Application of the SPI-KM Approach to Support the Implementation of the MPS Model in Small- and Medium-Sized Enterprises in Brazil

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Although small- and medium-sized enterprises (SMEs) represent most of the of Brazilian software industry, these organizations struggle to implement software process improvement (SPI) initiatives aiming to increase their competitive advantages. One cause of the failure of many SPI initiatives conducted by SMEs is the lack of adequate process implementation approaches aligned to common characteristics of SMEs, such as a lack of financial and human resources. During the last five years, the Brazilian software industry and research universities have been working cooperatively to develop and disseminate a Brazilian software process model, the MPS model, aimed at improving the quality of Brazilian software processes and products. To cope with the difficulties SMEs face during SPI implementation and to facilitate the dissemination of the MPS model, the authors developed an approach called SPI-KM, supported by a process-centered software engineering environment known as the Taba Workstation. The MPS model and the Taba Workstation are presented in this article. The results and lessons learned from the application of the SPI-KM approach in a group of five Brazilian SMEs that implemented the MPS model are also described.

Key Words

process-centered software engineering environment, small and medium-sized enterprises, software process improvement, software process reference model

SQP References

Process Model for Small Software Organizations
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Appendices

The appendices may be found in the online version of SQP at http://www.asq.org/pub/sqp/.

INTRODUCTION

Although small- and medium-sized enterprises (SMEs) represent most of the Brazilian software industry, these organizations struggle to implement software process improvement (SPI) initiatives that aim to increase their competitive advantage. In SMEs, SPI implementation approaches require special concerns due to material and human resources constraints. To ensure their survival in the increasingly competitive market, it is necessary to overcome these difficulties and improve their productive processes. For this reason, SPI implementation approaches must be developed to cope with these obstacles and to provide the means for increasing SPI programs success, especially for SMEs. For instance, the Software Engineering Institute (SEI) at Carnegie Mellon University has demonstrated interest in research focusing on SPI in small companies (CMU/SEI 2006a).

Since 2003, the Brazilian software industry and research universities have been working cooperatively to implement a successful SPI strategy that takes into account the constraints inherent to SMEs. The main goal of this initiative is to improve the quality of Brazilian software processes and products through the development and dissemination of a Brazilian software process model, the MPS model, based on software engineering best practices and aligned to Brazilian software industry context.

The MPS model was developed in the context of the MPS.BR Program, a nationwide Brazilian initiative coordinated by the Association for Promoting Brazilian Software Excellence (SOFTEX). The main objective is to enable the deployment of software engineering adapted to the reality of Brazilian companies, according to the main international approaches for software processes definition, assessment, and improvement (Softex 2007a). The focus of the MPS model is on SMEs that need to achieve significant improvements in software processes in a short timeframe and at low costs (Santos et al. 2005a). The MPS.BR Program provides mechanisms to facilitate SPI deployment and assessment of the most critical software processes. The adequate deployment and assessment of such processes promotes subsequent SPI deployment cycles and software process maturity growth.

COPPE/UFRJ is a Graduate School and Research in Engineering of the Federal University of Rio de Janeiro in Brazil. This institution has been providing SPI consultancy services to Brazilian organizations for more than two decades. Since 2003, the authors have been implementing software processes in SME groups in Rio de Janeiro. They developed and deployed a strategy called SPI-KM to support MPS model-based implementation in SMEs (Santos et al. 2007), which is supported by a process-centered software engineering environment (PSEE) called the Taba Workstation (Montoni et al. 2006).

This article presents the work carried out by a group of Brazilian companies regarding the deployment of the MPS model that used both the SPI-KM strategy and the Taba Workstation. The authors also discuss the lessons learned from implementing SPI in this group of SMEs and lessons collected from previous SPI experiences.

DIFFICULTIES OF SPI IMPLEMENTATION INITIATIVES IN SMES

Despite the fact that it is widely recognized, the importance of implementing models such as the Capability Maturity Model Integration (CMMI) (CMU/SEI 2006b) for increasing organization competitive advantages (Goldenson and Gibson 2003), software process reference models have been adopted by very few Brazilian organizations, especially SMEs (until 2003, only 30 Brazilian organizations had gone through CMM-based assessments) (Veloso et al. 2003). Many studies have been reported in the literature addressing the difficulties SMEs face in implementing SPI initiatives. For instance, Staples et al. (2007) present a study that shows that software organizations, especially small ones, will never benefit from process capability maturity improvement because they consider it infeasible to adopt CMMI mainly due to the small organization size, the high costs involved in providing SPI services, and the lack of time available to dedicate to SPI activities. Coleman and O'Connor (2006) also present a study of how SPI is applied in the practice of software development. Their results show that SPI programs are implemented reactively and that many software managers reject implementing SPI models such as the CMMI model and ISO standards because of implementation and maintenance costs.

