep them motivated to insert new suggestions. At the same time, the opportunity to create a suggestion and receive feedback, or report an error increased the perceived ability of making meaningful actions in order to improve the workplace. Moreover, the fact of being taken into

consideration helps some of them, especially the youngest workers, to ask for more responsibilities and power for actively participating in workplace re-design. The same workers' involvement is also perceived by the managers, although some of them agreed that workers could have been further motivated by offering them other forms of incentives.

5.4.2.2 Paper-and-Pencil Questionnaire Results

Three different paper-and-pencil questionnaires have been proposed to the Company B users. The first questionnaire (CEE1) mainly focuses on the *Suggestion and Feedback Management* component, the second one (CEE2) on the *Error Management* component and the third one (CEE3) on the *Change Analysis and Propagation* component. As for the semi-structured interviews, the paper-and-pencil questionnaire related to the CEE1 component has been provided to both, workers and management, the one for CEE2 has been given only to workers, and the one for CEE3 only to management. The items were mainly close questions on a 5-point Likert scale (where 1 = *I strongly agree* and 5 = *I strongly disagree*).

CEE 1: Improve internal communication and collaboration

On average, users (both managers and workers) agree on the perceived ease of use and ease of learning of the *Suggestion and Feedback Management* component. Different from what expected, the answers provided by the workers are slightly more positive than the ones provided by the management. This result can be in part explained by the different tasks that the two types of users were asked to perform on the component, which could require different efforts. Concerning the perceived efficiency component, while on average, all the respondents believe they have enough knowledge and resources in order to be able to use the component, half of them partially or completely believe that the usage of the system is time consuming. In this case also managers agree on the fact that interacting with the component requires some extra time, while workers disagree. This can in part be due to the difference of complexity of the tasks. In addition, the answers related to the perceived usefulness are overall positive: they all agree that the component speeds up task and team performance, as well as the communication and the re-design. In this case, the opinion of the workers is more positive than the one of the managers. Finally, all users agreed about their willingness to continue using the system. Among the strengths of the approach, managers appreciated the idea of a shared suggestion system, while workers appreciated the possibility to be involved in workplace improvements.

CEE 2: Facilitate context-sensitive error reporting

Concerning the perceived ease of use, the workers, with respect to the *Error Management* component, almost completely agree on the component's ease of learning and its overall ease to of use. With respect to the perceived efficiency, on average, all the respondents believe that they have enough knowledge and resources, many of them partially believe that the usage of the system is time consuming. In the case of the perceived usefulness, the answers of the respondents

were overall positive, too: they all agreed that the component speeds up task and team performance, as well as that it is overall useful for the company. Finally, on average, workers expressed a positive willingness towards the component's usage. Among the strengths of the system, some of them mentioned the potential benefits stemming from continuously monitoring supplier errors.

CEE 3: Facilitation of change and error analysis

Concerning the perceived ease of use of the *Change Analysis and Propagation* component, managers, on average, agree about the components' ease of learning and its ease of use, while they are slightly more sceptical about its ease to be understood. Concerning the perceived efficiency, managers are not completely convinced to have sufficient resources to use the system. They are a bit more confident to have enough knowledge to use the component and, in general, tend to agree with the fact that using the system would require more time. A similar trend can also be observed for the perceived usefulness of the component. On average, managers tend to agree about the fact that the support improves team performance, and that it is useful for the warehouse re-design; they have some doubts about speeding up task performance.

5.4.2.3 System Data Results

In this subsection, the data collected in order to evaluate the usage of the provided IT system support are reported.

CEE 1: Improve internal communication and collaboration

Overall, 19 suggestions have been put into the IT system in a period of usage of about one year. They have been directly inserted in the system by 5 different workers, although some of the suggestions have been added by two or more workers together. Out of these 19 suggestions, 4 have already been approved (at the time of writing), 2 have been rejected, while 12 are still pending. Most of the suggestions relate to the improvement of workplace aspects that concern more than one worker or colleague rather than the only proponent. According to the assessment of managers, the quality of the collected suggestions seems to be overall good. By inspecting the rejected suggestions, non-approvals are mainly due to missing capabilities of the company to meet the worker requests (either in terms of financings or management). Only 5 out of the 19 inserted suggestions have been classified according to a predefined contextual category. The lack of a classification for some of the activities can be mainly due to a difficulty the workers experience when selecting a category. By looking at the distribution of the sharing strategies, it turns out that in most of the cases workers have chosen to share their suggestion also with colleagues. Besides the feedback provided by the managers, while processing the suggestions discussions have also been used by the management to provide feedback after a suggestion's approval or rejection. Hence, any communication among workers and managers should be traceable, not only during the suggestion processing, but also when the suggestion has been accepted, and is going to be implemented.

CEE 2: Facilitate context-sensitive error reporting

Overall, 1229 product errors stemming from the incoming good area of the warehouse and from the quality check department have been inserted in the system. About half of these errors have been imported from the company ERP system, while the remaining ones are errors that have been manually inserted by the workers. Most of the errors are quality errors imported from the ERP system, followed by errors related to the transportation document and by errors due to incorrect quantities. Very few errors related to the comparison of the received items with the items already in the warehouse have been detected. No package integrity errors have been reported.

CEE 3: Facilitate change and error analysis

By looking at the plots and analysis offered by the system, managers are able to find the error rate per supplier and take decisive actions against error-prone suppliers. For instance, the data shows that the error rate of one of the suppliers has reached 10 %. With such data at hand, the management could, e.g. push the supplier to be more careful when delivering material.

