Analysis of the continuity of software processes execution in software organizations assessed in MPS.BR using Grounded Theory

Carlos Diego Andrade de Almeida
UNIFOR, IVIA
Fortaleza, Brazil
Email: carlosdiegoa@gmail.com

Thiago Crystyan Macedo
UNIFOR
Fortaleza, Brazil
Email: crystyanjlc@gmail.com

Adriano Albuquerque
UNIFOR
Fortaleza, Brazil
Email: adrianoba@unifor.br

Abstract—Many companies look for in a implementation of an Improvement Program based on software maturity models as a way of increasing their product's quality. For knowing their maturity level, they have to submit themselves for an assessment based in models. To be assessed, a company spends some time into the definition and implementation of the necessary software processes. However, after the assessment most of the companies have some difficulties to continue the execution of some activities of the processes or leave this execution. This paper proposes the analysis of the continuity of software processes into the companies assessed in MPS.BR, the Brazilian Maturity Model, identifying factors that help or make difficult to maintain the adherence of those process to the model and the easiest practices to be maintained in execution, after the company has been assessed. With this work, we hope to make easier for consultants to implement the processes, specially those that have more percentage of leaving or difficulties.

Keywords—Software processes; Maturity Model

I. INTRODUCTION

The software's importance grows every day and as the quality of the software products is so closely related to the quality of processes that are used to develop them, invest in the processes quality became very important to the software organizations [14].

Among these, the MPS.BR, the Brazilian Maturity Model, fits perfectly into a proposal of improving the quality of software produced in Brazil. According to [10], the program MPS.BR, launched in December 2003, aimed at improving software processes of micro, small and medium size companies.

The reference model, MR.MPS, contains the requirements that the processes of organizational units must meet to comply with the model. However, like others maturity models, after the assessment companies have trouble to keep their processes adherent to the reference model. Therefore, it is important to know the main difficulties to maintain such compliance.

This paper presents the results of a survey carried out with professionals involved at MPS.BR, which the objective was to find out the factors that influence positively in the continuity of the processes execution and the practices of the Project Management and Requirement Management processes considered more difficult to maintain the execution on new projects after the assessment.

This paper is organized in four sections. Section 1 is the Introduction. Section 2 presents the literature review. Section 3 presents all about the survey applied on assessed organizations. The section 4 presents the quality research using Grounded Theory. Finally, section 5 concludes the paper and presents further works.

II. LITERATURE REVIEW

As a starting point, the literature review was performed using some steps of systematic review, a kind of secondary study, widespread by [3], in order to identify factors that may influence the continuity of the software processes execution. We set a protocol for implementation of a systematic review based on the protocol developed by [13]. We used tools such as spreadsheets to supporting the registration and analysis of the data collected.

Initially, the literature review was conducted in the main papers published in relevant symposium and workshops to the software quality area in Brazil.

According to [11], [2], [6] and [12], the level of formalization of organizational structure is one factor that can facilitate the implementation of a process improvement program.

For example, [11] observed that the formalization of organizational structures in areas, functions, skills and responsibilities demonstrates a level of organization that allows a simple way to visualize how the company is organized to meet their goals. The formalization should not be understood, in this case, as bureaucracy, but as a mean to facilitate the communication into the organization. The higher the level of organization and formalization of organizational structure, the lower is the risk of short-term view on the implementation of process improvement.

This factor can also affect positively the maintenance of quality, because a company with a more formal organizational structure has the ability to get sucess and maintain awareness of their roles, responsibilities and areas.

Another factor was the level of tools and techniques for reuse of knowledge utilization. [6], [2], [4] and [12] said that a company that wants to improve the maturity of their processes needs to take advantage of existing knowledge in the organization. It might be supported by a knowledge management environment. From the reuse of knowledge the organization can implement improvements to the software processes and accelerates the implementation and execution of them.

This factor is also relevant to the continuity context, because the company that has tools and techniques to support the reuse of knowledge can more easily keep alive the knowledge of the implemented processes, encouraging
their use and keeping clear the need of their activities and tasks. [2] [6] and [12] described the use of return of investment (ROI) indicators as having a strong influence in the maintaining of a Improvement Program. [12] said that during the implementation of the processes, the team clearly felt the need for a mechanism to recognize the benefits associated with improvement efforts. It serves to motivate the members to continue the improvement of the processes aiming to achieve higher levels of maturity. [6] also advise organizations to analyze, often, the ROI achieved with the improvement of software processes, making them visible, because it decreases the risk of stopping the process of continuous improvement.

Others factor were: the level of available resources for the maintenance and improvement of the processes and the commitment of the high managers with the Improvement Program.