Staples et al. (2007) also recognize that despite the fact that models like CMMI can be tailored to small organizations, this tailoring involves justifying the exclusion of aspects of the model that compromise the execution of official appraisals. Therefore, those authors suggest recasting the CMMI so that an organization can start with minimal practices (or practices with perceived value) and add more practices according to their specific needs. Wangenheim, Varkoi, and Salviano (2006) also support this idea by emphasizing the need to focus SPI on the most relevant processes and keep the assessment costs as low as possible with the maximum coverage of relevant processes.

While many approaches have been developed to support SPI implementation, the inadequacy of such approaches is one of the main reasons most SPI initiatives fail (Zaharan 1998). For instance, the IDEAL model was developed by the SEI for initiating, planning, and guiding improvement action (Mcfeeley 1996). This model, however, is specific to support the implementation of the CMMI model, and it is not useful to support the adoption of other models (Niazi, Wilson, and Zowghi 2005a). Moreover, approaches like the IDEAL model help identify "what" activities are necessary to implement SPI, but do not explain "how" to implement SPI effectively (Wu, Ying, and Yu 2004; Niazi, Wilson, and Zowghi 2005a). Therefore, there is an urgent need for alternative approaches that guide and facilitate process implementation and reduce process assessment costs, thus fostering the achievement of SPI initiative benefits in a short timeframe within feasible costs.

MPS.BR PROGRAM AND SMES

The MPS.BR Program was initiated in 2003 by SOFTEX aiming to increase the software development capabilities of both large companies and SMEs and to enhance their competitive advantages (Softex 2007a). The main goal of this program is to improve the quality of Brazilian software processes and products through the development and dissemination of a Brazilian software process model– the MPS model—based on software engineering best practices and aligned to Brazilian software industry context. The basic need for developing a national model was the potential to evolve the model according to the specific interests of the Brazilian software industry. For instance, the latest version of the MPS model incorporates new processes such as reuse management and human resources management that are not explicitly considered in the CMMI and are very important for Brazilian software organizations.

The MPS model is made up of three main components: the MPS reference model, the MPS assessment method, and the MPS business model. Figure 1 presents the MPS model components and the elements that constitute each component.

The MPS reference model (MR-MPS) is documented in the form of three guides: the MPS general guide (Softex 2007a), the MPS acquisition guide (Softex 2007b), and the MPS implementation guide (Softex 2007d).

MPS General Guide

The MPS general guide provides a general definition of the MPS reference model (MR-MPS) and common definitions to all the other guides. The MR-MPS is conformant to ISO/IEC 15504 (ISO 2004a), since it fulfills the requirements of a process reference model defined in ISO/IEC 15504-2. The MR-MPS defines seven levels of maturity and establishes expected results and attributes of processes that an organizational unit must implement when undertaking an improvement to reach one of the maturity levels (Softex 2007a). The MR-MPS maturity levels are: Level A (optimization), Level B (quantitatively managed), Level C (defined), Level D (largely defined), Level E (partially defined), Level F (managed), and Level G (partially managed). For each of these maturity levels, processes were assigned based on the ISO/IEC 12207 (ISO 2000) standard and its two amendments (ISO 2002; ISO 2004b) and on the process areas of levels 2, 3, 4, and 5 of the CMMI staged representation (CMU/SEI 2006b). The MR-MPS maturity levels have a different graduation of the CMMI staged representation to enable a more gradual and adequate deployment in SMEs by focusing process improvements on the critical processes at each SPI cycle. Moreover, the MR-MPS defines more processes than the CMMI model. The MR-MPS also defines process attributes (PA) based on the ISO/IEC 15504-2 process attributes to define capability levels. The MR-MPS defines nine PAs:

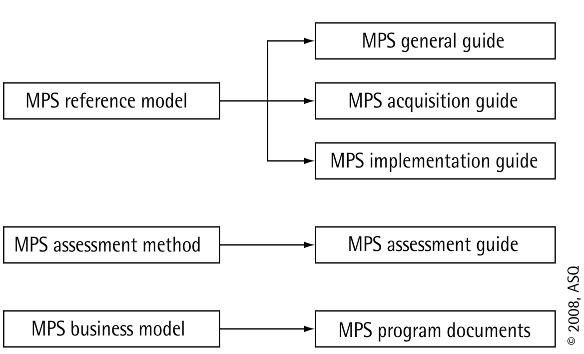
1) PA 1.1 (process performance attribute)
2) PA 2.1 (performance management attribute)
3) PA 2.2 (work product management attribute)
4) PA 3.1 (process definition attribute)
5) PA 3.2 (process deployment attribute)
6) PA 4.1 (process measurement attribute)
7) PA 4.2 (process control attribute)
8) PA 5.1 (process innovation attribute)
9) PA 5.2 (process optimization attribute)

Each PA comprises a set of process attribute achievement results (PAR) used to evaluate a specific PA implementation. Figure 2 presents the mapping between MR-MPS and CMMI maturity levels (ML), the MR-MPS processes, and the PA that will be added to each MR-MPS ML.

