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Data & Knowledge Engineering 52 (2005) 5–31
DATA & KNOWLEDGE ENGINEERING
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eParticipative Process Learning—process-oriented experience management and conflict solving

Björn Decker [a,*], Jörg Rech [a], Klaus-Dieter Althoff [a], Andreas Klotz [b], Edda Leopold [b], Angie Voss [b]

[a] Fraunhofer IESE, 67661 Kaiserslautern, Germany
[b] Fraunhofer AIS, 53754 Sankt Augustin, Germany

Available online 23 June 2004

Abstract

The indiGo project offers a solution for tackling resistance against and problems while executing process models: eParticipative Process Learning. Via moderated, web-based discussions, consensus about a process is created and process models are reviewed to achieve better understandability or other quality aspects. Furthermore, problems during the execution of a process are solved collaboratively and captured as lessons learned to facilitate upcoming process executions. In this paper, we present the method and technical infrastructure to support eParticipative Process Learning. To show that eParticipative Process Learning leads to improved and accepted process models, three case studies are described.

Keywords: Collaborative business process modeling; Process introduction; Process improvement; Cross-enterprise process management; Knowledge management in collaborative processes

1. Introduction

Process models of organizations operating in innovative businesses are considered major assets. One example of such innovative businesses is the software market, where changing business, new technology, and scientific advances imply the definition or adaptation of processes. To survive

* Corresponding author.
E-mail addresses: decker@iese.fraunhofer.de (B. Decker), rech@iese.fraunhofer.de (J. Rech), althoff@iese.fraunhofer.de (K.-D. Althoff), andreas.klotz@ais.fraunhofer.de (A. Klotz), edda.leopold@ais.fraunhofer.de (E. Leopold), angie.voss@ais.fraunhofer.de (A. Voss).

0169-023X/$ - see front matter
doi:10.1016/j.datak.2004.06.006

these changes, process models need to be constantly inspected, evaluated, revised, and improved. Furthermore, they need to be enriched with lessons learned about their application in practice.

The approach of the BMBF-funded project indiGo—called eParticipative Process Learning—is to increase the applicability of such process models as well as to support their inspection and improvement. indiGo offers employees of an organization to engage in moderated discourses about the structure, content or execution of a process model. We define eParticipative Process Learning as a means to involve potentially all employees of an organization into consensus building about how a process should be executed, and to stimulate the sharing of process-related experience. indiGo provides a methodology and technical platform to enact eParticipative Process Learning within an organization. Via moderated, web-based discussions, (a) consensus about a process is built up, (b) process models are reviewed to achieve better understandability or other quality aspects, and (c) problems during the execution of a process are solved collaboratively and captured as lessons learned to facilitate upcoming process executions. These lessons learned are then stored in an experience base. By retrieving those lessons learned that fit to the context of a user, process execution is also supported by application experience. Methodology and Technology are a joint effort of two German Fraunhofer institutes: Fraunhofer IESE (Institute for Experimental Software Engineering) in Kaiserslautern and Fraunhofer AIS (Autonomous Intelligent Systems) in Sankt Augustin.

As depicted in Fig. 1, the process improvement in indiGo starts with an initial process model created by the Process Owners, i.e., employees responsible for this process model. This process model is annotated, discussed, and enriched with lessons learned via a web-based platform. Based on these contributions, the process model is reworked into an improved process model.

Both the developed methodology and the technology were evaluated between mid-2002 and 2003 through three case studies at IESE.

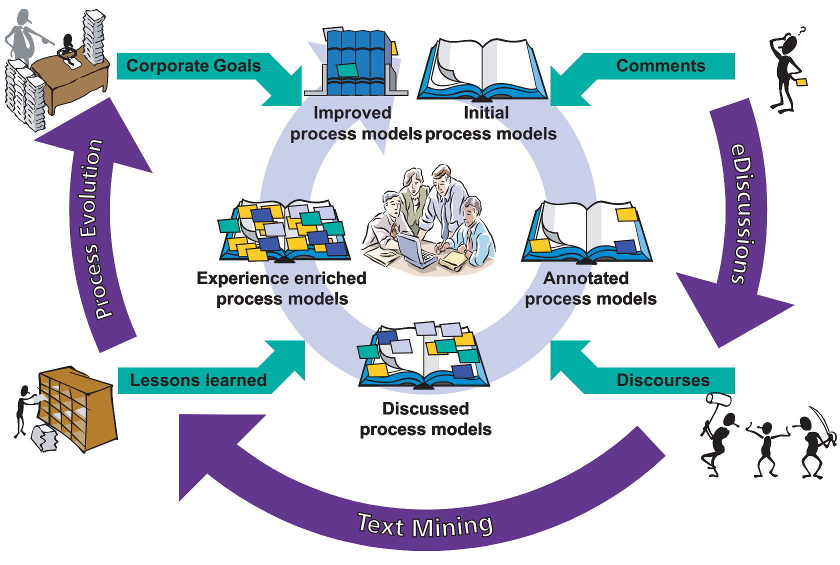

Fig. 1. Overview of eParticipative Process Learning.

This paper is structured as follows: In the second section, the motivation for indiGo is presented. Section 3 provides an example of how indiGo is used by the employees. Section 4 describes methodology und technical infrastructure of indiGo together with an overview of related work. Section 5 presents the design and results of the case study mentioned above together with the results of further applications. The article concludes with a summary and an outlook to future work.

2. Motivation: Why eParticipative Process Learning?

Well-defined and applicable process models provide a competitive advantage for an organization. However, when organizations try to implement a process, they will likely face the following problems: (a) employee resistance due to insufficient involvement, (b) insufficient knowledge to execute the process, and (c) high process modeling and maintenance effort. In this section, each of these problems mentioned above is described in detail, followed by the solution provided by eParticipative Process Learning.

The influence of *employee resistance due to insufficient involvement* is mentioned in a study by the German Institute for Learning Organization [28]: four of ten projects to accomplish organizational change achieve less than 60% of their objectives. The reason for this failure are not technical or factual obstacles, but mental-cultural barriers like lack of awareness regarding problems, missing network among stakeholders, and active as well as passive resistance to change. Due to the organization-wide influence of processes, these findings also apply to process modeling. When these barriers are not taken into account, process performers show resistance to apply the process model. One means to tackle these barriers the communication of the need for change and the involvement of the stakeholders of a process. This involvement is often neglected, as shown by the 2002 change management benchmark of Prosci [31]: Communication is one of five major success factors, but communication-related issues are also two of five major issues that are neglected.

With web-based, moderated discussion, eParticipative Process Learning offers an opportunity to involve potentially all employees, thus overcoming these barriers. This advantage for the organization—having an implemented and accepted process model—is supported by further advantages for the regular employee. The first and direct advantages of using indiGo are (a) that meetings dedicated to process improvement can be shortened or even substituted by eDiscussions, and (b) that participating in eDiscussion is self-determined with regard to time and space.

New or changed processes imply that the knowledge of an organization has to be adapted or needs to be newly created. This applies, in particular, to processes that describe creative and innovative work. This may create an *insufficient supply with experience*. In indiGo, a user can use private notes attached to the process model as a reminder for personal opinions and questions. Then—again using eDiscussions—an employee can state the question, which is answered by one of the other process performers or the process owner. These contributions are then compacted into lessons learned that are stored in the experience base. The lessons learned that fit best to the current situation of a user are retrieved, thus supporting the process execution with experience. This approach offers a quick solution to a question on the one hand, but also stores proven and discussed solutions for later use.

The third problem concerns *the effort related to modeling and maintenance of process models*. Unlike the two problems mentioned above, this problem is not relevant to the whole organization, but only to the Process Owners. However, these employees are a major factor on the way towards an implemented process.

