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Abstract Title: A study of quality management in software process production: a diagnostic in a software development area.

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1 Introduction

The worries related to software quality have been a strong source of research due to the high number of software projects that fail in this field, according to the last Chaos Report that shows only 32% of success in these projects, considering needs, deadlines and cost planned [22].

These worries led the Department of Defense of the United States of America (DoD) to sponsor the Software Engineering Institute of Carnegie Mellon (SEI) in the creation of a process model that allows the evaluation of the maturity of its software suppliers. Since then, the SW-CMM – Capability Maturity Model for Software was created [6]. Later on, with the CMM popularity and the creation of similar models to be used in non-related software development activities, SEI joined several concepts in an integrated model, called CMMI [6]. The extension of this model to software development is called CMMI-DEV and is nowadays world-wide accepted as a set of best practices for software development.

In Brazil, similar concerns made the Ministry of Science and Technology (MCT) create a program for software productivity and quality, called PBQP-Software [7]. The goal was to motivate companies from this sector to use methodologies and practices with the

purpose of advancing in global market participation and guarantee their competitiveness in relation to foreign companies. From this program surges SOFTEX, a Brazilian society to promote software exportation. Based on a 2003 MIT study, SOFTEX started the elaboration of Brazilian Software Process and Improvement Model called MPS.BR [16].

However, even with the great efforts done nationally and internationally, these methodologies mentioned are not usually applied for practical software development [3] and for this reason, the main objective of this paper is to diagnose the knowledge and use of existing and applied standards and Models for software quality management in a specific software development department.

The article is divided into four sections, having this first one as an introduction. The second section deals with the standards somehow related to software development; the two most used Brazilian models for definition of quality in software development process; and opens a discussion about the usage of these standards and models. A field research is presented in the third section. The fourth section presents final considerations, together with future researches that can be done from this paper.

2 Software Development Process Standards

[21] affirms that a software process represents a set of activities and results associated to software production. Besides, he emphasizes that such processes need to be improved, in order to increase the software quality and reduce costs and time of development. [6] concludes that these standards were made with the purpose of guiding the product creation and services supply. This concept is valid to software production and there are several ISO standards for this area, as it follows.

2.1 ISO 9001

The ISO 9001 Standard is part of a set of ISO 9000 standards and defines the quality assurance model for development, production, installation and services in an organization [5]. For this reason, companies in software development segment also use it. However, [21] indicates that this Standard is not specific for software and it is too much flexible. This impedes the comparison between companies when it comes to level of details in software production processes.

Before the 2000 review, the standard had a specific section related to software quality assurance systems, numbered ISO 9000-3. This document defined the production, installation, and maintenance issues, but it was voided [6]. After that, the ISO 90003 standard was proposed as a guide for applying ISO 9001 in Software Engineering, involving development, supply e maintenance. According to [2], this standard has guidance focused on software contracts and there are three big blocks. The first one describes the Quality System Structure; the second determines Project Lifecycle Activities, like requirements, implementation, tests, and maintenance; and the third block presents Support Activities, such as metrics, and training.

2.2 ISO 9126

The ISO 9126 is a standard focused on the product software quality, based on Software Engineering concepts [9]. It is divided into four parts, where the first treats the quality model; the second focus on external metrics for quality evaluation; the third involves internal metrics; and the last one mentions the use of metrics with quality [2].

The quality model discussed in the first part of the standard is subdivided in two other parts. In the first one, internal and external requirements for software product are defined, having categories to discuss Functionality, Confidence, Usability, Efficiency, Maintainability, and Portability. On the second part the requirements for quality in use

are presented, treating Effectiveness, Productivity, Security, and Satisfaction. The standard indicates that there is a direct influence between the levels of quality presented, and that these levels are influenced by the level of quality in the processes for developing the software, not declared on the standard.