MPS Acquisition Guide and Implementation Guide

The MPS acquisition guide (Softex 2007b) describes a software- and service-related acquisition process aimed at supporting organizations that want to acquire software products or software services based on the MR-MPS. The MPS implementation guide (Softex 2007d) provides information on how to implement each of the expected results and PAs in software organizations. The objective of

FIGURE 1 MPS model components



this guide is twofold: to provide important SPI knowledge to software organizations beginning an SPI initiative and to facilitate the capability of SPI consultants to provide adequate SPI services. The MPS implementation guide is divided into seven documents, one for each maturity level of the MR-MPS from level G to level A.

MPS Assessment Guide

The MPS assessment guide (Softex 2007c) basically describes the appraisal method and supporting process. The MR-MPS assessment method for process improvement was defined based on the ISO/IEC 15504 standard (ISO 2004a). The level of deployment of the expected results related to a specific process is evaluated based on indicators that evidence such deployment. These indicators are defined for each company, related to the expected results of a process, and can be one of three types: a) direct, b) indirect, or c) affirmations. Direct indicators are intermediate work products that result from an activity. Indirect indicators are generally documents that indicate that an activity was executed. Affirmations are results of interviews with the project teams of the evaluated projects.

The MPS Business Model

The MPS business model (MN-MPS) defines business rules for: a) training practitioners through MPS official courses, individual examinations, and recycling workshops; b) implementing the MPS model by organizations that provide MPS deployment services; c) executing process assessments by organizations that provide MPS assessment services; and d) organizing groups of enterprises to execute MPS deployment and assessment. The MN-MPS also comprises a specific business model (Softex 2007a) suitable to large companies that do not want to share MPS services and costs with other companies and a cooperative business model for groups of SMEs.

Adoption and Dissemination of the MPS Model

The possibility of rating companies' maturity considering more levels not only decreases the cost and effort of achieving a certain maturity level, but also makes visible the results of the SPI within the company and across the country in a short timeframe. To support the widespread adoption of the MPS model, SOFTEX organizes groups of organizations according to the MN-MPS cooperative business model for SMEs interested in implementing and assessing the MPS model, and sharing MPS services and costs. Forty percent to 50 percent of the overall MPS model-based implementation and assessment costs are provided by external sponsors such as the Inter-American Development Bank (IDB). Moreover, these organizations can also share other costs, such as training activities. By integrating these groups, organizations can significantly reduce the financial resources necessary to improve their processes. The implementation of the MPS model according to the MN-MPS cooperative business model has been recognized by SMEs as an important way to achieve process improvement benefits at reasonable costs. The SPI implementation results presented earlier are those of a group of five SMEs that implemented the MPS model under the MN-MPS cooperative business model.

The increasing adoption of the MPS model by Brazilian software organizations demonstrates that the development

FIGURE 2 Mapping between MR-MPS and CMMI maturity levels, MR-MPS processes, and process attributes (PA)

Maturity Levels		MR-MPS Processes	MR-MPS PA
CMMI	MR-MPS		
5	A	Causal analysis and resolution	1.1, 2.1, 2.2, 3.1, 3.2, 4.1*, 4.2*, 5.1* and 5.2*
4	B	Project management (new outcomes)	1.1, 2.1, 2.2, 3.1, 3.2, 4.1* and 4.2*
3	C	Decision analysis and resolution, risk management and development for reuse	1.1, 2.1, 2.2, 3.1 and 3.2
	D	Requirements development, product design and construction, product integration, verification and validation	1.1, 2.1, 2.2, 3.1 and 3.2
	E	Human resources management, process establishment, process assessment and improvement, project management (new outcomes), and reuse management	1.1, 2.1, 2.2, 3.1 and 3.2
2	F	Measurement, acquisition, configuration management, and quality assurance	1.1, 2.1 and 2.2
	G	Project management and requirement management	1.1 and 2.1

* These PAs are applicable only to selected processes. All other PAs must be applied to all processes.

of a national model was very important for disseminating SPI in Brazil. As of June 2008, 103 organizations had gone through successful MPS model-based assessments, and 70 percent of those assessments were in the lowest MR-MPS maturity level G. This high number shows that the MPS model is attractive to organizations seeking process improvement but do not have sufficient resources to commit to large improvement cycles. Moreover, 80 percent of the organizations that were assessed on the two bottom maturity levels (G and F) are SMEs that implemented the MPS model under the cooperative business model. The assessment results are published on the SOFTEX Web site at http:www.softex.br/mpsbr.