According to [6], a company that wants to continually improve their processes needs to provide the necessary resources, because it depends largely on investment in personnel, support tools, as well as in specialist consultants. Thus, the existence of committed high managers, providing the appropriate support, aids the company to achieve continuous improvement of their processes. High managers that keep the team motivated and the processes properly supported will likely remain adherent to the model, obtaining a continuous improvement of the processes' quality [8] [4].

One of the factors cited was the level of commitment of the Improvement Program coordinator to the implementation and improvement of the processes. [11] said that the ability of the company’s SEPG (Software Engineering Process Group) to conduct the Improvement Program affects directly the performance of the project.

In some companies, it was found that the attitudes of the SEPG may difficult the monitoring of the activities related to the implementation and maintenance of the processes execution. [11], [6] and [5].

The level of the formalization of communication is other factor described by [6] and [8]. [11] said that the higher the level of organization of communication in the organization, the lower the risk of failure in interpretation and understanding the requirements to implement the activities.

To maintain the continuous improvement of the processes and adherence to the maturity model, also depends of the formalization of communication in the level of projects and inside of the Improvement Program.

There are also two factors that have similarities and are cited by [6], [8] and [9], which are: the level of knowledge about software processes and software quality, and the level of use of software engineering methodologies and concepts.

To [11], a high level of knowledge and understanding of the collaborators, mainly opinion makers, on concepts related to software quality is very important to evaluate and to understand the impact that an Improvement Program can represent to the organization. The higher the level of knowledge about concepts related to software quality and to the maturity model, the lower the risk of underestimating the resources required to the Improvement Program. [5] said that the implementation of software processes involves knowledge-intensive activities. It means that those involved in software process improvement initiatives must have deep knowledge of software engineering and must be able to use this knowledge to guide the implementation of the processes.

The company that has knowledge about software quality and software engineering, distributed among its employees, has a better chance of maintaining their activities adherent to the maturity model.

Other factor which influences the maintenance of the Improvement Program is the level of resistance to cultural changes. The comfort zone that exists before the implementation of the processes and during the maintenance of the Improvement Program is a very important barrier.

The human being has a natural resistance to changes. Whenever the organization leaves the comfort zone, some employees opposed the execution of required tasks and the use of necessary methods and techniques [6]. [4] highlighted another important factor: the level of investment in training on software processes. [11], for example, said that difficulties related to cultural changes can be mitigated with training, lectures and meetings in complementary disciplines.

A continuous investment in training facilitates the continuity of the adherence to maturity models by improving the knowledge related to software quality and software engineering.

One factor that can make difficult the benefits of training initiatives is the high turnover of human resources, because it generates high cost and the knowledge cannot be used to support the Improvement Program [8].

According to [6] and [11] an important factor to the continuity of the Improvement Program is to deal with it as a project.

In fact, [11] said that as an Improvement Program has the philosophy of a project it should be planned and monitored as any software development project, including setting marks/checkpoints and constant monitoring of progress and costs involved in this initiative.

Another factor found in the literature is the importance of consultants to obtain and maintain the software processes adherence to the maturity model.

For [6], the importance of consultants becomes clear because many of them has the opportunity to participate in others organization assessments as a consultant or as an auditor and so they know exactly what is required and the reality of others companies (benchmarking). They observed that a well qualified consultancy facilitates the definition of better business goals to the company and a more adherence to the maturity model.

However, it should be highlighted that the continuity of the Improvement Program depends of how the consultants
are able to teach the collaborators to execute their activities and how the knowledge becomes a real asset of the organization, that is, they can leave and the software process culture remains on the company.

Finally, another factor was the level of utilization of support tools. The more support of tools, lower is the risk to neglect the practices required by the maturity model [11] [2].

III. SURVEY

A. Survey’s Methodology

The next step in the research was the completion of a questionnaire to identify the level of influence of factors, identified in the literature review, to maintain adherence to the software process maturity model.

We defined a questionnaire divided into three parts: the first was a set of objective questions, which sought to characterize the professional respondents, the second part listed the factors that influence the maintenance of software processes, according to the literature review, and was asked to respondents how important were the factors for the maintenance and implementation of the Improvement Program. Respondents could add others factors of significance. Finally, the third part of the questionnaire reported the expected results (practices) of processes evaluated at the level G of MPS.BR, which are the Project Management and Requirements Management, seeking to ascertain the more difficult activities to be continued after the assessment has been performed. Participants were encouraged to justify their evaluation if they considered important for his response.