2.3 ISO 12207

The ISO 12207 [10] is a standard that treats the software lifecycle. According to [12], this standard is used as a reference by many countries to reach competitive differences. The international version is the review ISO 12207. [6] affirms that this standard offers an structure so the organization defines its software development processes, covering the whole lifecycle, from requirements up to maintenance and depreciation of a product. The standard is presented as a guide, in order to inform responsibilities and needs in a software lifecycle. It is formed by fundamentals, support, and organizational processes. Fundamentals processes discuss categories related to acquisition, supply, development, operation, and maintenance. Support processes are divided into the categories of documentation, configuration management, quality assurance, verification, validation, peer review, auditing, and problems resolution. To finish, Organizational processes bring the topics of management, infrastructure, improvement, and training. Each category is divided into activities, subdivided into tasks [10].

2.4 ISO 15504

The ISO 15504 standard [11] is focused on the evaluation of the software development process. According to [6], the standard was originated from SPICE project (Software Process Improvement and Capability Determination) and its objective is to define a reference process model, in order to determine scope, requirements and expected results for each of the process presented.

The standard has seven parts which have the goal of describing concepts, vocabulary, guidelines to apply an evaluation, guidelines for process improvement use, a sample of process evaluation model, and a sample of system lifecycle evaluation model. [14] says that the parts eight and nine are being developed and there is an actual project to evolve the current version for a new ISO 33000 series.

[1] affirms that the standard is used as a process evaluation with two objects, improve and determine capability levels in the processes. For then, the standard defines the concept of capability level, which shows how capable the company is in relation to the execution of the process that is being evaluated. The standard presents six capability levels: Level 0, named *Incomplete* says that the process is not implemented, or fails in achieving its objectives. Level 1 is called *Performed* and describes that the process essentially achieves its objectives, even without plan. The Level 3 (*Managed*) indicates that the process and products are implemented within a plan. When the process is in Level 4, *Established*, it is implemented in a systemic and consistent way. In Level 5, *Predictable*, the process is executed in a way that enables target limits. To finish Level 6, *Optimizing*, says that process is continuously adapted to achieve business objectives.

3 Software process models

According to the last report from MCT [8], there are two main models used by Brazilian companies when it comes to quality assurance in software process. As an international reference CMMI-DEV is mentioned, and MPS.BR is the most-used national model, both of them discussed in the sections bellow.

3.1 CMMI-DEV

CMMI-DEV is nowadays the most known and accepted framework for software process improvement. This acceptance is related to its origins, due to its association to CMM, a

model created to evaluate the maturity of American software supplier companies [4]. It is based on ISO 9000, ISO 12207 and ISO 15504 standards [19].

It is clearly understandable this acceptance when [13] emphasizes that the concepts presented in the model have more than 20 years of know-how, and that CMMI have already time to prove its value, helping companies to keep costs, reach deadlines and reduce rework and defect rates, that means, improve quality.

According to the model [19], there are two ways to deal with the framework. The first and less used is called *Continuous Representation*, where each process area is evaluated separately by its six capability levels. The second is called *Staged Representation*, organized into five maturity levels, where a set of process areas is evaluated, so that each area needs to have a specific capability level to promote the set in a maturity one. The Maturity levels are described as (1) *Initial*, (2) *Managed*, (3) *Defined*, (4) *Quantitatively managed*, and (5) *Optimizing*. As a comparative of the maturity levels, CMMI-DEV says that companies in Level 1 have chaotic processes, instable environment, budget exceeds, and delays. The success of these companies depends on heroic people. On the other hand, Level 5 companies improve continuously their defined process. Causal analyses are performed to increase and develop the quality of the processes, always controlled statically.

The model is composed by 22 process 22 process areas, separated into categories related to Support, Project Management, Process Management, and Software Engineering. To reach the Maturity Level 2, it is necessary to achieve goals in the processes areas of Configuration Management; Measurement and Analysis; Process and Product Quality Assurance; Supplier Agreement Management; Project Monitoring and Control; Project Planning; and Requirements management.

3.2 MPS.BR

MPS.BR was created in 2003 as a Brazilian initiative coordinated by SOFTEX and sponsored by Ministry of Science and Technology (MCT), together with other government and private entities [17]. The main goal of this model is to improve Brazilian software processes and its references are ISO 15504 and 12207 standards; and CMMI-DEV model.