The advantages for employees described before, such as self-determined participation in eDiscussions, are valid for Process Owners as well. For this group, the following advantages are added: First, potentially all stakeholders concerned with a process can be involved in the discussion about a process. This holds, in particular, when participation is enforced by law, e.g., participation of workers' representatives. The consensus building about the process facilitates application of the process as defined. Second, the modeling phase is shortened, since open questions about how a process should be performed can be solved during eDiscussions. Third, eDiscussion can be done in a constructive manner, i.e., change suggestions can indicate what the process should look like. For example, process performers can take quotes from the process description and rephrase them to express their opinion. Fourth, during the operational phase, indiGo supports process maintenance in several ways: lessons learned offer a lightweight opportunity to capture specific hints to execute a process, which would otherwise clutter the process description. Furthermore, lessons learned also stretch the timespan between process revisions, since small changes of the process can be described as lessons learned and thus be evaluated before they are integrated into the process. Lessons learned also offer a criterion as to when to perform process maintenance: Based on the analysis of the lessons learned, process maintenance is triggered, which tries to integrate the evaluated lessons learned collected so far.

How eParticipative Process Learning contributes to the areas of knowledge management in collaborative processes, collaborative business process modeling, and cross-enterprise management, is described in the following.

indiGo also supports collaborative processes—i.e., processes with high interaction of the involved performers, by (a) providing a platform for collaboration and (b) a methodology to process the result of the collaboration into (re)-usable lessons learned. Furthermore, collaborative processes are likely to have a high degree of non-determinism und creativity. Therefore, the context of the execution of a collaborative process is likely to vary. The context-specific selection of lessons learned provides a focused support to process execution.

Concerning *collaborative business process modeling*, i.e., modeling a process in a group of users, indiGo transfers the technique of process workshops into a web-based form. With discussions, employees can participate in defining the process without the need to learn a process modeling language beforehand. Therefore, the discussion of the processes is expected to be open to a larger number of process stakeholders.

Cross-enterprise process management, i.e., the definition and enactment of processes between organizations, has several features that support the application of indiGo: The organizations that have to be coordinated by a process will be at least spatially distributed in most cases. This facilitates the move towards the self-determined participation offered by indiGo. Furthermore, the employees of these organizations do not see each other as frequently as employees of one organization do. indiGo offers a (partial) substitute for this informal exchange, since eDiscussions are also supposed to be an informal means of communication. Finally, the web-based documentation of process models acts as a technical least common denominator of the involved organizations.

3. An example of eParticipative Process Learning

This section describes how process performers and Process Owners are using indiGo for eParticipative Process Learning. It is structured according to the indiGo process lifecycle depicted below in Fig. 2.

Imagine Mr. McLane, a senior project manager who is responsible for maintaining the process model for the process ''project acquisition''. He can use indiGo in two ways, to develop and introduce the process or to evolve it during its application.

Starting in the *innovation phase,* he can either rework an already existing, problematic process model, or create a new one from scratch (process design). Let us assume he created a process model based on his own opinions and asked a colleague to check the result. With indigo, he has the opportunity to extract experiences—like known organizational problems—from an experience base while developing the model (process implementation). This includes publishing and discussing it to gain feedback from many process performers (process validation).

Therefore, the first step for him and the moderator is to create a draft and define several goals for the discussion like: ''Should the payment method be made more explicit or should every project manager negotiate his own payment method with the customer?'' Subsequently, he publishes the process model on the intranet and invites some process performers. Thereupon, every participant inspects the process model based on the given goals to understand, comment, and enrich it with their own experiences. Simultaneously, they look for typing errors, evaluate the ease of use, or make a dry-run of the process. Each participant can attach private annotations to the process and discuss it with other participants. The moderator summarizes the discourse from time to time and extracts ideas and lessons learned assisted by text mining techniques (process validation).

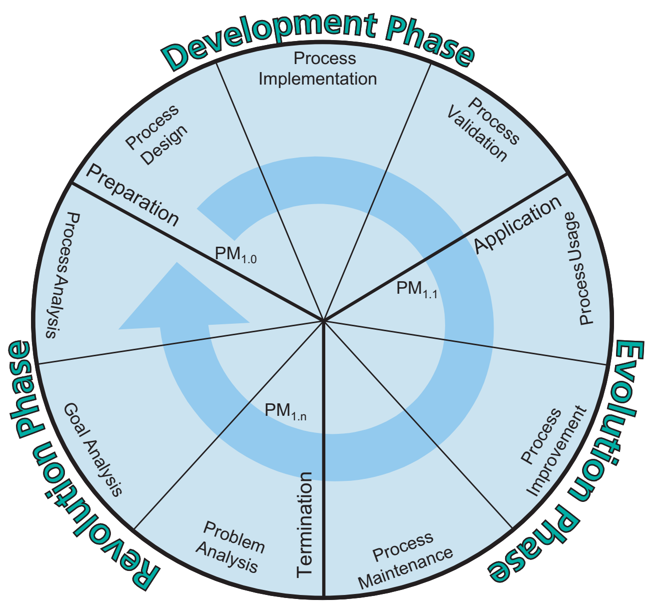

Fig. 2. Overview of the indiGo process lifecycle.

Finally, the project manager uses the ideas and experiences from the discussions to rework the process model. After the finalization of the process model, he publishes it on the corporate intranet and informs all concerned parties of the new process model.

In the first step of the *evolution phase*, the model will not be subject to major revisions, as it is currently in use (process usage). The goals of discussion in this step are fixing minor problems and collecting lessons learned about the application of the process model (process improvement/ process maintenance).

For example, assume Mrs. Legrelle (another Project Manager) has to compose an offer for a subcontract from a small start-up. The project acquisition process has a subprocess devoted to the contract. It suggests that the payment method should not be too fine-grained in order to minimize administrative overhead. Mrs. Legrelle feels uncomfortable with this guideline. The year before she had a subcontract with another start-up, MoCom, which went bankrupt. Therefore, the last payment was lost although the work had been completed. Mrs. Legrelle prefers to design the new offer with a frequent payment schedule, at the cost of more overhead in the administrative unit. Clearly, she should not modify the organization's process model for Industrial Project Acquisition on her own. She would probably attach a personal note to the subprocess and initiate her experience to be recorded as a lesson learned and shared with her colleagues through the discussion forum.

Either way, if a new solution or conclusion turns up and finds approval, it may be added as a new experience to the experience base. The process model would be improved periodically as substantial feedback is accumulated from the discussions and new experiences.

The process enters the *revolution phase*, when either (a) the number of problems reported is determined to be critical by the Process Owner or (b) major changes of a process are triggered elsewhere (e.g., strategic decisions). The general direction for this phase is to criticize the process and detect specific problems (problem analysis), reflect on the objectives of the process related to company goals (goal analysis), and to gain topics such as what aspect of the process should be changed and which one should be kept (process analysis).

To continue the example, imagine that the laws for reporting business results and thus, several administrative processes have to be changed by their process owner Mr. Shubashi. First, he has to assess the effect of these changes. Although being an experienced Manager, he might involve further process owners and the law department of the company. Since these experts are distributed across several locations, this consultation is done through the indiGo platform. Furthermore, the board of directors have feedback concerning alignment with business goals which has to be treated confidentially. This discussion will be held in a second, access restricted discussion group. After the discussions are finished, a new version of the process is created based on the reflection of the problem and the business goals. This version is the presented to the whole organization in a new innovation phase.

4. indiGo technology and methodology

This section describes the methodology and technology for eParticipative Process Learning developed in indiGo and how it has been installed at IESE since mid-2002. Although integrated, methodology and technology address different parts of eParticipative Process Learning: The methodology clarifies the responsibilities and tasks of the employees who are responsible for maintaining process descriptions and lessons learned. Therefore, it covers the human-oriented parts of work and installs eParticipative Process Learning within an organization. The technology of indiGo provides the platform for eParticipative Process Learning, and mainly provides services to the user of a process model.