The questionnaire received 27 responses and the profile of respondents was: 44% of them had master degree and 22% had finished the university. 40% had 6-9 years of experience in software quality and 30% had 3 to 6 years. 48% had been a project manager for five or more projects and 28% had managed 3-5 projects. 37% worked as project management for 1-3 years and 25% from 3 to 6 years. 66% had already participated in a software engineering process group, 40% were certified implementers, 33% were consultants and 29% were certified auditors of MPS.BR. 50% of respondents participated in one or two assessments and 30% participated in five or more.

B. Analysis of Results

To help the analysis, a table was built to register the relevance’s degree of each factor, the degree of difficult to continue the execution of each practice of the Project Management and Requirement Management processes, after an assessment.

The factors were analyzed using the following scale: 0 - No relevance; 1 - Low relevance, 2 - Reasonable relevance; 3 - High relevance, 4 – Indispensable.

### TABLE I. THE LEVEL OF FACTORS’ INFLUENCE

<table>
<thead>
<tr>
<th>Factors</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>F01-Organizational structure known by the</td>
<td>3.7%</td>
<td>18.5%</td>
<td>33.3%</td>
<td>25.9%</td>
<td>18.5%</td>
</tr>
<tr>
<td>F02-Effective structure for communication</td>
<td>0%</td>
<td>0%</td>
<td>22.2%</td>
<td>29.6%</td>
<td>48.1%</td>
</tr>
<tr>
<td>F03-High level of knowledge about content related to improvement process and software quality</td>
<td>0%</td>
<td>0%</td>
<td>34.6%</td>
<td>38.4%</td>
<td>26.9%</td>
</tr>
<tr>
<td>F04-High level of maturity of the organizational culture to use software engineering approaches and tools</td>
<td>0%</td>
<td>0%</td>
<td>18.5%</td>
<td>44.4%</td>
<td>37.1%</td>
</tr>
<tr>
<td>F05-High level of automated tools utilization in supporting the software process</td>
<td>0%</td>
<td>11.1%</td>
<td>14.8%</td>
<td>37.1%</td>
<td>37.1%</td>
</tr>
<tr>
<td>F06-Low level of resistance to changes</td>
<td>0%</td>
<td>0%</td>
<td>18.5%</td>
<td>44.4%</td>
<td>37.1%</td>
</tr>
<tr>
<td>F07-Commitment of project managers with the Improvement Program</td>
<td>0%</td>
<td>0%</td>
<td>7.4%</td>
<td>11.1%</td>
<td>81.4%</td>
</tr>
<tr>
<td>F08-Utilization of indicators that demonstrate the return obtained with the processes’ execution</td>
<td>3.7%</td>
<td>0%</td>
<td>14.8%</td>
<td>48.1%</td>
<td>33.3%</td>
</tr>
<tr>
<td>F09-Provision of the necessary resources by the High Managers</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>40.7%</td>
<td>59.2%</td>
</tr>
<tr>
<td>F10-Utilization of knowledge management approaches and tools</td>
<td>0%</td>
<td>18.5%</td>
<td>59.2%</td>
<td>22.2%</td>
<td>0%</td>
</tr>
<tr>
<td>F11-Guidance of an external consultancy</td>
<td>0%</td>
<td>7.6%</td>
<td>26.9%</td>
<td>50%</td>
<td>15.3%</td>
</tr>
<tr>
<td>F12-Effectiveness of the consultancy, that help the company to implement the software process, in transform the SEPG in an autonomous group and with a high level of knowledge</td>
<td>0%</td>
<td>0%</td>
<td>7.4%</td>
<td>48.1%</td>
<td>44.4%</td>
</tr>
<tr>
<td>F13-Low level of staff turnover</td>
<td>0%</td>
<td>0%</td>
<td>44.4%</td>
<td>44.4%</td>
<td>11.1%</td>
</tr>
<tr>
<td>F14-Maintanance of a strong and effective policy of trainings</td>
<td>0%</td>
<td>3.7%</td>
<td>29.6%</td>
<td>37.4%</td>
<td>29.6%</td>
</tr>
</tbody>
</table>

According to Tab. 1, the factors “F07” and “F09”, “F12” and “F02” were considered the most relevant for the continuous execution of software processes, after an assessment. This result corroborated with the literature review findings.

However, the factors “F01” and “F10” were considered as the less important ones for the maintenance needs.

The third part of the questionnaire aimed to evaluate the practices (expected results) of the level G in MPS.BR, corresponding to the processes: Project Management and Requirements Management.

