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

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Abstract. Software international 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 (PSEE) named Taba Workstation. It also presents some 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 process in software development companies [1]. Currently, the differential that must be present in software organizations, in addition to the improvement deployment itself, is the ability to objectively improve the organization's processes and products within time and cost constraints. Besides that, it is fundamental to address customer's needs in order to guarantee the success of improvement projects, because the success of an organization is directly proportional 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 [16]. Hyde and Wilson [17] 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, 3].

One important characteristic of a software process deployment initiative is the selection of an appropriate reference model to base the definition of the software processes and evaluation of the organization. International standards like ISO/IEC 12207 [4] and ISO 15504 [5], and software process quality models like CMMI (Capability Maturity Model Integration) [6] 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 aiming to define the Reference Model for Brazilian Software Process Improvement (MR-MPS.BR) [7, 8, 9]. Seven maturity levels were established in the MR-MPS.BR: 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 standard and on the process areas of levels 2, 3, 4 and 5 of CMMI staged representation. This division has a different graduation of the CMMI staged representation aiming to enable a more gradual and adequate 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 in the context of the QualiSoft Project [11], started in 2003. The goal of this project is to increase the organizations capability 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 an experience of use of the presented approach in a Brazilian organization, named BL Informática, aiming to improve the quality of its products. As results of the quality program, the company has obtained during this period the ISO 9001:2000 certification [10], and has been evaluated on the MPS.BR Level F [7]. This organization is now preparing to have their software processes evaluated against the CMMI Level 3 process areas [6]. The readiness is scheduled to occur in May 2006, and the official SCAMPI appraisal is scheduled to occur in July 2006.

The next section presents the QualiSoft Project goals and characteristics. Section 3 describes the Taba Workstation, a Process-centered Software Engineering Environment (PSEE) that supports software processes definition, deployment and enactment. In section 4, the software process deployment at BL Informática is described. Section

5 describes the quantitative results of the software process deployment at BL Informática supported by the presented approach. Finally, section 6 presents some lessons learned, and point out future directions and conclusions.

2 Qualisoft Project

The Qualisoft Project [11] is a result of a contract between the 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. Since the focus is on small and medium organizations, the project was executed with a pool of organizations with similar characteristics aiming to decrease the overall cost and increase the project feasibility. The first phase of the project started on August 2003 and addressed a pool of 10 organizations. The second phase, started on January 2004, addressed 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.

Although the project is continually evolving in order to cope with companies' characteristics and goals, the following basic activities are always conducted:

(i) Understand the individual characteristics and main goals of the organizations in the pool;
(ii) Definition of software development and maintenance processes adjusted for small and medium companies;
(iii) Training in Software Engineering methods and techniques and in the software processes defined;
(iv) Use of CASE tools integrated in a Process-centered Software Engineering Environment (PSEE) named Taba Workstation [12] and supported by Knowledge Management during the deployment and use of the software processes defined; 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 containing questions related to the organizational culture, software process stages and quality management systems adopted, software development practices, main problems in the current software development and maintenance processes, and organizational objectives related to software process improvement.

The following step is to define software development and maintenance standard processes adequate to the pool of small and medium organizations. The processes defined on the first project phase were based exclusively in the international standard ISO/IEC 12207 [4]. For the second phase, these processes were refined and adjusted to be adherent to the practices defined in the CMMI Level 2 [6] process areas and the processes of its equivalent MPS.BR Level F [7].

For the third phase, two of former companies decided to have their processes adherent to the CMMI Level 3 processes areas and MPS.BR Level C processes. All the processes defined maintained compliance to the ISO/IEC 12207.

