Taba Workstation: Supporting Software Process Improvement Initiatives Based on Software Standards and Maturity Models

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Abstract. International software standards and maturity models play an important role in Software Process Improvement initiatives defining best practices and providing knowledge to the definition of software processes. Nevertheless, the definition and deployment of software processes based on that standards and models is an expensive and knowledge intensive task. This paper describes an approach to the definition and deployment of software processes in small and medium size Brazilian companies supported by a Process-centered Software Engineering Environment named Taba Workstation. It also presents results related to a software process improvement initiative undertaken in a Brazilian organization that demonstrates the feasibility of the presented approach.

1 Introduction

Recent research efforts about quality in the software area demonstrate that a concentrated effort is imperative to improve software processes in software development companies [1]. The ability to objectively improve the organization's processes and products within time and cost constraints in addition to the improvement deployment itself is the differential that must be present in software organizations. Moreover, focus on customer's needs is very important to guarantee the success of improvement projects since the success of an organization is totally related to customer's satisfaction. The increase of productivity and quality are tangible benefits that can be quantified and equated to a common measure, usually dollars. On the other hand, intangible benefits such as better quality of work life, better organizational learning and communications are difficult to quantify and convert to a common measure. Nevertheless, it is believed that intangible benefits in some cases can represent the biggest payoff to an organization that invests on process improvement [15]. Hyde and Wilson [16]

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highlight the intangible benefits in software process improvement and suggest that the realization of intangible benefits is important and should be factored into decisions to undertake software improvement initiatives.

Mainly in Brazil, there is an urge to enhance software processes performance aiming to improve the software products quality and to increase Brazilian companies' competitiveness both in national and international markets. Since 1993, with the foundation of PBQP Software (Subcommittee of Software of the Brazilian Program for Software Quality and Productivity), Brazil invests on Software Quality improvement [2].

One important characteristic of a software process deployment initiative is the selection of an appropriate reference model to be used during the definition of the software processes and appraisal of the organization. International standards like ISO/IEC 12207 [3] and ISO/IEC 15504 [4], and software process quality models like CMMI (Capability Maturity Model Integration) [5] were developed aiming to define the requirements of an ideal organization, i.e., a reference model to be used in order to assess the maturity of the organization and its capability to develop software.

Based on these standards and models, Brazilian industry and research institutions have worked together during the last two years to define the Reference Model for Brazilian Software Process Improvement (MR-MPS.BR) [6, 7, 8]. Seven maturity levels were established in the MR-MPS.BR: Level G (Partially Managed), Level F (Managed), Level E (Partially Defined), Level D (Largely Defined), Level C (Defined), Level B (Quantitatively Managed) and Level A (Optimization). For each of these maturity levels, processes were assigned based on the ISO/IEC 12207 international standard and on the process areas of levels 2, 3, 4 and 5 of CMMI staged representation. The difference of MR-MPS levels graduation compared to CMMI staged representation aims to enable a more gradual and adequate software process deployment in small and medium size Brazilian companies. This model has been deployed in many companies in Brazil and official appraisals were already conducted.

This paper describes an approach to the definition and deployment of software processes in small and medium size Brazilian companies started in 2003. The use of Taba Workstation, a Process-centered Software Engineering Environment (PSEE) that supports software processes definition, deployment and enactment, is a key factor of this approach whose goal is to increase the capability of organizations through the adequate use of Software Engineering techniques in their software processes aiming to enhance the software products quality and, thus, increase organizational competitiveness. In order to evidence the benefits of this approach we describe its use in a Brazilian organization, named BL Informática. As results from its quality program, the company has obtained during this period the ISO 9001:2000 [9] certification, and has been evaluated on MPS.BR Level F. BL Informática will be evaluated on CMMI Level 3 process areas by an official SCAMPI appraisal scheduled to July 2006.