4.1. Methodology of indiGo

As depicted in Fig. 3, the indiGo methodology consists of five methods. The introduction method is used to instantiate an indiGo system in a new organization. How an organization can accomplish process improvement and enhancement using the indiGo platform (its technical side) is the core of the Process Learning Method. The Process Learning Method encapsulates the eModeration, Text Mining, and Process Evolution Methods by providing a framework for initialization and result handling. The process learning method and process evolution method themselves are described as processes, so that they can be adapted and improved using indiGo. Each method is described in one of the following subsections.

The task of the *Introduction Method* is the instantiation and adaptation of the other methods to the needs of a certain organization. This enables a quick, but controlled start of process learning in order to use the dynamics of change in the beginning. On the content level, the Introduction Method first takes care of associating of employees to process learning roles. Second, a plan for the bootstrapping introduction of the following methods via process discussion is set and executed.

The *Process Learning Method* guides the process learning efforts performed within an organization. It describes the responsibilities of the employees for the different phases of the indiGo process lifecycle as described in the example mentioned in the previous section. Furthermore, it coordinates the actions performed by the eModeration, Text Mining, and Process Evolution methods. It is represented as a process model and thus, itself subject to process learning. In

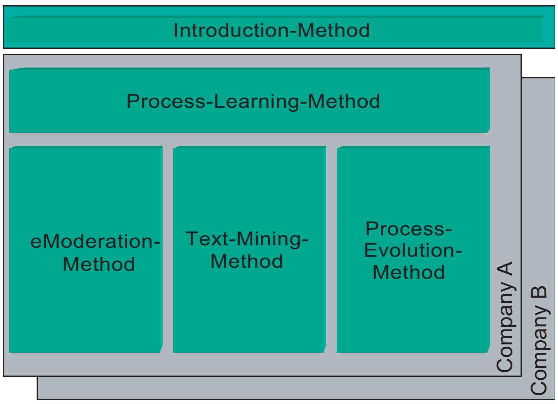

Fig. 3. Overview of the indiGo methodology.

particular, it is introduced by bootstrapping: By discussing the processes of this method, Process Owners learn about the indiGo methodology and technological platform in a productive pilot.

eModeration is the part of the indiGo methodology that keeps the eDiscussions going in order to focus the discourse on the predefined goals and elicit experiences from the participants. The eModeration starts when the process author is ready with the first approved draft of the process model and assigns the eModerator. As input, the eModerator receives the process model and context information about the why, who, how, for whom and for what the process is created or changed. Based on this information, the eModeration Method takes care of the full eModeration lifecycle. The lifecycle starts with the design of the discussion. The next tasks of the moderator are to start the discussion as well as to keep it going and focused. As the final step, the eModerator processes the results of the discussions (e.g., improvement suggestions and lessons learned) and forwards them to the interested roles like the Process Owner or the maintainer of the experience base. (For further details about this method, refer to [1].)

In indiGo, the available data is comprised of contributions to group discussions, process models and lessons learned, the type of the contribution, and their relations. The applied techniques from *text mining* will be text classification, text clustering, and text summarization. The goal is to simplify the work of moderators, process authors, and process performers in the indiGo context. Full automatization of any method mentioned above is still not feasible. Therefore, the Text Mining Method will describe how to use one of these text mining techniques to facilitate process learning: *Text Classification* will be used to detect different types of contributions like questions, opinions and doubts to create awareness for these contributions. *Text Clustering* procedures and the hierarchical analysis of textual similarities [27] can enhance the presentation of textual data in order to support the moderator in formalizing contributions as reusable experiences or cases. *Text Summarizations* will be applied to the whole discourses or to single lengthy contributions to facilitate reading them or to be the starting point of a manual discussion. Text mining itself and the underlying techniques are currently subject to development and will be evaluated in future applications of indiGo.

The *Process Evolution Method* ensures that changes in the process models are implemented, communicated, and recorded. The main trigger for the actions described in the process evolution method are the improvement suggestions taken from the discussions during the innovation phase of a process. Besides adapting the process model, the evolution method describes change propagation, change information, and process model versioning. The result of an execution of the Process Evolution Method is a published, official process model that is known to the employees affected by the process.

4.2. Technology of indiGo

The methodology presented in the previous section is supported by the web-based, technical infrastructure of indiGo. This technical infrastructure is described in the following way: First, general features of the technical infrastructure are described. Second, an overview of the technical infrastructure is given. Finally, the components of the infrastructure are described.

The main objective of the technical infrastructure is to support and involve a user of a process model. Therefore, its development was guided by the following general thoughts:

- Representation of process models in a way understandable to humans: A process model needs to be represented that a potential process performer can understand it—otherwise a process performer cannot contribute to the discussion.
- Easy participation: For a process performer, contributing to a process discussion is a subordinate objective compared to using the process model itself. Therefore, contributing must be made as easy as possible (e.g., by individual sign-on, cross-referencing between process model and discussion group). Furthermore, the discussion group should offer an opportunity for anonymous participation.
- Context-based access to lessons learned: Since at least the situation (i.e., the process) of a user is known when a process models is read, the technical platform should be aware of further context factors of the user.

These general thoughts were the guidelines for implementation of the indiGo platform. The general architecture is depicted in Fig. 4, with arrows depicting the flow of information: A process performer can access the components available as online services via a regular browser. The contents of these components are analyzed and created with tools that access the online services on demand. The names mentioned in italics are the actual names of the components in the installation of the indiGo system at IESE since mid-2002. In this installation, they are part of the Corporate Information Network (CoIN), which is the intranet of IESE.

Within this technical platform, the Integrator is the glue between the components of the online services and provides a unified, single sign access on to the indiGo platform: The Integrator connects processes models (CoIN-IQ [12]) with related discussion groups (Zeno [16,26,38]), allowing a user to go from a discussion group to a process description and vice versa. Furthermore, it supports querying the lessons learned repository (CoIN-EF) by combining context information from the process model (i.e., which process is currently being viewed) with additional context data. In the installation at IESE, this additional context data is information about the current project of a user (e.g., size, budget, type) derived from the Project Registry (CoIN-PR).

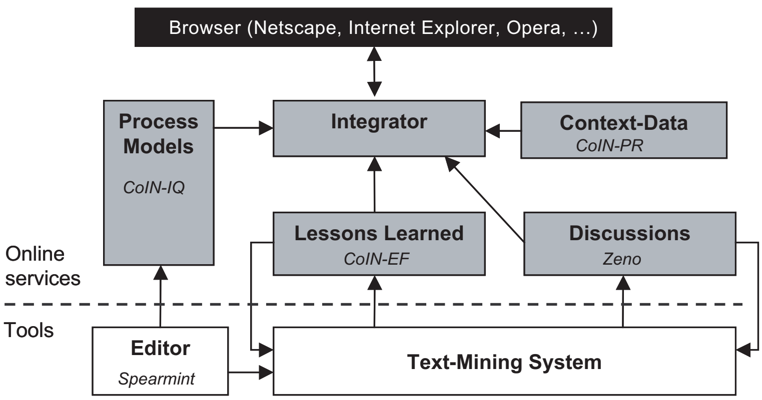

Fig. 4. Information flow in indiGo.

The process-related discussions are analyzed by text mining tools to detect new, previously learned lessons, and to provide drafts for discussion summaries, thus supporting discussion moderators and the maintainers of the lessons learned repository. Input to this analysis are lessons learned to train the text mining tools and the process models for relating information to processes. These process models are edited using a process model editor (Spearmint™ [5,22]), which also takes care of the publication of the process models.

In summary, the technical infrastructure supports two main user groups in the application of the indiGo methodology: First, it supports the *user of a process description* by providing additional integrated services based on the current processes model. Second, it supports organizational members responsible for maintaining process descriptions with tools for process modeling and mining discussions.

All components of the online services are implemented using Java Technology. As installed at the intranet of IESE in mid-2002, they run on one tomcat server [37]. Implementation issues concerning the tools are described in the respective subsections. The components are described in more detail in the following subsections.