SPI-KM: A Software Process Improvement Approach Supported by Knowledge Management

To support SPI deployment initiatives, the authors developed a strategy—SPI-KM—(Santos et al. 2007) that has evidenced its feasibility and benefits over past well-succeeded SPI appraisals (Santos et al. 2005a; Ferreira et al. 2006). The strategy consists of a set of defined phases that focus on specific issues related to SPI initiatives' deployment; it has the support of knowledge management and takes advantage of the use of the Taba Workstation, a PSEE. The strategy is depicted in Figure 3.

SPI-KM PHASES

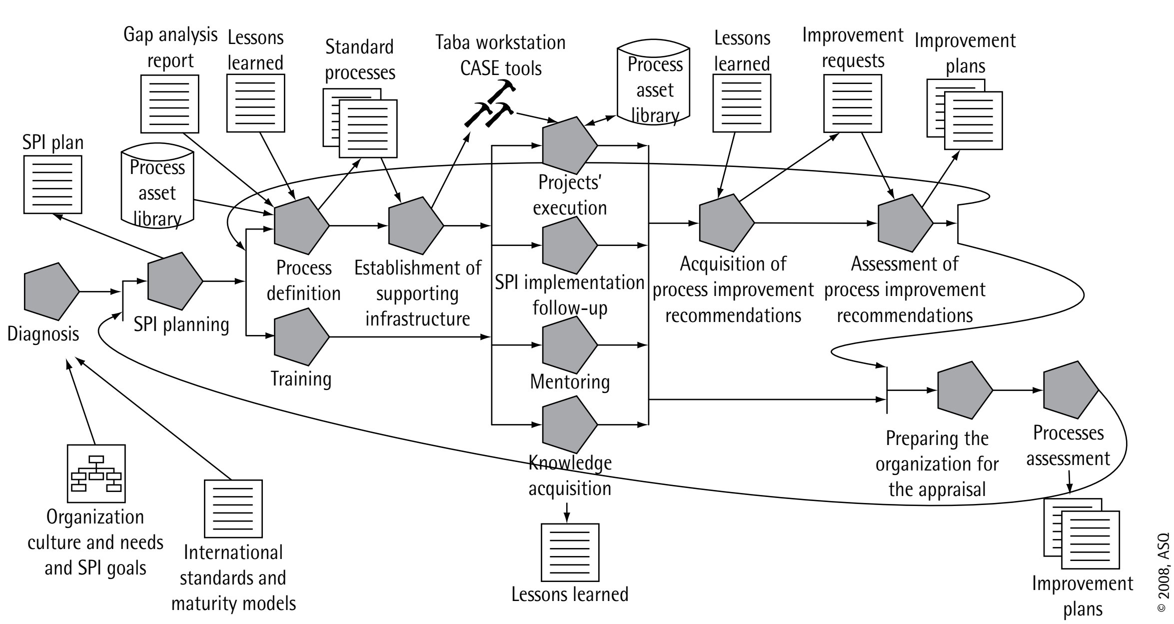
Diagnosis

The strategy begins when the software organization aiming to enhance its processes gets in touch with the COPPE/UFRJ research group. At first, the organization's business needs and goals, the organizational culture, the SPI goals, the software process reference model to be used, and the level desired are identified with the help of high-level management. The organizational unit that is going to take part in the SPI initiative is also identified.

SPI Planning

During this phase, a plan for the SPI initiative is developed. This plan comprises, among other things: a) the consultant team that is going to be allocated during the initiative; b) the organizational members to be trained; c) the schedule for the training; d) the processes definition prioritization regarding organizational goals, strategic needs, and process reference models to adopt; e) the creation of groups of work with designated responsibilities; f) the definition of supporting tools, infrastructure, and operation responsibilities; and g) the expected appraisal date. The SPI plan is reviewed at predefined milestones (for example, after a review of process improvement recommendations or after informal process assessment).