The next section describes the Taba Workstation. Section 3 presents how software processes deployment is carried out with the Taba Workstation use. In section 4, describes the software process improvement initiative at BL Informática. Section 5 presents the quantitative results of this initiative. Finally, section 6 presents some lessons learned, and point out future directions and conclusions.

2 Taba Workstation

Taba Workstation [17] is a Process-centered Software Engineering Environment (PSEE) composed of several integrated CASE tools to support software processes definition, deployment and enactment. Knowledge Management tools are also integrated into the environment to facilitate the organizational knowledge preservation and support activities execution. The Taba Workstation has been developed since 1990 in the context of an academic project and it is not commercialized. Nevertheless, it is granted to small and medium size Brazilian organizations with no costs. During the last years, the Taba Workstation evolved to comply with CMMI levels 2 and 3 processes areas and MPS.BR levels G, F, E, D and C processes.

2.1 Software Processes Definition Based on Software Standards and Maturity Models in the Taba Workstation

The Software Processes definition approach adopted in the Taba Workstation establishes phases and intermediary products using the ISO/IEC 12207 as a basis for the definition of standard software processes. Figure 1 depicts this approach.

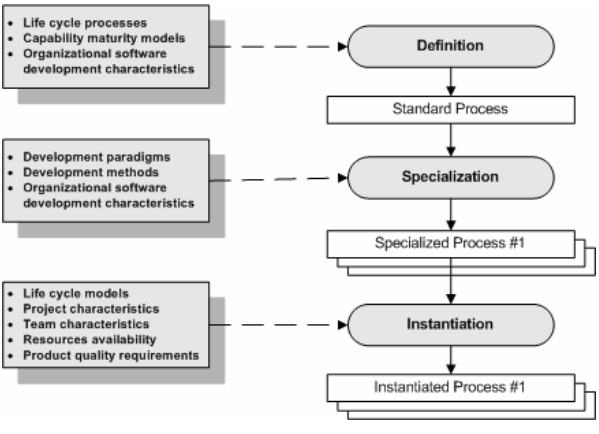

Fig. 1. Software processes definition approach in the Taba Workstation

The standard processes and the specialized processes are considered to be organizational level processes. The instantiated processes are project level processes. This approach guarantees the implementation of some practices of CMMI Level 3 process areas and MPS.BR Level E, for instance, the establishment of defined processes for each process area and tailoring criteria of these processes to each project.

During the Standard Process definition phase it is also considered the organizational software development characteristics related to the work environment, knowledge and experiences of the teams involved and the organizational software development experience and culture. From the Standard Process, different software processes can be specialized according to different kinds of software produced by the organization, (e.g., specialists and information systems) and to development paradigms adopted (e.g., object

oriented or structured). At this point practices required by the maturity models are included in the organizational set of standard processes. The definition of the organizational standard process for a specific organization is done during the configuration of a specific PSEE for the organization. The configured environment for the organization contains not only the standard process and the specialized processes, but also specific knowledge related to software development and maintenance. By using this environment, software engineers are able to generate instantiated environments to each of the projects to be developed.

In order to be used in a specific project, the most adequate specialized process must be instantiated to satisfy the characteristics of the project (e.g., size and complexity of the product and relevant quality characteristics), development team characteristics etc. At this time, the life cycle model, methods and tools are selected. Once the software process for a specific project has been defined and a PSEE has been instantiated, the basic means for software process deployment and enactment are established. At this point, software engineers have access to several CASE tools designed to support the activities in the instantiated software process of the project.