4.2.1. Editor: Spearmint

Spearmint is IESEs process modeling environment. The graphical notation of Spearmint is based on the process modeling language MVPL [8]. A process in this notation consists of activities, roles, artifacts, and tools. Activities can be refined based on the product flow between sub-activities (i.e., which activity consumes and produces which artifacts) and the control flow. To support transferring the process model to other process modeling languages, Spearmint allows to export the process model in XML. Since Spearmint is implemented in Java as a standalone application, it can be used on several application platforms.

A major application scenario Spearmint process model can be published on the web as an electronic process guide (EPG). In the course of this transformation, relationships such as product flow, role assignment, or refinement are converted into hyperlinks, and the information described in the attributes appears as text in the EPG. This EPG is then read by a process performer who wants to apply a process. The subsequently described component CoIN-IQ is an instance of such an EPG (Fig. 5).

4.2.2. Process models: CoIN-IQ

CoIN-IQ (IESE Quality Management) is IESEs web-based business process model repository. The topics currently covered range from core processes (e.g., project set-up and execution) to support processes (e.g., using the IESE information research service) to research-focused processes (e.g., performing Ph.D. work at IESE). As a single system, it has been online since mid-2000 and currently contains about 50 process descriptions, 60 role descriptions, and 140 process-related documents.

A process within IQ is structured into "actions and subprocesses", "when to apply?", "objectives, results, and quality measures", "roles involved", "templates", "checklists", and "guidelines".

Overview pages support a user in navigating through the processes and their elements. As process descriptions are not intended to be read on a daily basis, special attention is paid to raising awareness of changes. A special overview is devoted to the changes in and new additions of

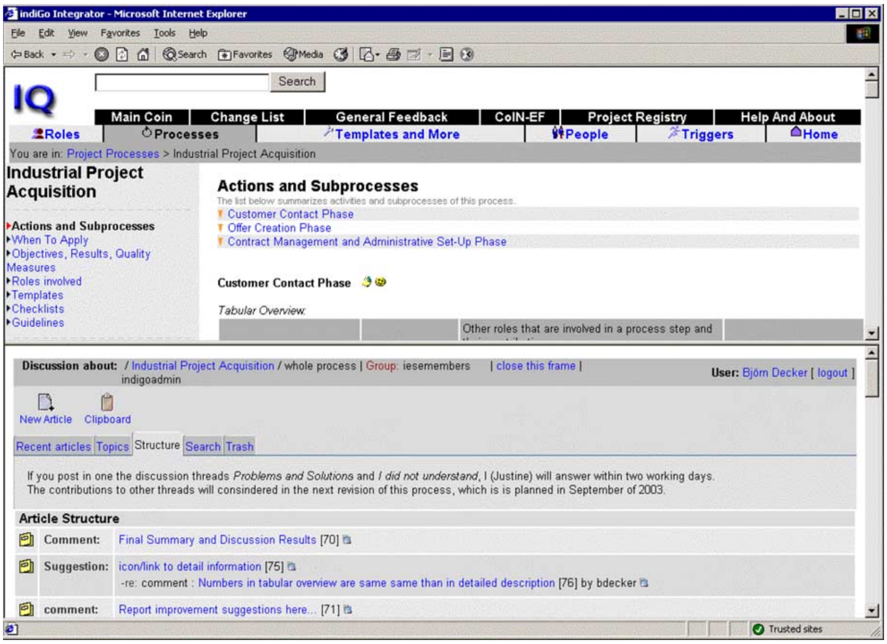

Fig. 5. Split view with CoIN-IQ at the top and a related discussion in Zeno beneath.

objects to CoIN-IQ. Furthermore, changes or new objects in CoIN-IQ are marked by a "new" or "changed" icon (see middle of Fig. 6). When operated via the integrator, CoIN-IQ acts as the portal to indiGo listing the most recent changes and the new discussion contributions since the last login.

4.2.3. Discussions: Zeno

The objective of Zeno is to provide its users with a tool for structured and distributed discussions.

It was first presented at CeBIT 1996 and continuously improved up to version 1.9 in 1999. Since then, a completely new system has been implemented to address a broader spectrum of discourses in the knowledge society: participatory problem solving, consensus building [38], mediated conflict resolution [26], teaching and consulting (see Fig. 7). The new Zeno focuses on eDiscourses and supports eModerators in turning discussions into discourses, elaborating the argumentation and carving out rationales.

A discourse is a deliberative, reasoned communication; it is focused and intended to culminate in decision making [14]. Turoff et al. [36] argued that building a discourse grammar, which allows individuals to classify their contributions into meaningful categories, is a collaborative effort and its dynamic evolution is an integral part of the discussion process. A discourse grammar (or ontology) defines labels for contributions, labels for references (directed links) between contributions, and may constrain links with respect to their sources and targets. Supporting communities in evolving their own discourse grammars has been a key issue in the design of Zeno.

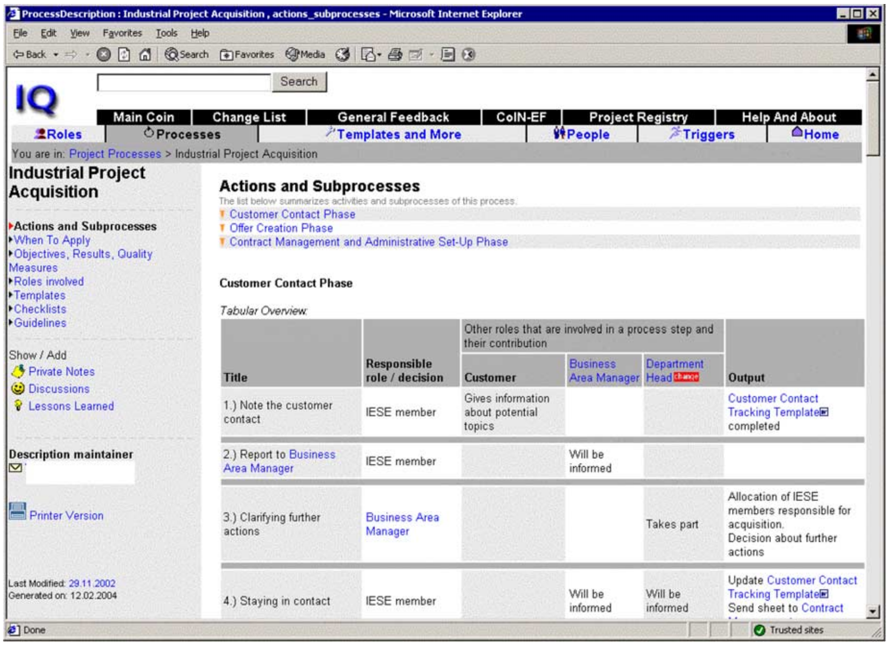

Fig. 6. Screenshot of a process description.

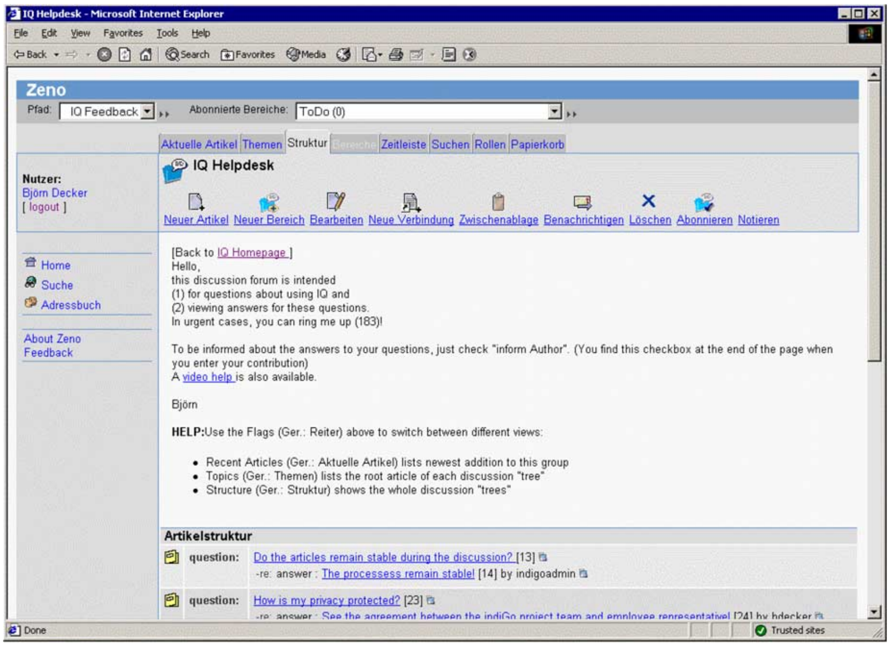

Fig. 7. Screenshot of the Zeno discussion overview.