FIGURE 3 SPI-KM phases



Process Definition

Process definition involves a series of meetings to assess the organizational processes in order to identify their current state of practice. At this time, a process is defined based on the activities that software developers in the organization already execute, being adherent to the process reference model identified in the prior phase. If the company already uses a software process, a gap analysis is performed to identify practices needed to accomplish the SPI goal (for example, expected process results of maturity process models). If the company does not have defined software processes, a new one is defined based on the consultancy experience and lessons learned. Regardless of the maturity model and the level selected, a standard software process is always defined and institutionalized at the organizational level. The authors are confident that the adoption of an institutionalized process to guide project execution since the initial phases of SPI initiatives is essential to catalyze improvement changes and to make the SPI cycles faster. The software engineering knowledge base available in the Taba Workstation through the use of a knowledge management tool called Acknowledge (Montoni et al. 2004a) provides valuable lessons learned and best practices to improve the efficiency and correctness of the processes to be defined.

Training

In this phase training in software engineering methods and techniques is provided to organization members. The training program is tailored to the characteristics and needs of the organization and its SPI initiative; for example, it may comprise the process areas of CMMI level 3 or MR-MPS level G processes (project management and requirements management). Often it includes training in the software processes defined, practices required by the CMM, and tools to be used. Some training activities are also carried out along with mentoring sessions during project execution.

Mentoring

Mentoring takes place during project execution and involves direct knowledge transfer to organizational members. COPPE/UFRJ software engineering consultants are present while the software developers carry out any process activity for the first time, explaining how to execute that activity and the benefits expected. This close contact between the organization's members and consultants accelerates the learning process, increases the awareness of SPI benefits, and minimizes resistance to changes. The knowledge items of the software engineering knowledge base help the consultant support the activities of the organizational member during the mentoring phase. Nevertheless, the knowledge is always available to any user of the Taba Workstation.

SPI Implementation Follow-up

Follow up occurs on a regular basis, for instance, once a week, and involves discussion with the members of the organization responsible for the SPI initiative details about process directives important to keep the processes on track. Moreover, during these meetings, SPI strategies are defined to be implemented in order to overcome inherent difficulties that may affect the success of the SPI initiative, such as resistance to change.

Knowledge Acquisition

This phase involves the acquisition of knowledge from consultants and organizational members regarding software process activities and the SPI initiative in order to allow organizational knowledge preservation and dissemination. After collecting the knowledge, it is filtered, packaged, stored, and made available to guide process executions and SPI plan reviews. The support to knowledge management in the Taba Workstation is provided by the Acknowledge CASE tool (Montoni et al. 2004b), which is integrated with the other CASE tools in the environment.

Acquisition and Assessment of Process Improvement Recommendations

The acquisition of processes improvement recommendations occurs in parallel with project execution. Process improvement ideas appear while developers get a better grasp on the process. These improvement suggestions are collected and assessed by the organizational process group and, if approved, they are incorporated into the standard software processes and can influence future reviews of the SPI plans. People affected by the changes are trained again and new projects can use the new processes.

Preparing the Organization for the Appraisal

High-level management defines the expected appraisal date and commits all necessary resources to achieve the SPI goals. To increase the success of the appraisal, two activities are executed during the appraisal preparation phase: 1) the fulfillment of the evidence worksheet that will be assessed by the appraisal team; and 2) training the project members for the appraisal interviews that will be carried out during the appraisal. Basically, the worksheet contains the practices that an organization has to implement to adhere to the selected level of the software process reference model, and under these good practices the organization must link artifacts that provide evidence of these practices implementation in the organization. During this phase the consultants also explain to the project members the different questions that will be asked during the interviews and how they will be conducted.

Processes Assessment

The assessment of the improved processes is important to increase the visibility of the impact and the benefits achieved with the SPI initiative. Therefore, one characteristic of the strategy is that an official appraisal constitutes the final milestone of the SPI initiative.

TABA WORKSTATION: SUPPORTING THE SPI-KM STRATEGY

The Taba Workstation is a PSEE that supports software process definition, deployment, and enactment. The use of this PSEE is a key factor in the SPI-KM strategy presented in the last section, mainly because it helps to increase the process capability of organizations through the suitable use of software engineering techniques in their software processes aiming to enhance software product quality. This PSEE was developed by the COPPE/UFRJ software process engineering research group in the context of an academic project, and it is granted to software development organizations at no cost. This research group also provides software development services to the Brazilian industry, and it was recently assessed in the MPS model maturity level E (partially defined). This assessment was important to attest the quality of the processes used to develop the Taba Workstation CASE tools, and also to provide adequate installation and maintenance services. For instance, updates of the suite are released monthly with little upgrade effort in the operational environments, so that software organizations can efficiently implement process improvements just by downloading the most recent updates of the suite. Mentoring activities on the improvements of Taba Worksation CASE tools are performed regularly to enable the quick dissemination of the improvements throughout the organizations.