As we said above, each practice (expected result) was evaluated in relation to the level of difficulty to continue to perform it, after a MPS.BR assessment. For this, the following scale was used: 1 - Difficult to continue; 2 - Reasonable difficult to continue; 3 – Easy to continue. In cases when a respondent selects “1 - Difficult to continue” for the practice the questionnaire suggested the participant to justify it.
The Tab. 2 presents the obtained results for the practices (expected results) of the Project Management (PRM) process.

<table>
<thead>
<tr>
<th>Practices (Expected results)</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRM1 – The work scope for the project is defined</td>
<td>0%</td>
<td>6%</td>
<td>94%</td>
</tr>
<tr>
<td>PRM2 – The project tasks and work products are dimensioned using appropriate methods</td>
<td>6%</td>
<td>50%</td>
<td>44%</td>
</tr>
<tr>
<td>PRM3 – The model and the project’s life cycle phases are defined</td>
<td>0%</td>
<td>13%</td>
<td>88%</td>
</tr>
<tr>
<td>PRM4 – The effort and cost to perform the tasks and work products are estimated based on historical data or technical references</td>
<td>50%</td>
<td>19%</td>
<td>31%</td>
</tr>
<tr>
<td>PRM5 – The budget and project schedule, including the definition of milestones and checkpoints are established and maintained</td>
<td>25%</td>
<td>44%</td>
<td>31%</td>
</tr>
<tr>
<td>PRM6 – Project’s risks are identified and their impact, likelihood and priority to treatment are determined and registered</td>
<td>25%</td>
<td>38%</td>
<td>38%</td>
</tr>
<tr>
<td>PRM7 – The human resources for the project are planned considering the profile and knowledge needed to perform it</td>
<td>19%</td>
<td>56%</td>
<td>25%</td>
</tr>
<tr>
<td>PRM8 – The resources and work environment needed to run the project are planned</td>
<td>6%</td>
<td>44%</td>
<td>50%</td>
</tr>
<tr>
<td>PRM9 – The relevant data of the project are identified and planned considering collection, storage and distribution aspects. A mechanism is established to access them, including, if pertinent, issues of privacy and security</td>
<td>38%</td>
<td>31%</td>
<td>31%</td>
</tr>
<tr>
<td>PRM10 – A general plan to run the project is established with the integration of specific plans</td>
<td>6%</td>
<td>19%</td>
<td>75%</td>
</tr>
<tr>
<td>PRM11 – The feasibility of achieving the goals of the project, considering the constraints and resources available, is evaluated. If necessary, adjustments are made</td>
<td>25%</td>
<td>38%</td>
<td>38%</td>
</tr>
<tr>
<td>PRM12 – The project plan is reviewed with all stakeholders and the commitment to it is obtained</td>
<td>25%</td>
<td>31%</td>
<td>44%</td>
</tr>
<tr>
<td>PRM13 – The project is managed using the project plan and other plans that affect the project and the results are registered</td>
<td>13%</td>
<td>44%</td>
<td>44%</td>
</tr>
<tr>
<td>PRM14 – The involvement of stakeholders in the project is managed</td>
<td>19%</td>
<td>44%</td>
<td>38%</td>
</tr>
<tr>
<td>PRM15 – Reviews are carried out in project’s milestones according to the planning</td>
<td>6%</td>
<td>69%</td>
<td>25%</td>
</tr>
<tr>
<td>PRM16 – Record of identified problems and the results of the analysis of relevant issues, including critical dependencies are established and treated with stakeholders</td>
<td>25%</td>
<td>38%</td>
<td>38%</td>
</tr>
<tr>
<td>PRM17 – Actions to correct deviations from the planning and to prevent the recurrence of identified problems are established, implemented and followed until its conclusion</td>
<td>25%</td>
<td>38%</td>
<td>38%</td>
</tr>
</tbody>
</table>

The practice (expected result) for “REM3” was considered one of the three expected result most difficult to be continued by the respondents. For one of them, a consultant, this result is due to the lack of automated tools that can ensure the bidirectional traceability. The tools may facilitate a little more the continuity of this practice.

IV. Qualitative Research Using Grounded Theory

A. Grounded Theory Research Methodology

Grounded Theory is a qualitative research method that uses a set of systematic procedures for collecting and analyzing data to generate, develop and validate substantive theories about phenomena, essentially, social, or broad social processes [15]. Application of Grounded Theory in the areas like software engineering and process improvement is even more sparse, as said [16]. But some studies have been highlighted.

Their authors, Glauser and Strauss, argue that there are two basic types of theories: the formal and substantive, as they say [17]. The first type consists of conceptual and comprehensive theories, while the second type is specific for a particular group or situation and is not intended to generalize beyond their substantive area.