In parallel to the processes definition activity, training in Software Engineering methods and techniques was provided to the members of the organizations. During the first phase, this training was performed as lectures on the following topics: Software Engineering, Software Process, Requirements Engineering, Configuration Management, Project Management and Software Products Quality. The training during the second phase also considered other important topics, such as Peer-review, Tests, Measurement and Analysis, Supplier Agreement and Knowledge Management. In the third phase the training covered the process areas of CMMI Level 3 and MPS.BR Level G processes (Project Management and Requirements Management), according to the organizations processes objectives. After the theoretical training, project managers and software developers had specific training on the standard software processes defined.

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 considering the characteristics identified in the beginning of the project, such as types of software developed, documents produced and software development paradigms adopted. After the approval of the adaptations by the organization, a PSEE was configured based on these adaptations.

3 The Taba Workstation

The Taba Workstation has been developed in the context of an academic project and it is not commercialized. Nevertheless, it is granted to small and medium size organizations of Brazil with no costs. During the last years, the Taba Workstation evolved to comply with the software organizations capability maturity models different levels. It is constituted of integrated tools to support software processes definition, deployment and enactment. These tools are adherent to the practices of the CMMI Levels 2 and 3 process areas. The functionalities of other tools to support Knowledge Management activities are integrated into the environment to facilitate the organizational knowledge preservation and support activities execution.

3.1 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 [4] as a basis for the definition of standard software processes. Figure 1 depicts this approach.

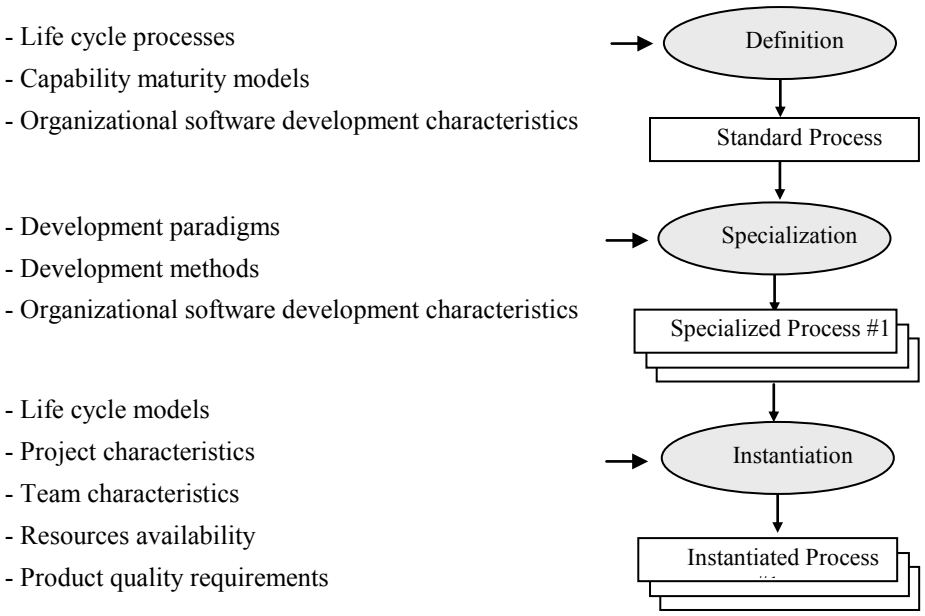

Fig. 1. Software processes definition approach in the Taba Workstation

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

During the Standard Process definition phase we also consider 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, (i.e., specialists and information systems) and to development paradigms adopted (i.e., object oriented or structured). At this point practices expected by the maturity models are included in the organizational set of standard processes.

The definition of 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, the software engineers are enabled 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 (i.e., size and complexity of the product and relevant quality characteristics), development team characteristics, etc. In this phase, the life cycle model, methods and tools are selected. Once the software process for a specific project has been defined and a Software Engineering Environment 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 present in the instantiated software process of the project.

3.2 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) adaptation of the organization standard processes for a specific project; (iv) definition of the organizational structure [13]; (v) acquisition, filtering, packaging and dissemination of organizational knowledge [14]; (vi) planning the organization of specific projects; (vii) time, costs, risks, human resources planning, monitoring and control [13, 15]; (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.