The main objective of the Taba Workstation is to provide an infrastructure to overcome the difficulties of SPI implementation initiatives such as a lack of financial resources. Moreover, the knowledge required to execute the improved processes is captured within the Taba Workstation knowledge base and disseminated throughout a set of integrated process-based tools that provide an efficient and effective mechanism to execute complex tasks. Nevertheless, the Taba Workstation was adopted by Brazilian SMEs in the last years aiming to overcome financial, human, and infrastructure restrictions and to provide an efficient mechanism for implementing MPS model-based initiatives. Figure 4 provides a complete list of the Taba Workstation CASE tools. Appendix A describes in detail the support provided by the Taba Workstation in implementing MPS model-based initiatives in SMEs.

LESSONS LEARNED DURING THE DEPLOYMENT OF THE SPI-KM STRATEGY

The authors believe that lessons learned from previous experiences can facilitate software process deployment and increase the success of SPI initiatives. A study carried out by the COPPE/UFRJ (Santos et al. 2007) software process engineering research group identified common issues of process deployment, regardless of the organization or strategy used on the initiative. The authors consider these lessons important assets that act on feedback and refinement of the presented approach and thus are described in more detail next.

Lesson 1: SPI initiatives should effectively improve software processes

One important factor the authors have observed is the importance of SPI results monitoring activities to guarantee that the initiatives are effectively improving software processes. SPI initiatives can be monitored by defining performance indicators to ensure that process performance is on track. Moreover, process monitoring and feedback mechanisms must be established to support the use of feedback data to evaluate the payoff for doing improvements (Zaharan 1998; Krasner 2001). If SPI costs are viewed as an investment, then the payoff is expressed in a temporally

FIGURE 4 TABA workstation CASE tools

Tool	Description
Acknowledge	Supports knowledge acquisition, filtering, and packaging throughout software process execution (Montoni et al. 2004b).
ActionPlanManager	Supports action plan management both at the project and organizational level.
AdaptPro	Supports software process adaptation for specific projects based on organizational standard processes (Santos et al. 2005b).
AvalPro	Supports assessments of defined software processes.
Metrics Repository	Provides an infrastructure to support storage of measures, questions, and objectives previously defined aiming to be used in the elaboration of measurement and analysis planning activities.
Asset Library	Supports the definition of an Organizational Process Asset Library integrated to the configuration management supporting tool (GConf).
Config	Supports configuration of specific PSEE to a software organization (Montoni et al. 2005).
ControlManager	Supports planning and controlling of software projects.
GConf	Supports configuration management of products produced in the context of a software project.
MBR	Supports decision-making activities about making, buying, or reusing a specific component in the context of a software project.
MedPlan	Supports measurement and analysis planning both at the organizational and project level.
Metrics	Supports data collection based on a measurement and analysis plan defined with the support of the MedPlan tool.
OrgPlan	Supports software project organizational planning.
Pilot	Supports pilot project planning and control aiming to assess improvement opportunities of organizational process assets.
TimeSheet	Supports registering project members' activities status.
ProjectStatus	Supports registration and communication of current projects status.
QFuzzy	Supports identification of software products quality characteristics using fuzzy logic.
ReqManager	Supports requirement management and rastreability across software items.
RHManager	Supports professionals allocation planning, monitoring, and assessment of professionals' competencies (knowledge, abilities, and experience).
RiscManager	Supports software project risk planning and monitoring based on reuse of organizational knowledge related to risk management (Farias, Travassos, and Rocha 2003).
Sapiens	Supports preservation and maintenance of organizational structures comprehending information about organization members and their competencies (Montoni et al. 2004a).
TechSolution	Supports the selection of alternative solutions related to software project technical issues (Figueiredo et al. 2006).
TempManager and CustManager	Supports software projects time and costs planning and controlling based on reuse of organizational knowledge about past projects and parametric models such as COCOMO II and Function Point Analysis.
ValidationManager	Supports software validation throughout software process execution.
VerificationManager	Supports software verification throughout software process execution.

shifted, return-on-investment (ROI) model (Krasner 2001). Management indicators within ROI models of SPI include, for instance, measures of product quality, process quality, project predictability, and customer satisfaction. Nonetheless, some of the biggest payoffs of SPI are expressed in human terms, not monetary units. They might involve better job satisfaction; pride in work; an increased ability to attract, retain, and grow experts who will innovate; company reputation for excellence; and so on (Krasner 2001).