According to the line proposed by Strauss, GT (Grounded Theory) is based on the idea of encoding (coding), which is the process of analyzing the data. When coding, concepts are identified (or codes) and categories. A concept (or code) names a phenomenon of interest to the researcher, abstract an event, object, action, or interaction that has a meaning for the researcher [18]. Categories are
groupings of concepts together in a higher degree of abstraction.

The encoding process can be divided into three phases: open coding, axial and selective. The open coding involves breaking, analysis, comparison, conceptualization and categorization of data. According to [15], in the early stages of open coding, the researcher explores the data scrutinizing what you believe relevant due to the intensive reading of texts. In the phase of open coding, incidents or events are grouped into codes by comparing incident-incident.

Also the open coding is performed to create categories that add the codes to reduce the number of units that the researcher will work [19].

After the identification of conceptual categories for open coding, axial coding examines the relationships between categories that make up the propositions of substantive theory [15]. The relationships between the codes can be defined by the researcher. As proposed by [18], these relationships form what the authors call as paradigm: causal conditions, players, strategies and consequences of actions / interactions.

Finally, selective coding refines the process, identifying the core category theory, with which all others are related. The core category should be able to integrate all the others and express the essence of the social process that occurs between those involved. This core category can be an existing or a new one [19].

B. Results Analysis of Grounded Theory

In this qualitative study, were performed three stages of coding proposed by grounded theory, it was possible to find the set of theories to answer the question under study (what influences the continuation or the abandonment of processes compliant with the model after an evaluation?).

From interviews with members of the SEPG of assessed companies, responses were transcribed into documents which collected their quotes. We did not use seed categories - an initial set of codes to begin coding has been created in vivo codes from the text of the questionnaires. In some codes, the quotes are changed to facilitate reading and to collect more citations. These changes have led to codes found that resembled with those components of critical success factors of [16].

The step of open coding and axial is overlap and come together because of the interactivity of the process. The codes and categories identified gone through successive revisions, of which 28 were produced codes associated with three categories and two subcategories, and all under a central category.

The core category called "Factors that influence the maintenance", and this has (using the notation "is a part of" as suggested by [20]), the following categories "Social and Cultural", "Technical", "Resources and Commitment". The Figure 1 presents, graphically, this organization.

As a memo, during the search were found many citations that reported results of a company with a presence and the with a absence of the same factor. Thus, to avoid creating two categories show that the presence and absence of them in companies realities, it was decided to add these quotes in just one factor, which would be named on the presence of the same, but would add that the quote also reported their absence. And you are using the notation "Evidence of difficulty" for when they were found only quotations that show the influence of a negative factor related to maintenance.

In several, the category with more quotes aggregated is one that combines technical factors, in other words, is the one that has a direct connection with the model MPS.BR. Two subcategories were used in those categories, to aggregate the coding process areas, given as the more difficult to keep the outcomes of the G level. Figure 2 shows the connection of these codes with the category "Technical" through the use of the notation "is a" according to [20].

In this category codes that stand out are “Process has many activities”, “Process inflexible”, that complain about the bureaucracy and about the inflexibility of the model. One of the respondents cited “If it were a process more flexible and it had not so many activities, it would be an easier process for the company to keep”. Another that stands out is the code that denotes a bidirectional traceability requirement, by the model in GRE3 expected outcome, thus confirming what was said in our quantitative research.

Another category coding was found in the "Social and cultural", which collects the social and cultural factors that may influence the maintenance process of acceding to the model as follows in Figure 3.
The code that stands out in this category is the "Institutionalization of Good Process", one respondent commented that to avoid abandonment of the processes is necessary to "Add the process and project management to the company's culture."

The last category involves the factors that mention the need for resources, be they personal, cost or time, or the need for commitment of members involved in the process, managers or senior management. Figure 4 represents the connection of these codes.

"Commitment of top management" was the code of this category that received more citations, confirming its importance as an influencing factor. Even the responses relating to this factor was mentioned that "top management commitment is one of the main factors that help maintain. The more committed to senior management, easier to maintain the process ".

V. CONCLUSION AND FURTHER WORKS

This work presented the result of a literature review, a survey and a qualitative research, using Grounded Theory, related to the difficulties that the software organization faces to maintain the adherence of their software processes to the maturity models, after the assessments.

The results corroborated with the literature findings, that is, the software organizations have a lot of difficulties to continue to perform some practices, considering the competitive scenario of the industry of software.

This work can be used by the software organizations to guide their actions to do not permit the abandon of some practices necessary to the adherence to the models.

As further works, we intend to increase the size of the sample and define a set of actions that may facilitate the implementation of the most difficult practices (expected results).

REFERENCES