Zeno is integrated in indiGo is the following way: Each process model and each of the subsections mentioned in the description of CoIN-IQ has at least one discussion group. If needed, contributions within these groups are linked to point participants in one discussion to other interesting discussions in other threads.

4.2.4. Lessons learned/context data: CoIN-EF and CoIN-PR

CoIN-EF is the experience base of indiGo, operated as a single component since mid-2000. It is implemented using IESEs experience management environment INTERESTS [2]. Currently, it contains about 350 lessons learned from past projects of IESE. Each lesson learned has its author listed to allow a querying IESE member to ask the providing colleague for further information.

Before capturing lessons learned via indiGo, these lessons learned were captured by project retrospectives. To search for a lesson learned applicable to the current project of a user, the user describes the context of this project (e.g., project type, topics). CoIN-EF compares this context to the project context of the available lessons learned with similarity-based retrieval [24]: A measure indicating the degree of similarity in the current context is calculated. The lessons learned are ordered according to this similarity value.

Within indiGo, the user does not need to provide in this information explicitly: A user can query the Project Registry CoIN-PR about current projects via the integrator and select one. The information about his project (e.g., size, budget, type) is stored as project context until it is changed again. When viewing a process model, this project context and the current process of the user are combined into a query by the integrator without further interaction.

An example of a lesson learned is described in Fig. 8.

To allow this comparison of context, the lessons learned are stored according to the ontology presented in Fig. 9. The context of these lessons learned is modeled by the two concepts ‘‘project’’ and ‘‘process’’. A ‘‘*project*’’ is a characterization of the project in which the lesson learned was gained (e.g., person month, duration). The ‘‘*process*’’ concept names the business process and thus the project phase in which the lesson learned was gained. Therefore, an employee involved in a project team can specify his current environment as well as the current situation to search CoIN-EF for similar experiences.

Project Experience “Less Effort” (ID 2183)

Type: Observation
Category: Best practice experience

Description: “Although project was negotiated to end on Sep 30, 1999, the project work was already finished on July 15, 1999. The reason was that the systems we were to measure were provided earlier than expected. Thus, analysis could start and finish earlier.”
Objective of project:
“Investigation of the impact of distribution techniques and programming languages on the maintainability and reusability of software systems for space applications.”
Funding: Industrial
Project type: R&D
Project manager: Jürgen W.

Fig. 8. Shortened example of a project experience.

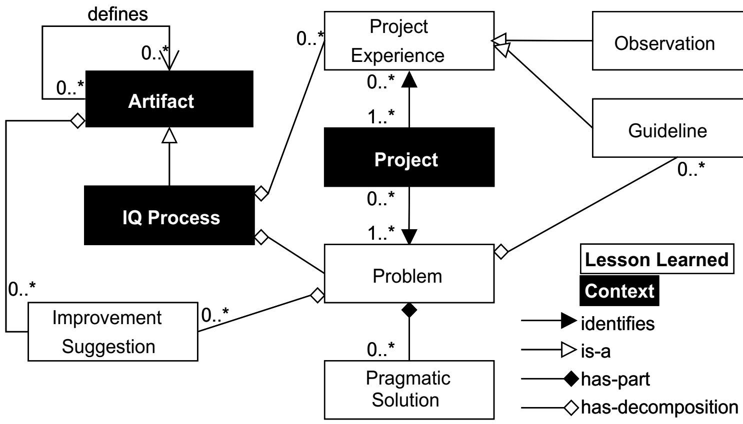

Fig. 9. COIN Ontology [35].

To further facilitate retrieval, lessons learned within CoIN-EF are grouped by type and category. The category groups the lessons learned based on their content. The type determines the intended usage of a lesson learned, which can be an *observation*, a *problem*, *guideline*, *pragmatic solution*, or an *improvement suggestion*. How these types interrelate is also described in Fig. 9, followed by their detailed description.

- *Observations* are facts that are of interest to future projects, often expressing some baseline (e.g., "it took 10% of the total effort to manage the project") or some positive effect (e.g., "the customer was happy because we provided him with a ready-to-use tutorial").
- *Problems* are descriptions of negative situations that occurred during a project (e.g., "the expectations of the customer were not met"). Guidelines, improvement suggestions, and pragmatic solutions relate to one or more problems.
- *Guidelines* are recommendations on how a particular business process should be performed. For example, a guideline could be the following: "Interact with the customer frequently, at least twice a month".
- An *improvement suggestion* is a proposal to change an artifact to avoid problems that occurred during its usage.
- *Pragmatic solutions* are sequences of immediate countermeasures taken by a project team in response to a recognized problem. While a guideline aims at preventing a problem from occurring in the first place, a pragmatic solution is applied after a problem has already occurred.

4.2.5. Text mining tools

In indiGo text mining is used to support the moderator and other eDiscussion participants. Classification with support vector machines (SVM) [21] is used to cluster similar contributions in order to structure the contributions and help moderators in building summarizations. Self-organizing maps (SOM) [23] are used to cluster and visualize the contributions within eDiscussions and between different eDiscussions. The text classifier are trained on contributions from previous eDiscussions and continuously improved and adapted based on completed eDiscussions. SOMs are used to visualize the contributions and their clusters based on information from various attributes (e.g., author, date, or type) as well as their content. This enables the moderator to detect similar threads in different eDiscussions. Before feeding the SVM and SOM algorithms the contributions are exported from Zeno into a XML compliant format for graphs [17] GXL (Graph eXchange Language. An enriched GXL is then generated with additional information (e.g., the classification or SOM coordinates) from the text mining algorithms that can be feed back into Zeno.

4.3. Related work

One central issue in knowledge management is how to offer the right knowledge at the right time. As the domain of indiGo is based on process models, they form the backbone for knowledge delivery. While applying a particular process model, employees find supplementary knowledge with regard to the user's current project context. This supplementary knowledge is provided through associated discussions in the users' groups, his private annotations and, of course, records lessons learned from other projects. In the remainder of this section, we discuss several related systems for participative process learning as realized by the indiGo approach.

As a preliminary conclusion, indiGo is more comprehensive than other approaches to organizational process learning [6,35] and distributed knowledge management because it bridges the gap between informal, communication-oriented knowledge and formal, organization-oriented knowledge and provides a socio-technical solution that covers individual knowledge usage as well as social knowledge creation. The solution is built upon established base technologies like process modeling tools, discussion group software, and case-based reasoning. These technologies are integrated to provide easy access to discussions and lessons learned services. Furthermore, Text Mining techniques are a substantial part of indiGo (a) to lower the cost of experience acquisition by summarizing discussions into lessons learned and (b) by providing overviews of discussions. The methodology ensures that the organizational aspects of eParticipative Process Learning are considered as well and thus, that the platform is integrated into the flow of work in an organization.

The related work in the area of process learning can be subdivided into discussion group software, collaborative modeling of business processes, process model related discussion and experience capturing as well as lessons learned systems. Each of these areas is presented in the following with one or more examples. (For a more detailed overview from a technical perspective, please refer to [2].)