4 Deploying Software Processes at BL Informática

In order to demonstrate the feasibility of the approached presented in the last sections, we discuss in this section a software process improvement initiative in a Brazilian organization named BL Informática. The next section describes the quantitative results of this initiative.

BL Informática, founded in 1987, is a Brazilian organization concerned with software development, maintenance, deployment, integration and factory. Its main objective, defined by the company quality policies, is to focus on customers, collaborators and stockholders satisfaction through solutions implementation in information technology, developed by defined, controlled and continuously improved processes which ensure the requirements achievement. This section reports BL experience on software process deployment, started in 2003, aiming to improve its products development quality.

The first step in order to obtain the ISO 9001:2000 certification [10], main goal of the company in 2004, was the choice of development and maintenance processes consistent with this standard. Another relevant criterion for the selection of the processes was that the processes, by some way, must already have been tested before and that they must be able to provide products with quality. At the same year of 2003, COPPE/UFRJ consulting was requested to support the software processes's definition. Coincidently, during 2003, the QualiSoft Project was created and BL Informática formalized the participation on its first phase.

4.1 First Phase of QualiSoft Project

Trying to decrease the impact during the process deployment, at the beginning it has been decided to introduce the process proposed by the QualiSoft Project, leaving the Taba Workstation utilization to a further phase.

Initially, the process has been executed without the support of any management specific tool during all the analysis phase. The difficulties on the control mechanisms arrangement pointed out the tool support need in order to help the process utilization and, moreover, the planning, control and execution of the project. Due to this necessity perception, Taba Workstation utilization was considered again. From this moment, the Configured Environment resources began to be utilized entirely. Regarding the Instantiated Environment (which supports the execution and control of the project), it was utilized only to register the beginning and the ending of the activities. As the process utilization progressed, Taba Workstation tools began to be used gradually, supporting each step of the process enactment.

In parallel, the process's adaptation regarding the organization culture proceeded, without loosing the QualiSoft Project's process original characteristics.

Despite the fact that the pilot project had not satisfied the schedule, its execution has been considered successful. The customers have followed all the process closer, being aware of the artifacts and non-compliances detected and performing evaluations at the end each activity.

Within the period of one year the process was stabilized. The organization's processes deployment has required more time and resources than has been estimated initially, but on the other hand, produced better results than people have expected. The success factors of this stage have been: (i) high level management support; (ii) trainings investments; (iii) a process group engaged with the results and trustful of the future benefits; (iv) Taba Workstation tools, SGP (Process Management System) and SGD (Document Management System).

The main benefits achieved during this phase have been: (i) re-work decrease; (ii) produced artifacts with a greater quality; (iii) better Software Engineering understanding through the collaborator's qualification; (iv) dissemination of the processes culture by the all company and of the quality and commitment expected of its collaborators; (v) maintenance of the knowledge in the organization making the project team more independent. The main difficulties of this initial stage have been: (i) culture change; (ii) software engineering knowledge absorption; (iii) obtain commitments from the customers; (iv) choice of the pilot's projects.

4.2 Second Phase of Qualisoft Project

Due to the good results of the first phase's investments, the company has decided to proceed with the processes improvement. The MPS BR Level F internal project has received the same priority, resources allocated, monitoring and control, as others organization's projects because it is part of the organizational goals.

The factors that have guaranteed the stage's success have been: (i) frequent internal and external auditing aiming the ISO 9001:2000 standard (as the organization knew the benefits of a external auditing, the "Software & Projects Factory" area, which is

the evaluation's scope, has not been the only involved); (ii) the process team commitment and the knowledge about Project Management; (iii) the high management support; (iii) TABA, SGP, SGD e SFT (Work Flow System) supporting tools.