Lesson 2: One will not succeed without a leader

According to the authors' experience in several organizations, a leading group responsible for promoting SPI awareness and supporting knowledge sharing among different practitioners is crucial to the success of SPI initiatives. This group is sometimes a full-time resource with responsibility to manage the deployment and coordination of SPI activities (Zaharan 1998) and to obtain and sustain high-level commitment with different management levels and project members during all SPI deployments.

Lesson 3: Commitment is crucial

One factor that was perceived to have influenced the success of the authors' SPI experiences is related to organizational commitment (from lower level to the higher one); it is very difficult to obtain member commitment to SPI in some organizations. People involved with the SPI initiative must perceive the benefits deriving from its deployment and not only its costs. Another difficulty was to maintain the organization commitment during all SPI cycles. To cope with this problem, SPI quantitative data related to time, cost, quality, and customer satisfaction were continuously communicated to high-level managers, so managers could perceive the benefits deriving from the SPI deployment and not only the costs.

Lesson 4: No brain, no gain

Once this difficulty is found in an organization, most of the methods and techniques used to support software development and management must be taught, increasing the cost, difficulty, and time to achieve the SPI goals. Therefore, a capacity program for enhancing members' knowledge eases the employment of new practices at both project and organizational levels. This type of training catalyzes knowledge transfer and is considered to be one of the pillars for creating a learning software organization. The most relevant deficiency the authors have detected in many organizations is the lack of knowledge in software engineering and project management. Mentoring activities performed by specialists are part of the authors' SPI strategy as consultants and are carried out during the whole SPI cycle, sometimes on a daily basis. Mentoring activities, besides teaching engineering methods and techniques, how to use CASE tools, and how to execute the software process also help consultants enforce the benefits of the SPI program and the necessity of being committed to the improvement goals.

Lesson 5: SPI is facilitated by software process infrastructure

Most organizations with low maturity software processes do not have suitable infrastructure for SPI deployment. To provide an adequate software process infrastructure to software organizations, the authors' SPI strategy is supported by the Taba Workstation that supports individual and group activities and project management activities (Ferreira et al. 2006; Montoni et al. 2006).

Besides those lessons, the authors also identified another one from their experience coordinating SPI initiatives in a different group of software organizations. This lesson is described next.

Lesson 6: The decentralization of SPI implementation knowledge is fundamental to sustain SPI initiatives

The implementation of SPI is a long-term endeavor. Thus, people turnover can also affect the team responsible for conducting SPI initiatives. To reduce this and other risks to SPI initiatives within an organization, it is fundamental to decentralize SPI implementation knowledge. By achieving such a goal, more people will be able to spread the word of SPI and to increase the organization's member support and commitment to the software processes.

Although these lessons do not represent novelty in the SPI area, they reinforce the findings of studies conducted to investigate the critical factors that affect the success of SPI initiatives, such as the studies of Baddoo and Hall (2002) and Niazi, Wilson, and Zowghi (2005b), and as a consequence provide more evidence of the need for better SPI implementation approaches that help to cope with the inherent difficulties of conducting SPI initiatives.

Implementing Software Process Improvement Initiatives in Small- and Medium-Sized Brazilian Organizations

From 2006 to 2007, a group of five organizations implemented the MPS model supported by the Taba Workstation. This group was coordinated by an accredited organization that provides services for organizing groups of enterprises to execute MPS model-based deployment, and the group activities are executed in conformance to the MPS cooperative business model for groups of SMEs interested in implementing the MPS model and sharing SPI services and costs. The group was divided into two subgroups: a group of three SMEs implementing the MPS model level G (partially managed) and a group of two SMEs implementing the MPS model level F (managed).

The Taba Workstation has supported the deployment of the MPS model in more than 20 projects in this group of SMEs. Informal process assessments were conducted to reduce assessment risks and to guarantee that the projects executing the processes are providing adequate evidences based on the MPS reference model and the MPS assessment method. Formal MPS-based assessments were successfully conducted on all five SMEs between June 2007 and October 2007.

In all five organizations, the deployment approach applied was very similar to using the SPI-KM approach and Taba Workstation CASE tools, but respected the characteristics, experiences, and maturity of each organization. In Appendix B, the authors briefly describe the main business goal of each of the SMEs and their perceived benefits of implementing the MPS model. Figure 5 presents the MPS model level intended by each organization and their process deployment results.

LESSONS LEARNED

During the improvement program in these five organizations, the authors used the lessons presented earlier that were learned from applying the SPI-KM approach to reduce the inherent risks of SPI initiatives conducted under the authors' coordination. The authors were also able to collect another set of lessons learned by applying the SPI-KM approach to implement the MPS model in the group of SMEs presented in the last section. These two sets of lessons are not concurrent, but complementary.