As for discussion group software, this area itself can be subdivided into three sub-areas that are relevant to process learning: consensus building, collaborative problem solving, and document review. Since all these areas can be supported more or less by conventional web-based discussion groups or news servers, examples are only given for systems specializing in one of the sub-areas. For consensus building, i.e., deciding about a disputed topic, the German town Esslingen acts as an example for eGoverment [26]. Concerning collaborative problem solving, i.e., several people working on solving a problem, there are examples from general decision-making like Compendium [9], or dedicated eLearning systems like WBT-Master from the CORONET project [3]. As a third sub-area, examples for document review software are D3E [11], which allow discussing a document as a whole or in sections.

Tools for *collaborative process modeling* allow locally and temporally distributed persons to design a process. One commercial example is the ARIS collaborative suite from IDS-Scheer [4].

CHIPS [18] from Fraunhofer IPSI offers additional support for process execution by linking process instances with resources on BSCW servers.

Examples for *process annotating* systems are a combination of the Electronic Process Guide with the discussion software page seeder [32] and the WESPI system from DaimlerChrysler [20]. Both of them allow discussing process models, the latter also allows to create frequently asked questions lists based on email contributions.

Finally, *lessons learned*-based decision support systems capture experience. Examples that capture experience from software engineering projects are CoIN-EF [2] and the Lids System from Daimler Chrysler [20].

When we extend out the view concerning related work with direct relevance to eParticipative Learning, further work can provide input to eParticipative Process Learning:

Process Mining and Performance measurement tools like ARIS PPM [31] can support the creation of new process models by deriving them from information within an Enterprise Resource Planning (ERP) system like SAP R3. The analysis of related process metrics and the comparison between intended and actual processes can be input to process-related discussions. Furthermore, it allows evaluating the effects of the suggestions derived from the discussions by comparing process performance before and after implementing the suggestions.

Workflow systems provide a basis for enactment of a process model. Classical workflow management systems focus on enactment of repetitive processes. In this case, indiGo can be used to gain a consensus about the execution of the workflow beforehand.

For applying workflows to knowledge intensive tasks, the field of weakly structured workflows emerged. These allow to revise incomplete definitions of workflows during their execution and provide access to related knowledge sources. Examples for these systems are FRODO [15] and INCOME [29].

The idea of replanning and extending workflows is also present in extensions of commercial groupware. One example is the GroupProcess system, which allows replanning and extension of LotusNotes-based workflows [19]. Another commercial example, focusing on performing project work, is Microsoft Project Office Server [30], which supports the distribution of tasks derived from a project plan.

As the last field of related work reflected in this paper, process sensitive software environments (PSSE) support the enactment of also—weakly structured—software processes. Examples for such systems are EPOS [10] and the MILOS [25] system.

Whether weakly structured workflows, extended groupware or PSSEs, the decision about how to extend and enact a process will lie within the responsibility of the people using the system. Therefore, solving process-related conflicts between several stakeholders might be a minor issue in this area of application. However, when the need arises to integrate and standardize processes across several departments or sites, eParticipative Process Learning can provide a means for consensus building.

5. Evaluation of indiGo

Since its start in mid-2002, indiGo has been used at IESE. In the following, three case studies of this application are presented, with the first one being the main part of the evaluation of indiGo.

In the first case study, the focus was on whether employee participation during the introduction of processes would improve acceptance and perceived quality. In the second case study, an application for collaborative refinement of a process draft was tested. In the third case study, indiGo was applied for collaborative experience creation and capturing. Since all these case studies employed actual business processes of IESE as these subjects, they can be only described on an abstract level due to confidentiality. A reflection of the case studies results finishes this section.

To give the context of these case studies, the *IESE as setting of the case study* is described: The IESE employed about 97 full time employees at the time of the case studies. Of these, 70 scientists work on applied research as well as on the evaluation and transfer of software engineering knowledge in a broad range of industrial and publicly funded projects. These scientists are located at one main office and a subsidiary office within Kaiserslautern. As applied research is the core business of IESE, process models about research and project execution are central and affect most of IESEs staff. It is vital that they accept and "live" the process models and cooperate to continuously improve them. Due to the variety of projects, the processes can reasonably be captured at an abstract and decontextual level only. That means, the execution of an abstract process model is knowledge-intensive.

5.1. Case study 1: Participative introduction of processes

The methodology and technical system developed for indiGo were evaluated through a case study, which was performed at the Fraunhofer Institute for Experimental Software Engineering (IESE) starting in the summer of 2002. The main objective of this case study was to evaluate whether discussing process models in the introduction phase would increase their acceptance and perceived quality. Another objective was to gather practical experience with the use of the technical infrastructure and (parts of) the methodology. A summarization of this case study will be described with the following structure: First, the context and design of the case study will be described. Second, the results of the case study regarding the above mentioned objectives will be presented. A more detailed description of the results is available in [13].

5.1.1. Case study context and design

To give an impression of how the case study was executed, its context and design are presented in this section. First, the process models used as context of the case study are described. Second, design and tools used for the evaluation are presented.

Concerning participation, each IESE member decided on his/her own to participate in the case study. Each IESE member had the opportunity to contribute to the discussion or to answer the questionnaires. Actual participation was voluntary and supported by upper management.

The *process models* that were introduced using indiGo were Industrial Project Acquisition and Conference Participation Planning: Industrial Project Acquisition describes the creation of an offer for an industrial customer. Conference Participation Planning coordinates attendance at conferences. The main reason for selecting these processes was their importance for IESE: They address the research as well as the application part of applied research. Furthermore, they have a high potential of uncertainty and conflicting interpretations, which implies a need for discussions about these process models. Both process models were created by IESE members experienced in the execution of the process and possessing process modeling skills.

The *design of the case study* was focused on the main objective of examining whether the evaluation of acceptance and perceived quality would improve. To show this effect, evaluation before the discussion and evaluation after the discussion (when the results have been integrated into the process model) is necessary. Consequently, a pre–post design was chosen: At the start of the discussion in June 2002, a questionnaire was distributed via email among all IESE members to give a personal evaluation of each of the two processes. After the improvement suggestions resulting from the discussions were implemented, a second questionnaire with the same evaluation questions was distributed to evaluate the changed process in July 2002. This second questionnaire was again distributed to all IESE members by email. This email also contained a summary of the discussions and the notification that the accepted changes were implemented. Then the results of the participants who completed both questionnaires were compared. Each questionnaire contained a set of 13 questions for each process about acceptance and different aspects of perceived quality. For each item, a statement was given agreement scale from one (high agreement) to six (high disagreement). The quality aspects were then condensed into two condensed measures to facilitate evaluation: "single quality aspects" and "overall quality aspects".

5.1.2. Case study results

The presentation of the case study results is divided into two parts: First, the differences in acceptance and perceived quality are presented. Second, the main practical experiences and findings are presented. Both parts rely on the distribution of participants that is presented in Table 1. In particular, the differences in acceptance and perceived quality are based on the participants who completed both questionnaires, who are about 16% of all IESE members.

None of the participants who completed the 1st and 2nd questionnaire were part of the project members of indiGo. Since the absolute number of participation is quite small, transferring these results to other organizations should be done with caution. Based on the case study, further evaluations will be performed at IESE and in future projects. Nevertheless, the results of this case study give hope that the effects observed can be replicated in these future evaluations. (Threats to validity are discussed in detail in [13].)

For measuring *acceptance and perceived quality* (single quality aspects and overall quality aspects), two major findings hold for both processes: When the results of the pre-phase (1st questionnaire) are compared to the ones in the post-phase (2nd questionnaire), the median of all results improves. The only exception is the median of acceptance for Conference Participation Planning, which remains stable. Furthermore, the bandwidth of results decreases, i.e., participants evaluate the process in the pre-phase more differently than in the post-phase. In other words assuming that these effects are caused by the process discussion the resulting processes are evaluated better and more consistently with respect to acceptance and perceived quality.