2.2 Taba Workstation CASE Tools

The CASE tools integrated in the environments offer automated support to: (i) definition of the organizational set of standard processes; (ii) execution of pilot project aiming process improvement; (iii) tailoring of the organization standard processes for a specific project; (iv) definition of the organizational structure [12]; (v) acquisition, filtering, packaging and dissemination of organizational knowledge [13]; (vi) planning the organization of specific projects; (vii) time, costs, risks, human resources planning, monitoring and control [12, 14]; (viii) planning and execution of Configuration Management activities; (ix) identification of software product quality requirements; (x) documentation planning; (xi) supporting the planning and monitoring of corrective actions; (xii) supporting measurement and analysis activities based on the GQM method; (xiii) project monitoring through the generation of periodic reports and measures; (xiv) controlling of the activities executed during a specific project; (xv) requirements management; (xvi) supporting software technical solutions through the use of design rationale; (xv) supporting software verification and validation planning and execution; and (xvi) post mortem analysis.

3 Software Processes Deployment with the Taba Workstation

Since 2003 the Taba Workstation is been used by the Brazilian software industry. The first organizations that used it were part of the Qualisoft Project [10], an initiative of RioSoft (a non-governmental organization that integrates the Softex Program - Society for the Support of Brazilian Software Production and Exportation) and the Federal University of Rio de Janeiro. This ongoing project aims to form a pool of small and medium size organizations with similar characteristics in order to decrease the overall cost of processes deployment and increase the feasibility of their quality

program. Since then, others organizations have used the Taba Workstation independently with good results.

Although the way software processes were deployed has evolved in order to cope with characteristics and goals of each organization or pool of organizations, the following basic activities are always conducted:

(i) Understanding of the individual characteristics and main goals of the organizations;
(ii) Definition of software development and maintenance processes adequate to the organizational culture;
(iii) Training in Software Engineering methods and techniques and in the software processes defined;
(iv) Use of Taba Workstation [11] environments and CASE tools; and
(v) Follow-up of the companies to support the deployment of the software processes through the execution of pilot projects.

In order to understand the individual characteristics and main goals of the organizations, interviews to high managers are carried out by the process specialists. Alternatively, the high manager or the person responsible for the software quality initiative in the organization is asked to fill out a form with questions related to the organizational culture, software process stages and quality management systems adopted, common software development practices, main problems in the current software development and maintenance processes, and organizational objectives related to software process improvement. The following steps comprise the definition of software development and maintenance standard processes adequate to the organization or the pool organizations and configuration of a specific PSEE to each organization, as explained in section 2.1. In parallel to the processes definition activity, training in Software Engineering methods and techniques are provided to the members of the organizations. This training comprises lectures on topics such as Software Engineering, Software Process, Knowledge Management, Software Products Quality, Project Management, Supplier Agreement, Risk Management, Configuration Management, Measurement and Analysis, Requirements Engineering, Peer-review, Tests, Technical Solution, Product Integration, Decision Analysis and Resolution. The training program is adapted according to the organizations processes objectives, for example, cover the process areas of CMMI Level 3 or MPS.BR Level G processes (Project Management and Requirements Management). After the software engineering theoretical training, project managers and software developers are trained in the standard software processes defined.

3.1 The Qualisoft Project Phases

The first phase of the Qualisoft Project started on August 2003 and addressed a pool of 10 organizations. The second phase started on January 2004 addressing a second pool of 9 organizations. The third phase started on January 2005 and addressed more 5 organizations. The next phase is about to start and will address at least 5 more organizations.

The processes defined to the first phase were based only on the international standard ISO/IEC 12207. For the second phase these processes were refined and adjusted to comply with the practices defined in CMMI Level 2 process areas and the processes of

its equivalent MPS.BR Level F. For the third phase, two companies decided to have their processes adherent to the CMMI Level 3 processes areas and MPS.BR Level C processes. All the processes maintained compliance with the ISO/IEC 12207. The following steps focused on the deployment of the processes and the configuration of a PSEE to support the processes in the organizations. These steps were carried out individually considering the particularities of each organization. Initially, the standard processes were adapted to each company characteristics, such as types of software developed, documents produced and software development paradigms adopted. A PSEE was configured to each organization after the approval of the adaptations.

The next section presents the software processes improvement initiative at BL Informática which participates of the Qualisoft Project since its beginning.