Next, the authors present some lessons that may be useful in the definition of strategic SPI action plans:

- The internalization of the advantages and benefits of the improvement program is favored by the constant presence of consultants in the organization as long as the consultants perform their activities aimed not just at evaluation success but also the at effective improvement of the processes.
- Organizations that never followed a process have difficulty defining one without help. Therefore, the definition of an initial process by the consultancy is important. During its use in software projects, the organization acquires the necessary knowledge to evolve this process by adapting it to specific organizational characteristics. Moreover, the commitment to the SPI program and to the process adherence is increased.
- The first project using the defined process usually presents some difficulties. The project team members need time to adapt their practices to the new process activities and tools. In some cases, this project is performed as a pilot for the process deployment and is not included in the set of projects to be formally assessed by an MPS-based assessment.
- A key point is the formal commitment during the project. Therefore, sometimes there is internal and external resistance related to obtaining the commitment for project work products. Some stakeholders, mainly customers, may not be interested in establishing a formal commitment.
- An adequate software process infrastructure facilitates training, deployment, and institutionalization of software process, since it decreases the process deployment time. If the organization has already been using support tools to software process activities, the process changes are introduced with less resistance. Moreover, the use of the Taba Workstation was very important for learning new concepts and practices related to process deployment. These concepts and practices also help the organization define new requirements for other supporting tools.
- The strategy based on a gradual deployment of software processes adherent to the MPS model is feasible, since the software organization observes the benefits of disciplining the development based on processes.
- Small organizations intending to establish MPS model maturity level G usually have limited financial resources that hinder SPI implementation. The faster the institutionalization of the processes, the smaller the risks related to the SPI program.
- If the organization process group has a background related to software engineering, a smaller consultancy effort is needed for program deployment, thus, reducing SPI implementation costs.
- During SPI deployment, the organization has better control of management and development activities (that begins with MR-MPS maturity level G). Thus, they can negotiate changes of project scope with costumers after requirements changes by demonstrating the quantitative impact of these changes for project performance.

CONCLUSIONS

This article discussed the application of the SPI-KM approach to support the MPS model deployment in a group

FIGURE 5 Organizations' characteristics and status of SPI milestones achievement

	Org. no. 1	Org. no. 2	Org. no. 3	Org. no. 4	Org. no. 5
MR-MPS Level	F	G	G	F	G
Project's beginning	Jul/06	Jul/06	Jul/06	Jan/07	Jul/06
Process definition and Taba Workstation configuration	Aug-Sep/06	Aug-Nov/06	Jul/06	Jan/07	Jul/06
Training of the theory	Sep/06	-	Jul/06	-	Aug/06
Deployment beginning	Sep/06	Nov/06	Aug/06	Jan/07	Aug/06
100% of the deployment	May/07	May/07	Dec/06	Jul/07	May/07
Initial assessment (MA-MPS)	Aug/07	Jun/07	Apr/07	Aug/07	Sep/07
Final assessment (MA-MPS)	Oct/07	Jun/07	May/07	Oct/07	Sep/07

of SMEs in Brazil. The main organizational characteristics were presented as well as their quality objectives, characterization, and deployment results. The authors also presented lessons learned from SPI initiatives that implemented MPS model levels G and F between 2006 and 2007. All of these organizations performed the MPS model's official appraisals and the results were excellent, which supports the viability and soundness of the approach.

The success of the SMEs that adopted the Taba Workstation demonstrates its feasibility to manage factors that have influence on SPI initiatives, for instance, lack of supporting tools and lack of software engineering knowledge of organization members. Therefore, the SPI-KM approach with knowledge management support provided by the Taba Workstation CASE tools is a good alternative solution to facilitate SPI implementation initiatives when compared to other approaches such as the CMMI and the IDEAL models that only explain "what" to do and not "how" to implement SPI.

Another important characteristic of this approach is that the deployment of the Taba Workstation using the MPS cooperative business model helped to reduce more than 60 percent of SPI costs by suppressing the necessity of buying expensive supporting tools and by obtaining external financial resources from organizations like the IDB. After the formal assessments, some of these organizations committed to start another SPI cycle aiming to improve their processes maturity to higher levels. Moreover, the authors are also applying the SPI-KM approach to support MPS model-based implementation initiatives in another group of five SMEs. The formal MPS model-based assessments of the organizations integrating this new group should occur by the end of 2008.

Nevertheless, the lessons learned are important assets that act on COPPE/UFRJ's adopted strategy feedback and refinement. Moreover, the authors expect that these assets can be useful to other organizations undertaking SPI initiatives in order to enhance the expected results.

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