Table 1
Distribution of participants

Participant in	No. of participants	≈% (from 97)
1st Questionnaire	24	25
2nd Questionnaire	26	27
1st and 2nd Questionnaire	15	16
Discussion	21	22

These effects are depicted exemplarily by the results of Industrial Project Acquisition in Figs. 10 and 11. For the single quality aspect measure shown in Fig. 10, the median increased from about 0.77–0.90 (with 1.0 being the best possible result for this measure). The overall quality aspect measure (also shown in Fig. 10) increased from about 0.8–0.83 (again, 1.0 being the best possible result). As depicted in Fig. 11, the median of acceptance measurement increased 2 to 1 (with 1 being the best and 6 being the worst measure).

The significance of the difference—i.e., whether the difference is caused coincidentally or has a statistical significance was investigated using the Wilcoxon matched pair test [33,34]. For case studies like these, a level of significance or P-value of 10% or lower [7] is an acceptable indicator of

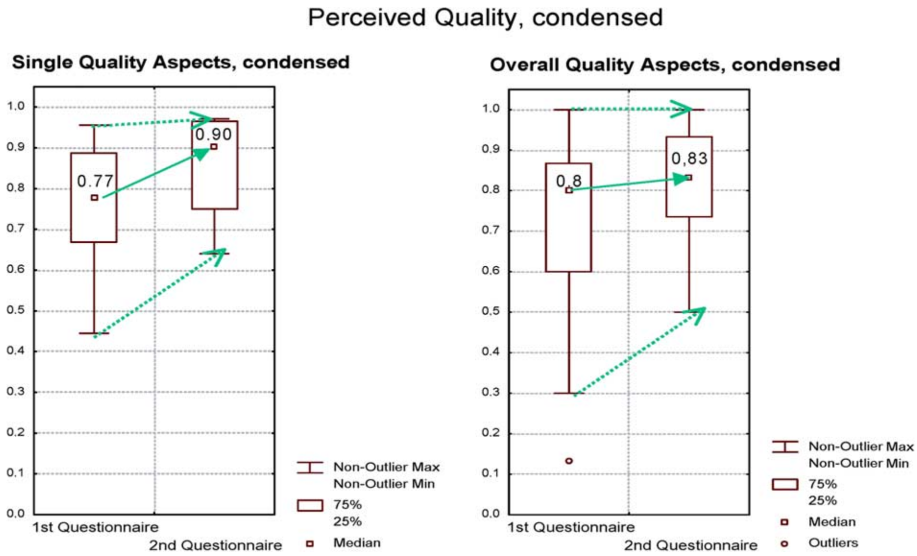

Fig. 10. Pre–post evaluation of perceived quality for Industrial Project Acquisition.

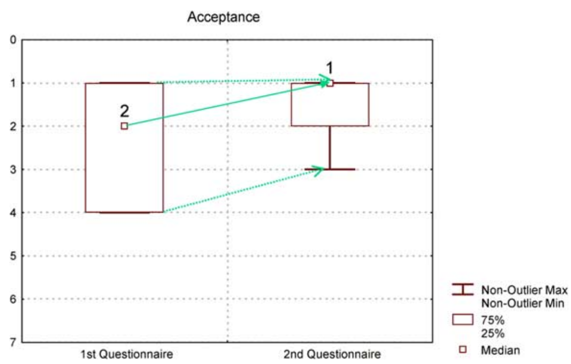

Fig. 11. Pre–post evaluation of acceptance for Industrial Project Acquisition.

significance. Based on this level of significance, the Wilcoxon-matched pair test was successful for two of the three criteria of each process. The criterion where it failed differed between the two processes: The test for Overall Quality Aspects failed for Industrial Project Acquisition. For Conference Participation Planning, the test failed for the Acceptance aspect. Therefore, the improvement observed has to be checked in future evaluations especially for these aspects with failed tests. Furthermore, due to the low number of participants, the power could not be calculated. Consequently, no statement can be made on whether no difference is, in fact, present.

The decreasing result bandwidth is shown graphically by smaller boxes (25–75%) and the distance between the non-outlier min and non-outlier max (see legend for details) between the pre- and post-phase.

The *practical experiences* gathered about indiGo add to the above findings: The major findings concerned the indiGo technical infrastructure, the process learning method, and the eModeration method. These findings were drawn from the answers to further questions within the two questionnaire, the discussion groups intended for user feedback, and by analysis of the process-related discussion groups.

For the indiGo technical infrastructure, discussion groups about indiGo itself were the most important source of improvement suggestions. From 36 contributions, 26 improvement suggestions could be deduced, which are currently under development. In addition, four improvement suggestion were issued in process-related discussion groups and were directly implemented. From the first questionnaire, sufficient usability and availability could be deduced.

Concerning process learning, 26 improvement suggestions could be deduced from 120 contributions in four weeks. 16 of them were implemented. Since IESE-internal processes were discussed, these improvement suggestions can be described on an abstract level only. Table 2 gives an overview of the improvement suggestions and the number of improvement suggestions implemented and rejected. For each category mentioned in the upper row of the table, an explanation and an example will be given in the following. Information Flow states the number of suggestions concerning documents or other data passed in the course of the process. An implemented example was a set of rules concerning registration for conferences. Role responsibilities are suggestions to change the responsibilities of a role within the process. A rejected example for this category was

Table 2
Overview of improvement suggestions by categories

Process	Implemented?	No. of suggestions	Information flow	Role responsibilities	Deregulation	Clarification
Conference Participation Planning	Yes	9	3	2	2	2
	No	2	1	0	0	1
	All	11	4	2	2	3
Industrial Project Acquisition	Yes	7	2	2	1	2
	No	8	1	5	1	1
	All	15	3	7	2	3
Both	Yes	16	5	4	3	4
	No	10	2	5	1	2
	All	26	7	9	4	6

late involvement of the Project Manager. Deregulation summarizes suggestions to delete rules mentioned in the process description. An implemented example was changing the mandatory creation of a conference travel report to a voluntary basis. Clarification counts suggestions where parts of the process should be detailed. An implemented example for this category was adding a checklist about customer expectation clarification.

The first questionnaire revealed a generally positive attitude towards process discussions and experience sharing. Asked about their participation in the future, six participants of the 2nd questionnaire answered that they would not participate. Nineteen participants stated that they would participate in future discussions. The most important factor for future participation is relevance of the topics and processes discussed.

The eModeration Method was improved by several lessons learned from the case study. For example, the roles of the Moderator and Process Author should not be performed by the same person. Furthermore, most of the participants in the 2nd questionnaire were satisfied with the relevance, results, and moderation of the discussions.

Simplified, the case study showed the following: acceptance and perceived quality increases with process discussion. indiGo supports this discussion well. Due to the (potential) involvement of all organizational members, improvement suggestions concerning the processes could be collected that would not have been (practically) collected in classical, workshop-based process modeling.

5.2. Case study 2: eParticipative refinement of process draft

In the case study, process models that were the result of a complete process modeling effort were the objects of the study. To evaluate whether elaborated, but incomplete drafts of processes could be improved via eParticipative Process Learning, another application of indiGo was performed in May 2003. The object of this application was the After Sales Marketing process, which belongs to the group of project processes, like the process Industrial Project Acquisition. This process describes the activities to be performed after a project has been executed. In particular, it describes how to stay in contact with a customer to gain real-life application experience of IESE methods and technologies. Therefore, this process also acts as a source of new lessons learned for the Experience Base.

The main process performers are IESE members responsible for coordinating projects in several application domains. Due to this business, these stakeholders have conflicting schedules caused by their out-of-office activities. indiGo offered an opportunity to involve all process performers in the discussion about how the process should be executed.

In a regular meeting of the process performers, a short, 30-minute introduction to the content of the process and the objectives of the discussion was given. The discussion itself was then performed via indiGo. The process performers not present at this meeting were invited via a separate email. Therefore, no separate process improvement meeting had to be scheduled, and all process performers were offered the opportunity to participate.

Eleven IESE members participated in the discussion. Five of the participants belonged to the group of the nine major process performers. They created 50 contributions, from which nine new Guidelines for the process could be extracted. Furthermore, the templates for data collection and procedures concerning data evaluation were improved or newly defined.