The greater benefit in this project has been the success of the Level F MPS-BR evaluation, being a motivation factor with a high impact on the company. The team's confidence regarding the organization maturity, the high management feeling of the investment return and the motivation have been crucial for the quality consolidation in the company. Another significant benefit has been the rigor of the evaluation performed, enriching the conquest and considered important in the result's delivering.

The MPS-BR Level F deployment also has required more resources than the planed, but the benefits achieved have been considered crucial for the beginning of the next improvement project: CMMI Level 3.

4.3 Third Phase of QualiSoft Project

The quality team's organizational structure had to be changed and expanded in order to address the Level 3 CMMI process areas requirements. The CMMI Level 3 improvement project has generated the greatest impact on the company among all other projects. The MPS-BR Level F process deployment requires involvement from the management level, therefore, there is a high impact to the project managers, while other people perceive the results without having great changes on its activities. The CMMI Level 3 focus mainly in the engineering activities, a process group having certifications in project management has not been enough to the definition and deployment. The investments on training, consulting and risks mitigation actions have been the largest of all projects.

Considering these facts, the greatest success factors of this project are being: (i) high management support, endorsing mitigation actions (for instance, new resources hiring, training, investment on tools) of the biggest risk from these projects (to do not satisfy the schedule when the project is utilizing a new process), accepting the preventive action's cost and ensuring that the external customer satisfaction is not going to be affected; (ii) the external consulting has been fundamental during the understanding of the CMMI Level 3 process model and during the indicator spread sheet's construction; (iii) communication mechanisms/systems to ease the information exchange, improvements proposals, lessons learned, doubts from the projects, better employment of the allocations; (iv) external and internal trainings.

Among the main benefits, we can highlight: (i) greater knowledge of the company capacity and productivity in more granular levels (requirement time construction); (ii) greater lessons learned register regarding the technologies and requirements development; (iii) lesser execution time of the testing and construction activities.

The most important lesson learned was the need of making project teams realize, as early as possible, the need of being adherent to the CMMI Maturity Level 3 and that the comprehension effort regarding the areas and their relationships is bigger than in Level 2. This early understanding makes the deployment faster and easier.

5 Quantitative Analysis of Software Development Improvement Initiative at BL Informática

BL Informática gathered quantitative results related to the software process improvement initiative described in the last section during the projects: with the beginning of the improvements projects the time perceptual elapsed with the process activities has changed. In this section we present and discuss the following data: (i) relation between the activities adoption regarding software quality and rework (any activity that comprises early processes phases produced artifacts changing or adjustment, i.e., to change ill defined requirements during codification) along the project, and (ii) increase of the time expended by managers during the management activities

5.1 Project Management Activities Improvement

Table 1 and Figure 2 show the mean time evolution dispended by the organization project activities along the different stages of the processes enactment.

Table 1. Evolution of time spent in software development activities

	Construction and Tests	Analysis and Design	Management	Others
Before Qualisoft Project	19,1%	66,0%	11,5%	3,4%
1st Phase of Qualisoft Project	34,9%	39,7%	14,9%	10,6%
2nd Phase of Qualisoft Project	34,8%	50,5%	7,9%	6,9%
3rd Phase of Qualisoft Project	27,3%	51,8%	17,8%	3,2%

Initially, when the company did not use a defined process, it took a large amount of time in activities regarding construction and testing, resulting in large rework cost. The activities were not clearly defined, forcing managers to take part of the analysis and construction activities, harming the management tasks execution. By specifying the project management activities in the QualiSoft Project first phase process, managers could act more and had planning, monitoring and control goals for its projects.

During the Qualisoft Project second phase, the management time decreased because of the support and management tools adoption. The analysis time increased and quality evaluations began to be executed along the process (not only during the construction stage as the previous process). These evaluations used as base criteria list, initially generic, which evolved in order to reflect the organization reality and its products.

The CMMI Level 3 consistent process adoption has caused the increase of the time elapsed with the management activities because the manager has began to take care only of its projects management activities (in the previous process, managers were responsible by analysis and design activities).