4 Software Processes Improvement at BL Informática

BL Informática is a Brazilian organization founded in 1987 concerned with software development, maintenance, deployment and integration. The major objective in its quality policies is to focus on customers, team members and stockholders satisfaction through implementation of solutions in information technology developed with defined, controlled and continuously improved.

In order to demonstrate the feasibility of the approach presented, we discuss in this section the three phases of the software process improvement initiative at BL Informática started in 2003 aiming to improve its products development quality. The next section describes the quantitative results of this initiative.

4.1 First Phase: ISO 9001 Certification

BL Informática's quality program started in 2003 when the company decided to be ISO 9001:2000 certified until 2004. The definition of development and maintenance processes consistent with this standard was the first step to accomplish this goal. COPPE/UFRJ consulting was requested to support this activity since the company had no experience in software process definition. When the QualiSoft Project was created, BL Informática formalized the participation in its first phase.

To decrease the impact during the initial stages of its process deployment the company decided not to use the Taba Workstation. At first, the development process was executed without any management tool support during all the analysis phase of the pilot project. But difficulties to manage the project pointed out that a CASE tool was necessary to support the process utilization and, moreover, to support the planning, control and execution of the project. Due to this, Taba Workstation utilization was reconsidered and from this moment on the environment configured to the organization started to be used. In the beginning the environment was used only to control the flow of the software process activities. Eventually all Taba Workstation CASE tools started to be used to support each step of the process enactment. In parallel the process's adaptation to the organization culture proceeded maintaining its original characteristics.

Despite the pilot project had not satisfied the schedule its execution has been considered successful. The clients have followed the project closer and were aware of all artifacts produced and non-compliances detected and performed evaluations expected at the end of each activity.

After one year the process was considered stabilized. The deployment required more time and resources than estimated but produced better results than expected. The success factors as pointed out by team members were: (i) high level management support; (ii) trainings investments; (iii) the existence of a process group engaged with the results and confidence in future benefits; (iv) the use of Taba Workstation CASE tools and the internal CASE tools SGP (from the acronym in Portuguese for Process Management System) and SGD (from the acronym in Portuguese for Document Management System).

The main benefits achieved during this phase were: (i) decrease of rework; (ii) production of artifacts with better quality; (iii) better Software Engineering understanding due to team members' qualification; (iv) dissemination of "process culture" by the organization; (v) maintenance of the knowledge on software engineering inside the organization making the project team more independent. The main difficulties of this initial phase were related to cultural changes needed by project teams and clients in order to follow the processes.

4.2 Second Phase: MPS.BR Level F

Due to the great results accomplished, BL Informática decided to evolve its process improvement initiative during 2004. The organizational intended to have its processes evaluated as MPS.BR Level F compliant. A new version of software processes was defined and deployed according to Qualisoft Project's second phase schedule.

The main factors that have made this phase also a success were: (i) the constancy of internal and external ISO 9001:2000 auditing; (ii) the commitment of project teams; (iii) the knowledge about Project Management; (iv) high level management support; (v) the use of Taba Workstation CASE tools and the internal CASE tools and SFT (from the acronym in Portuguese for Workflow System).

The bigger accomplishment of this phase was the success of the Level F MPS-BR evaluation which became an important motivation factor to the company continues its quality program. The project teams' confidence regarding the organization maturity, the high management feeling of return of investment and the team motivation were crucial for the quality program consolidation in the organization.

This phase required more resources than planed but the benefits achieved were considered very important for the beginning of the next process improvement phase: the CMMI Level 3 evaluation.

4.3 Third Phase: CMMI Level 3

This phase had more impact in the organization than the previous ones. The structure of the quality team had to be changed and expanded in order to address the CMMI Level 3 process areas requirements. The deployment of a MPS-BR Level F based process requires more involvement of project managers; most team members perceive

the results without significantly changing the way they execute theirs activities. As CMMI Level 3 focuses mainly in engineering activities most developers' activities are also affected. Besides, as the process group only had strong experience in project management techniques it was necessary more support to the definition and deployment of the new processes. The investments on training, consulting activities and action plans to risks mitigation were the largest compared to the other phases.