5.5 Conclusion

The activities carried out throughout the case have been driven by a people-centred methodology based on the assumption that the *force and power of the individual* as a person can be understood according to three meanings (Cesaro 2016):

- The opportunities that the individual recognizes in himself which are the basis of his life plan
- The capabilities and potentialities the individual can exploit
- The possibility in the sense of giving oneself hope (it is possible that …)

The starting point of this methodology is the historic philosophic thought about the relationship between human being and machine and people's alienation. This situation especially occurs when there are daily needs that have to meet product-related process automation of economies of scale, and people need to respect timing and methodologies imposed by the machine. The fundamental question has always been whether to maintain the *human/machine/human* relation or rather the most frequent *machine/human/machine* requested by productive needs and by the technology domain over humans.

This methodology puts at the first place the relationships among people (human/human) taking into consideration that hierarchies, and the need of making decisions must find a balance between power exercise and a positive organizational climate. The second point of attention is related to the workplace life quality, particularly focusing on the actual measurement of those parameters that could be

related to safety, stress level, health and rhythm within the company and working time. A good working relationship facilitates problem solving for workers who can perceive and communicate useful changes in the workplace. Making the working environment efficient and effectual is the natural consequence of a way of working in which both communication and a solid trust system could become the key element of a positive organizational strategy. Saving time and positive economic results are the most important objectives in every company. However, these goals have to be shared by all the different levels of the company organization. Starting from these assumptions, the methodology is based on three main pillars:

1. People
2. Company processes (both organizational and industrial processes)
3. Tools (IT tools, ERP systems and the like)

These three pillars can be, respectively, supported by three types of activities that complete and strengthen each other:

- Proper specific training
- Ad hoc consultancy
- IT tool implementation.

These basic activities have to be instantiated based on the actual needs of each company. By applying the methodology, we have learned that these three activities need to be balanced in order to make interventions on the company effective and efficient. Such a balance can be reached only by connecting people, the organizational system and IT solutions, i.e. providing training activities, on-the-field consultancy and adequate solutions in terms of products and services. Training activity alone, indeed, is perceived as lacking of practical implications. On the other side consultancy and support activity alone lack awareness and answers to the many different daily problems oriented to people's autonomy. Using tools and technologies helps reducing activities timing and costs.

By looking at the case as a whole, beyond this general lesson, few concrete lessons can be learnt for each of the three aspects.

[People] Involving users from the beginning of the project increases their willingness to participate. The people-centred approach adopted from the initial phases on and the involvement of the workers in the analysis and design phases supported the project participation in terms of motivation and commitment. Both Company B management and workers declared that such an active involvement allowed creating something actually useful and helpful for their daily working experience.

[People] Formative and case evaluation complement each other. Formative and case evaluations are useful for a twofold purpose: (i) supporting the system development and iterative refinement; (ii) user-centredness. On the one hand, they provide an effective means to support the development process, starting with the design of the system until iterative refinements. Since the perception a developer

has of the to-be system is likely to differ from user expectations, early feedback and iterative development supports the alignment between users, the organization and the development. On the other hand, the involvement of workers in the suggestion and evaluation phases and the importance given to their feedback increases their understanding of the system as well as their motivation to use a system.

Furthermore, the following aspects with respect to formative and case evaluation activities were observed to be beneficial:

- Management commitment
- Discussion of different support aspects for certain groups of users (to develop a common understanding)
- Sufficient time for workshops (thus avoiding that participants have only a limited amount of time and do not really engage in the evaluation activity)

[Company processes] S-BPM modelling is not always intuitive. The S-BPM process modelling language has been easily understood and learned by Company B management. Company B managers, indeed, are used to work with processes—e.g. they designed and certified the company quality process (e.g. quality process through ISO certifications). Shop floor workers, who do not have a process-oriented background, instead, found the S-BPM full-fledged notation, e.g. the behavioural diagrams, too complex to understand, while they found quite intuitive the S-BPM Interaction Diagrams, i.e. subjects exchanging messages. The Subject Interaction Diagram of the suggestion handling process has indeed been added to the users' interfaces of the system as a facilitator of understanding the process orchestration. The workers' background was not based on processes but on tools and mechanical knowledge. In addition, their training at work is more related to daily-job routines. Thus, the addition of a graphic representation of the process turned out as facilitator for workers, and a necessary system feature to be developed.

[IT solutions] The system has to be tested on-site. It happened that some of the components remotely tested did not correctly work in the field, e.g. the scrollbars of the user interfaces on the monitors of the Company B devices or the e-mail server for sending e-mails. Before deploying a system, it is hence of utmost importance to test the system also on-site.

Finally, by looking at the last phase, i.e. the case evaluation, it seems that there is still room for improving the provided solution not only on the implementation level but also on the methodological level. Involving employees from the first phases and throughout all the intermediate steps is essential, since it allows for their actual involvement in the design of the solution they are going to use. Collecting feedback and understanding fears and worries related to people and the organization as a complex system is extremely important throughout all the phases. In real and complex scenarios such as a factory, it is always important to use, as in economics and psychology sciences, a systemic approach, allowing researchers to take into consideration not only the people and the variables in the studied group but also all other circumstances, such as company culture, collective and individual values, as well as other employees not involved in the project and their interactions. The case

implementation provided evidence that workers want to continue using the system. This suggests a high motivation for improving their workplace and a strong commitment to the company.

By looking back, it would be probably worth to involve users even more in all the phases. In particular, it would be useful to provide users with a more intensive training phase so as to help them to better understand and get in touch with the new functionalities, as well as to expand the evaluation phase, e.g. by planning intermediate evaluation steps that would allow developers and evaluators to get further interesting feedback after the system has been used for a while.

For the future, it would be interesting to apply the devised approach, enhanced with the lesson learned so far, to other use cases.

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