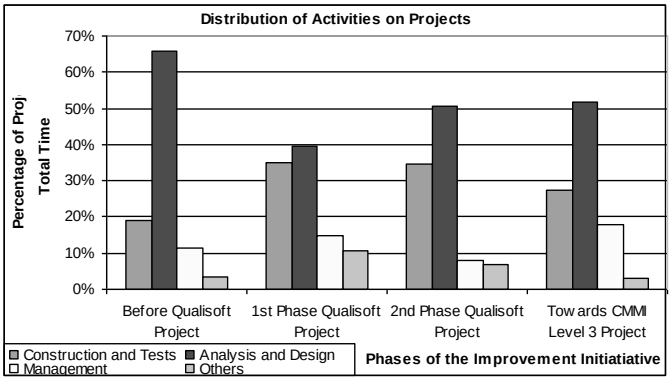

Fig. 2. Time division by the project activities

5.1 Software Quality and Rework Relation

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

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

	Rework	Quality
Before Qualisoft Project	44,0%	0,0%
1st Phase of Qualisoft Project	26,7%	9,2%
2nd Phase of Qualisoft Project	11,2%	3,0%
3rd Phase of Qualisoft Project	7,3%	10,8%

With the first process adoption, the time spent in analysis and design has increased, but the rework has decreased. These facts can be explained by the quality assurance activities insertion.

Along the Qualisoft Project's first phase, rework has proceeded to reduce due to the evaluation activities rigor. As the errors/failures were found early, the number of evaluations concerning a specific product has also decreased.

The time spent with quality evaluations has increased by adopting a process based on CMMI Level 2 because of the larger number of quality evaluations during the process (this is explained by the larger number of artifacts that need to be evaluated and by the new roles involved in these evaluation activities). Besides, the appraisal reports for evaluating the specific Level 3 CMMI products are yet evolving in the organization, forcing more evaluations realizations or the execution of evaluations which spent more time.

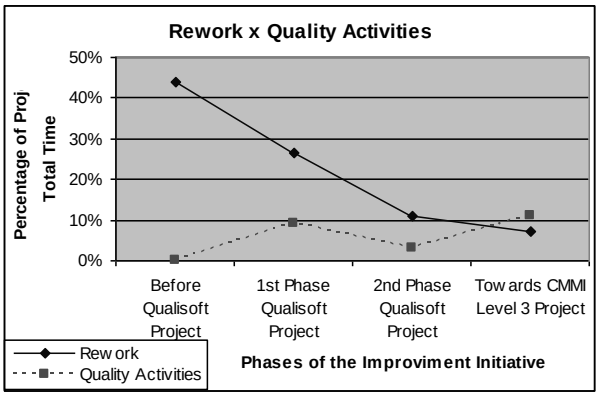

Fig. 2. Software Quality Activities and Rework Relation

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 characteristics and software products and services quality. The Taba Workstation has 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.

Qualisoft Project's results are excellent under different aspects. First, it showed the feasibility of carrying out the project with very particular characteristics since the costs were significantly diminished. Second, it showed that it is possible to promote technology transfer between universities and other kinds of organization producing good results to all the involved parts. The companies in 3rd Phase of Qualisoft Project are expected to be evaluated by an official SCAMPI Appraisal later this year.

The quantitative results of applying the presented approach in a Brazilian organization are significant: it has obtained ISO 9001:2000 certification, has been ranked MPS.BR Level F and is currently engaged in the CMMI Level 3 appraisal process. Furthermore, it has improved the processes and product's quality, decreased costs and conflicts, reflecting the high management support regarding process improvement activities, the larger collaborator's satisfaction and the decrease of people turnover.

Nevertheless, the Taba Workstation is continually evolving. The next steps is to evaluate the adequacy of the tools that support CMMI Level 3 process areas, and to define and integrate other tools to support CMMI Level 4 and 5 process areas, to help the elevation of organization software development maturity to higher levels.

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