The most important success factors of this phase until the moment are: (i) high level management support and endorsement of critical risk mitigation actions (for example, new resources hiring, training and investment on tools so project schedules can be satisfied and clients satisfaction is not affected even if a new process version is used by the first time); (ii) external consulting support and knowledge transfer; (iii) improvement of communication mechanisms and systems to ease the information exchange, appraisals of improvement proposals, lessons learned dissemination and distribution of tasks; (iv) investment in external and internal trainings.

Among the main benefits of this ongoing phase we can highlight: (i) improvement of the knowledge the company has about its capacity and productivity (for example, know in how much time a requirement will be implemented); (ii) increase of lessons learned regarding the technologies used and requirements development; (iii) decrease of time spent on activities regarding testing and codification.

The most important lesson learned of this phase was the importance of the early understanding of how new activities of the software process (like CMMI Level 3 practices related to engineering areas) affect each team member. The earlier the changes are understood, the easier the process deployment.

5 Quantitative Analysis of Software Process Improvement Initiative at BL Informática

Even before the beginning of its software process improvement initiative BL Informática gathers quantitative data related to the execution of its software projects. Analyzing this data we could observe that the distribution of time spent on software development activities has significantly changed. In this section we present and discuss (i) the increase of the time expended during management activities, and (ii) the relation between the adoption of specific software quality activities and time expended on rework[1] along the project.

5.1 Project Management Activities Improvement

Table 1 and Figure 2 show the mean time spent during software projects at different phases of processes enactment in the organization. "Construction and Tests" category comprises activities like planning and execution of tests (e.g., unit tests or functional tests) and peer reviews and codification activities. "Analysis and Design" category comprises activities like requirements elicitation, use cases elaboration, architectural design, database design etc. "Management" category comprises all activities related to

[1] A rework activity is defined as any activity that comprises change or adjustment of artifacts produced on early project phases, e.g., changes to ill defined requirements during codification.

project planning and monitoring. "Others" comprises uncategorized activities (for example, general purpose meetings).

Table 1. Evolution of time expended in software development activities

	Construction and Tests	Analysis and Design	Management	Others
Before Process Adoption	19,1%	66,0%	11,5%	3,4%
1st Phase – ISO 9001 Process	34,9%	39,7%	14,9%	10,5%
2nd Phase – MPS.BR Level F	34,8%	50,5%	7,9%	6,8%
3rd Phase – CMMI Level 3	27,3%	51,8%	17,8%	3,1%

Before the process adoption the activities of project teams were not clearly defined so project managers sometimes had to perform analysis and construction tasks deviating themselves from the execution of management tasks. Besides that, a large amount of time was spent in rework during the construction and test of the software.

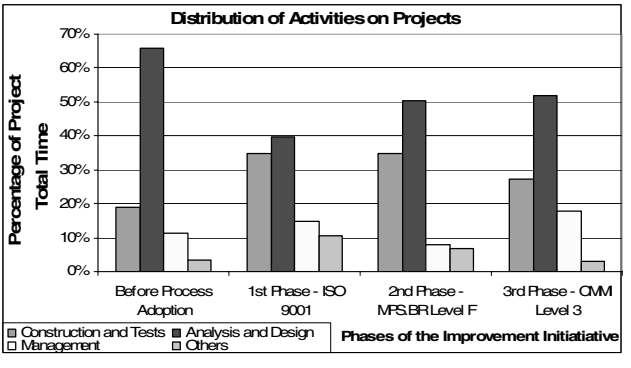

Fig. 2. Time division by the project activities

Due to the definition of project management activities in the first version of the process, manager had more time to plan and control its projects. Time spent by managers decreased due to the use of appropriate case tools after the deployment of the second version of the process. The effort to execute Analysis and Design activities increased and quality evaluations of the artifacts produced were executed continuously and not only during the construction phase. The evaluation of each artifact was done using a generic checklist which evolved in order to reflect the organization characteristics and its products. The third version of the process caused the increase of the time elapsed with the management activities because the manager were, for the first time, no longer responsible for analysis and design activities, only for project management activities.