In the authors' opinion, this application shows the advantage of participating asynchronously (i.e., independent of time and space). Furthermore, since discussions were directed to web-based discussion groups, the time needed for conventional process improvement meetings with process performers present was decreased. In addition, it was easy to involve further stakeholders like the workers' council in the discussions about the process.

5.3. Case study 3: Collaborative experience creation

In the third application of indiGo, a combined approach of meetings followed by subsequent eDiscussions was used to create and capture lessons learned. The topic of this effort was the creation of proposals for public projects to enrich the respective process with further experience. The initial group of participants consisted of four IESE members who were involved in the creation of at least one public project proposal. The starting point were two 1.5 h meetings to get an initial set of guidelines, checklists, and further topics to be discussed. These results were then transferred into eDiscussions and refined further by the initial group. After one month, and after a critical mass of contributions was reached, the eDiscussion was opened for all IESE members.

The result of this discussion were 42 contributions, which contained 21 new lessons learned (like checklists about financing and proposal creation) and text fragments (like templates for workpackages). These results will be integrated into the process models and the experience base after the end of the current proposal activities, which will be finished at the end of the year.

Again, this application showed the advantages of self-determined participation. Two further practical advantages supported the discussion: First, the participants attached text fragments and examples of proposals, which could be used instantly for future proposals. Second, a discussion about potential project proposals was built upon the results of this discussion group. In the future, more discussions like this will be performed when more than three IESE members are involved in a discussion, since unlike the exchange of ideas via email, eDiscussions are open to all participating members and the contributions to these discussions do not get lost in the email account.

5.4. Reflection of results

This section reflects whether the problems mentioned in the motivation were addressed.

The effect on eParticipative Process Learning to *employee resistance* due to insufficient involvement were shown in the first case study by the increased acceptance of the changed process model. The increase in the subjective quality of the process model is also an indicator for this effect.

Capturing experience for new and changed process to address*insufficient experience* was shown in the third case study, were 21 new lessons learned were created. Furthermore, in the other case studies, additional lessons learned were created.

Lowering the *high effort for process modeling and maintenance* was subject of the second case study, were a draft version of a process was discussed. During the modeling phase, the opportunity to discuss open questions in the subsequent discussion released the process modeling team to clarify these questions before publishing.

6. Summary and outlook

indiGo has shown to be a valuable system for a process-related discussion to learn about and improve an organization's processes. It is used to identify and record experiences from participants of discussions in order to feed them back into an organization-wide experience base. Through indiGo's process learning method, stakeholders of a process can decide which issue that attracted their attention should be discussed within a selected group of people. The technical infrastructure enables the organization of parallel discussion groups. The structured and goal-oriented execution of those discussions is ensured by the eModeration Method.

In the first case study, a positive effect on the acceptance and perceived quality was observed. Based on this case study and further case studies, we can draw the following conclusions: eParticipative Process Learning with indiGo works when the discussion is triggered explicitly. This is valid, in particular, for process introduction. What did not worked well was self-determined problem-solving, where users of indiGo solve a problem presented by another user. Therefore, for each discussion group attached to a process, the employee responsible for the process should guarantee an answer within a reasonable timespan. Communicating this timespan to the process performers increases the possibility that users will use indiGo to solve a problem, which is the basis for further contributions to the experience base. Furthermore, when the objectives and topics being discussed still need clarification (e.g., in the start-up phase of experience creation), meetings should be held to populate the discussion group with sensible contributions.

Future work within the scope of the indiGo project will be the improvement of the methodology and the platform. Using the contributions from the case study, text mining techniques for classification, clustering, and summarization will be evaluated to support the eModerator and the participants in process learning. This improvement will be done in further research and application projects. Since the user of a process description was the focus of work on the technical platform in indiGo, the subsequent development focus will be the support of the organizational members involved in the maintenance of process models. Another direction for future activities is to offer user further opportunities for participating to the process performer. Here we plan to investigate to combine discussion and wiki-style editing of process descriptions.

Due to the component-based nature of the indiGo methodology and technical infrastructure, part of indiGo can be applied to augment existing systems by adding indiGo features. For example, if an organization is already using web-based process descriptions, discussion groups can be added to these descriptions. Concerning the methodology, only the eModeration Method is needed in this case. Further components of the indiGo methodology and technical infrastructure can be added on demand (e.g., the text mining tool, when a sufficient number of contributions have been reached.). The main prerequisite to apply indiGo within existing process description systems is to have a process model in a form understandable by humans.

Furthermore, we consider extending the indiGo approach to applications where process models do not play such a central role. Although a platform for organizational learning should eventually cover all knowledge categories treated in indiGo, the first steps to organizational learning need not necessarily involve process models. An organization can introduce indiGo in a stepwise manner simply by starting with an eParticipation forum.

Acknowledgements

indiGo (Integrative Software Engineering using Discourse-Supporting Groupware) is funded by the German Ministry for Education and Research (BMBF) under grant number 01 AK 915 A [see http://indigo.fhg.de/].

Thanks go to Astrid Haas for her work on eModeration and Torsten Willrich as well as Markus Nick for their help in the development of indiGo. We also thank our students for their work on the first prototypes of the indiGo technical architecture and process model processing framework.

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Björn Decker received his Diploma in Computer Science from the University of Kaiserslautern in 1999. Since 2000, he is researcher at the Fraunhofer Institute for Experimental Software Engineering. His main research interests are Business Process oriented Experience Management and Management of organizational Change.

Jörg Rech received his Diploma in Computer Science from the University of Kaiserslautern, Germany in 2000. From 2000 to 2002 he was a research assistant at the software engineering research group at the university of Kaiserslautern. Currently, he is a researcher at the Fraunhofer Institute for Experimental Software Engineering. His research mainly concerns knowledge discovery in software repositories, software analysis, and knowledge management.

Klaus-Dieter Althoff received his Ph.D. on an architecture for knowledge-based diagnosis of engineering systems and his Habilitation on the evaluation of case-based reasoning (CBR) systems from the University of Kaiserslautern, Germany. He was/is responsible for a number of research projects on knowledge-based systems, machine learning, CBR, knowledge management (KM), learning software organizations (LSO), and experience based information systems at the University of Kaiserslautern and the Fraunhofer Institute for Experimental Software Engineering (IESE). He is member of various program committees and reviewer for many scientific journals. He was/is co-chair of a number of international events like the 3rd Conference on Professional Knowledge Management WM 2005 (as well as LSO'01, ICCBR'99, EWCBR'93, EKAW'92). Currently he is department head for Experience-based Systems and Processes at IESE.

Andreas Klotz received his Diploma in Spatial Planning from the University of Dortmund, Germany in 1999. From May 2000 to August 2001 he worked as scientific assistant at the German Institute of Urban Affairs (Difu) in Berlin. Since September 2001 he has been a scientific assistant at Fraunhofer AIS coordinating technical developments concerning e-participation applications. His research focuses on embedding e-participation applications in administrative processes.

Edda Leopold has earned Diploma degrees in mathematics and musicology in March 1989 and June 1990 from the University of Gießen. From January 1991 to December 1995 she was research Fellow at the Department of Computational Linguistics of the University of Trier. She received her Ph.D. in quantitative linguistics in July 1998 from the University of Trier. Since May 1999 she is senior researcher in the Knowledge Discovery Team of the Fraunhofer Institute for Autonomous Intelligent Systems in Sankt Augustin. She is currently working on the application of different data mining techniques to text and multimedia mining problems. Her research interests include text- and multimedia categorisation, spatial representation of meaning, multimedia semiotics and multimodal communication.

Angi Voss is associate manager of the Department for Spatial Decision Support at Fraunhofer AIS. Until 2004 she was responsible for the Department for Knowledge and Communication at AIS. Angi Voss has managed several national and European projects on computer-supported cooperative work, knowledge management, knowledge engineering and knowledge-based systems and co-authored some books in these areas. Angi Voss studied computer science at the University of Bonn and received her doctoral degree at the University of Kaiserslautern in 1986.