One of the great factors that contributed to the creation of the model was the costs adjusts for the Brazilian market, issue discussed in a 2003 MIT study, which indicated that Brazilian companies were not applying for CMM [16].

In the terms of concepts, the model is very similar to the ones presented up to here, having the same concepts of maturity levels and process areas. The differences are related to the processes areas needed and the number of maturity levels, divide into seven levels: *Partially Managed* (G); *Managed* (F); *Partially Defined* (E); *Largely Define* (D); *Defined* (C); *Quantitatively Managed* (B); and *Optimizing* (A). The processes discussed in the model are Project Management; Requirement Management; Acquisition; Quality Assurance; Configuration Management; Project Portfolio Management; Measurement; Organizational Process Evaluation and Improvement; Organizational Process Definition; Human Resources Management; Reuse Management; Requirements Development; Product Integration; Product Project and Construction; Validation; Verification; Development Using Reuse; Decision Management; and Risk Management.

Another difference can be found in the model documentation, composed by 13 guides, having a general one, one related to evaluation, a specific one for acquisition and 10 others organized for implementation of the different maturity levels.

3.3 The use of Standards and Models for software development

In the last report presented by Brazilian Ministry of Science and Technology, named *Pesquisa de Qualidade no Setor de Software Brasileiro* [8], the rate of companies that answered the questionnaire, when it comes to standards and models for software development, was below 31%, where ISO 9001 was answered by 19.2% of the companies, CMMI-DEV rates were 16% and MPS.BR ones were 30.6%.

From the results presented on that research, it is important to emphasize that not all companies that answered the questionnaire have certifications for the standards and models researched. According to the report, 64% of the companies that answered questions related to ISO 9001 are already certificated, while 33% intend to apply for the certification in 15 months. The numbers for CMMI-DEV are worse than the ones from ISO 9001, having only 44% certificated and 42% of intention for certification. MPS.BR has numbers equivalents to CMMI-DEV, having 46.7% of certificated companies and 45.7% that intend to apply for the certification in 15 months.

It is possible to conclude with the study that there is a limited use of software process models for quality and productivity improvement in Brazilians companies. But this is not a particular Brazilian situation and, actually, the use of these models is increasing in the country. According to the last report about CMMI-DEV appraisals all over the world [20], Brazil is in the list of the countries which have high rates of increase of evaluations, having a total of 181 appraisals. MPS.BR has also been increasing considerably in the last years, with a total of 257 appraisals in 2010 [16].

However, the sum of these appraisals are not enough to reach 5% of the companies that develop software in Brazil, considering only the ones that have as main revenue the development of software [18] and not considering the existence of companies that have both CMMI-DEV and MPS.BR certificates.

These results lead to a set of questions about the use of these models, the reasons why companies do not worry about using the techniques and which ones are actually used for software construction.

4 The Field Research

The company studied is a metallurgical industry nationwide leader in its segment. It invests in research and development projects and nowadays counts with over 1500 employees, having as a quality management system NBR ISO 9001:2008 standard.

The object of the presented study is the Software Project Area. That department has today 17 employees assuming several tasks in the development of software as coordinators, analysts, programmers, and testers. The goal of these workers is to develop software to incorporate in the products sold by the company. As mentioned by [21], the fact that the ISO 9001 is flexible has made that only part of the software development process is in the company's Quality Management System.

With the objective of diagnosing the knowledge of the team in relation to the existing models and standards for software development, a questionnaire was applied to discover their opinion in the studied issue [15]. That questionnaire was formulated with closed questions, some of them having as options for answers the information in the *Likert* scale of five points.

The questionnaire was sent electronically to all Software Project workers and had 82.3% of responders. Five factors were measured: the academic profile of the employees; the level of knowledge in standards and models presented in the article; the knowhow of the team in relation to the positioning in the software development process in the Quality Management System of the company; the perception of the interviewed in relation to the frequency of studies for the improvement and evaluation of the process; and the evaluation of the employees in relation to the company's software development

maturity level, considering the areas of the process demanded to the certificate level 2 of the CMMI–DEV.