5.2 Relation Between Software Quality and Rework

Table 2 and Figure 3 show the relation between quality related activities effort expended and rework during software projects.

Table 2. Relation between time expended in rework and software quality related activities

	Rework	Quality Activities
Before Process Adoption	44,0%	0,0%
1st Phase – ISO 9001 Process	26,7%	9,2%
2nd Phase – MPS.BR Level F	11,2%	3,0%
3rd Phase – CMMI Level 3	7,3%	10,8%

Quality activities were not conducted before the adoption of the first version of the process. Due to that 44% of total time of the projects was spent in rework activities. The adoption of quality assurance activities in the first version of the process caused the decrease of time expended in rework activities.

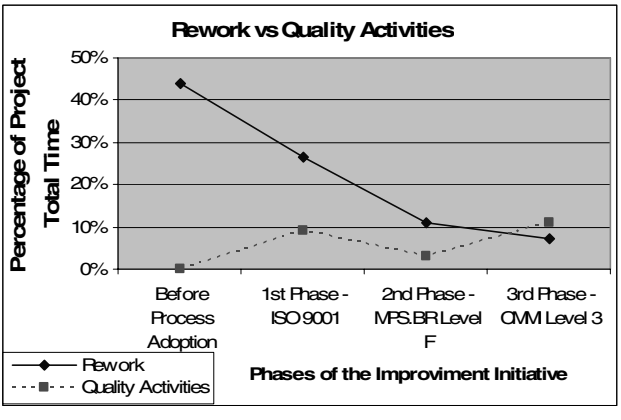

Fig. 3. Software Quality Activities and Rework Relation

Along the Qualisoft Project's second phase, time expended in rework has been continuously reduced due to more rigorous artifacts evaluation. Finding errors in early phases of the project caused the decrease of the number of evaluations of a specific artifact and thus the reduction of the time expend in evaluations. The time spent on quality activities increased after the adoption of the third version of the process due to the larger number of artifacts being evaluated and to the necessity of involvement of new roles in these evaluation activities. Besides, the checklists used to evaluate the new artifacts of the process were evolving in the organization, forcing more and longer evaluations.

6 Conclusions

This paper described an approach to the definition and deployment of software processes in small and medium size Brazilian companies with the support of Taba Workstation, a Process-centered Software Engineering Environment. By applying this approach to define and deploy software processes based on ISO/IEC 12207, CMMI and

MPS.BR, organizations can significantly increase both competitiveness and software products and services quality. The Taba Workstation is been used by the Brazilian software industry since 2003, and was identified during three official SCAMPI appraisals as one of the greatest organizational strengths to facilitate the success of software process deployment initiatives and to overcome the inherent difficulties. Moreover, it was also identified as an important organizational asset to guarantee the quality of software process and product quality in other three official MPS.BR appraisals.

The quantitative results of applying the presented approach in BL Informática are significant: it has obtained ISO 9001:2000 certification, has been evaluated MPS.BR Level F and is currently engaged in the CMMI Level 3 appraisal process. Furthermore, the processes and product's quality have improved and costs and conflicts decreased. As a direct effect of these achievements we can point out high management strong support to all software process improvement activities, great collaborators` satisfaction and significant decrease of people turnover.

Nevertheless, the Taba Workstation is continuously evolving. The next steps comprises the evaluation of the adequacy of its CASE tools that support CMMI Level 3 process areas, and definition and integration of other tools to support CMMI Level 4 and 5 process areas which will support organizations to achieve even higher levels of software development maturity.

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