4.1 Results and Analysis

The results of the research points to a development team with good scholarship, since more than 70% of the interviewed have completed their higher education, having 43% of the interviewers completed their post-graduation. Other important fact is the team diversity of knowledge, composed by systems analysts (36%); testers (29%); firmware engineers (21%); programmers (7%); and supervisors (7%).

Concerning the knowledge of the team on the standards and models related to the software production, the results found a certain limitation, as shown on Figure 1, since the majority of the answers was directed to the lack of knowledge or, at most, the theoretical knowledge of the standards or models, not applying it to practice.

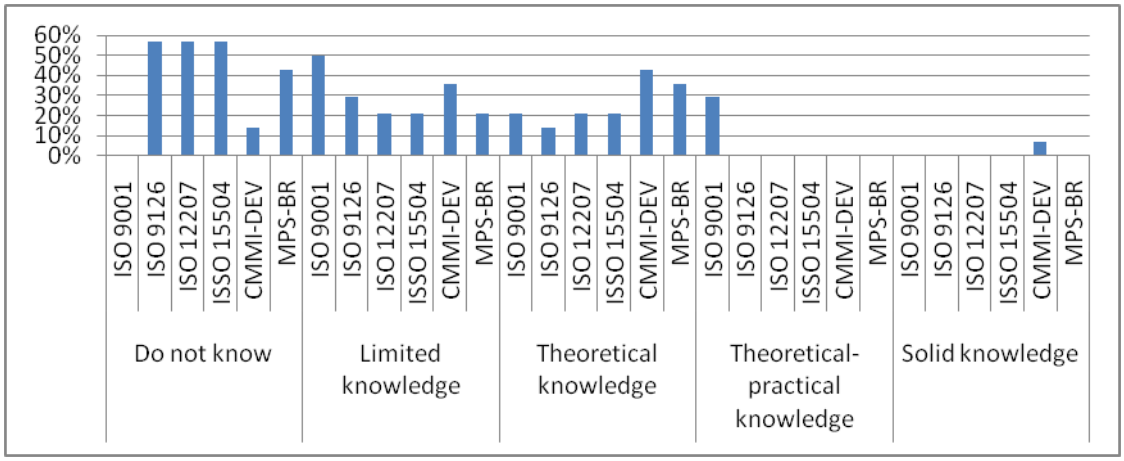

Fig. 1. Team rate of knowledge in standards and models for software development.

When it comes to the usage of the software development process, all of the workers are aware of its existence, but the team has doubts if it is documented in the Quality Management System of the company – 43% of the responders say the process is documented, other 43% say it is not and the remaining 14% did not know what to

answer. Besides the divergence related to the documentation, 85% of the responders mentioned the relevance of the process in their activities.

In the improvement and evaluation of the process, the results show the meeting frequency ranges from low to the average, where 42% of the answerers indicate low frequency and 29% consider it to be on the average. In the process evaluation, based in internal audits, the number is even more worrying, since 43% say they have never had internal audits concerning the process, 36% say the frequency of these activities is low and only 21% affirm the frequency is adequate.

To finish the presentation of the results, the group was asked about their perception concerning the usage of the processes considered by CMMI-DEV as necessary to reach the maturity level 2 [19]. The results demonstrate the use of the practices proposed by CMMI-DEV only in some projects, where the average of the answers indicates that the practices are used depending on the project (44%). This perception suggests that the company doesn't have institutionalized its process, classifying it as Maturity Level 1. This does not mean that the projects done by the company do not work, but it means that the deadlines and costs are not accomplished as planned, processes are abandoned during critical situations and there is a difficulty in succeeding projects [19].

5 Final Considerations

The presented study can conclude that there is a limited usage and knowledge of standards and models for software development in the company evaluated. This consideration can be defined due to the results presented in the experiment. The study does not have ways to affirm that this is a characteristic of software development companies in general, although the methodology used to determine the diagnostic can be used in other companies to do so. A new and widely study, collecting data from other companies can be taken to define if it is or not an existent characteristic. On the other

hand, the limitations of the firm researched suggest a set of studies, since how to incentive companies to use standards and models for software creation, up to the proposal of a software model that points out in numbers the importance of the standards and models discussed in this paper.

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