The Influence of Human Aspects on Software Process Improvement: Qualitative Research Findings and Comparison to Previous Studies

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Abstract— Background: Understanding how to successfully deal with human and technical aspects involved in Software Process Improvement (SPI) programs is a challenging issue. Technical aspects are not enough to guarantee the success of activities. Human factors (e.g., experiences, opinions and perceptions) impact the effectiveness of SPI programs. Aim: this paper aims to improve our current understanding on how human aspects can influence SPI programs from the point of view of the professionals involved in such efforts. We compare our findings with the results of previous studies in order to analyze the different contexts in which human aspects influence SPI. Method: We conducted a qualitative study in the context of small companies involved in SPI programs in Amazonas State in Brazil based on the Brazilian Maturity Model - MPS.BR. We used semi-structural interviews with software engineers. Results: We identified new characteristics that motivate actors to get involved in SPI programs. Finally, while previous research indicated that the process of individual decision making as a negative aspect, we identified this as a positive aspect. Conclusions: Despite the differences in companies’ size and maturity models, our findings corroborate many of the important results of previous case studies. The consistency of the presented results with previous research in different organizations, teams, and countries suggest that these results are true for software engineering in general. However, there were differences related to the motivating factors and the perception of the individual decision making. In our study, we observed that the personality, perception and employee selection aspects were also significant to the SPI program’s success. This has not been reported before in the literature. In fact, we need to stress that studies like the one presented are important because they help to create a body of evidence regarding SPI.

Keywords: Human aspects, Software Process Improvement, Qualitative studies.

I. INTRODUCTION

During the last years, software companies have been more and more concerned about Software Process Improvement (SPI) programs [1]. In this context, the SPI literature presents many papers that discuss the aspects involved in such programs, including motivations, resources and professional capabilities. There is a concern in understanding the interaction among these aspects, commonly denominated Critical Success Factors (CSF) [2], their causes, effects and, if possible, their treatment.

Seaman [3] argues that Software Engineering (SE) is a complex discipline because it combines both human and technical aspects. The actors involved in the software development process are of particular interest, since the success of most SE activities, including SPI activities, depends frequently on their behavior and commitment [3][4]. Hall and Wilson [5] point out that the experiences, opinions and perceptions of software practitioners affect the effectiveness of SPI programs. Understanding how to successfully deal with human and technical aspects involved in SPI programs is a challenging issue [1]. There is a need to better understand how human aspects influence the execution of SPI activities.

One way to investigate human aspects is to use qualitative methods. Such methods support a better comprehension of the issues that need a more specific and detailed analysis. According to Seaman [3], the use of qualitative research allows to consider human behavior and thoroughly understand the object studied.

Several studies discussed the critical factors that influence SPI programs [2]. However, the amount of qualitative studies in the area is still below the necessary to enable a better understanding of such factors in different contexts [6]. In order to address this gap, we have conducted a qualitative study in two different small organizations to shed light on human aspects in the context of SPI programs. We analyzed the obtained data using Grounded Theory (GT) [7] procedures. Furthermore, we also compared our finding with the outcomes from other studies describing companies’ experience with SPI.

The remainder of this paper is structured as follows: Section II presents the definition of the human aspects considered on this research. Section III and IV present the
details of the qualitative study and our findings. Section V compares the major outcomes from this research with previous results from the literature. Finally, we present our conclusions and future research suggestions in Section VI.

II. HUMAN ASPECTS

The human aspects considered on this present work are based on the concepts of organizational behavior proposed by Robbins [8]. Robbins’ concepts are often used in social science [9] and software engineering research [10, 11]. Table I shows the definitions of the human aspects in [8].

<table>
<thead>
<tr>
<th>Human aspect</th>
<th>Description</th>
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<tbody>
<tr>
<td>Motivation</td>
<td>Processes responsible for an individual’s effort intensity, direction, and persistence towards attaining a specific goal.</td>
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<tr>
<td>Personality</td>
<td>Ways in which an individual reacts and interacts with others.</td>
</tr>
<tr>
<td>Emotions</td>
<td>Intense feelings that are directed at someone or something.</td>
</tr>
<tr>
<td>Perception</td>
<td>A process by which individuals organize and interpret their sensory impressions in order to give meaning to their environment.</td>
</tr>
<tr>
<td>Training</td>
<td>Process which goal is to improve professionals’ performance on organization through preparation and improvement of professionals’ abilities and knowledge.</td>
</tr>
<tr>
<td>Learning</td>
<td>It is any relatively permanent change in behavior that occurs as a result of experience.</td>
</tr>
<tr>
<td>Leadership effectiveness</td>
<td>The ability to influence a group toward the achievement of goals</td>
</tr>
<tr>
<td>Job Satisfaction</td>
<td>A general attitude toward one’s job. A positive feeling of one’s job resulting from an evaluation of its characteristics.</td>
</tr>
<tr>
<td>Individual decision making</td>
<td>It occurs as a reaction to a problem in an organization. Every decision needs a data interpretation and evaluation.</td>
</tr>
<tr>
<td>Performance appraisal</td>
<td>Traits, behaviors and individual task analyses outcomes using professional productivity variables</td>
</tr>
<tr>
<td>Attitude Measurement</td>
<td>Evaluative statements or judgments concerning objects, people, or events.</td>
</tr>
<tr>
<td>Employee selection</td>
<td>Process which goal is to adequate the personal characteristics for job requirements.</td>
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<tr>
<td>Work design</td>
<td>Responsibilities, job satisfaction and motivation depend on work design because an incorrect definition of the activities can affect the professional’s behavior.</td>
</tr>
<tr>
<td>Work stress</td>
<td>A dynamic condition in which an individual is confronted with an opportunity, constraint, or demand related to what he or she desires and for which the outcome is perceived to be both uncertain and important.</td>
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</table>

These are the human aspects that form the basis of this research. We show the design of our qualitative study in the next Section.

III. RESEARCH DESIGN

We developed a qualitative research in which we observed people who worked in companies executing SPI programs. We visited two different software organizations where we interviewed managers, analysts and software developers. These software organizations were the two first companies in the Amazonas state to achieve level G in MPS.BR (Brazilian Model of Software Process Improvement [12]). The level G of MPS.BR consists of the Project Management and Requirement Management processes. Compared to CMMI-Dev [13], these processes correspond to three process areas: Requirements Management, Project Planning and Project Monitoring and Control.

These two software organizations are small companies with less than fifteen collaborators. Such companies develop corporative solutions and focus on web software technologies. We discuss the stages of this research in the next subsections.

A. Data Collection

We prepared a questionnaire with open questions about the human aspects described by Robbins [8]. Table II shows some of the questions and their relationship with the human aspect addressed in this work. Some of the questions addressed the aspects of other professionals in order to avoid personal bias in the answers.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Human aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>How did you assimilate the knowledge needed for the SPI activities?</td>
<td>Learning, Training</td>
</tr>
<tr>
<td>How did you judge the other professionals’ motivation?</td>
<td>Motivation, perception, Attitude Measurement</td>
</tr>
<tr>
<td>Which were the senior managers’ attitudes when some activity didn’t work? What did you think about such attitudes? How did you react about this?</td>
<td>Motivation, job satisfaction, Attitude Measurement, Work stress and emotions</td>
</tr>
<tr>
<td>How did you classify the other people’s disposition about the SPI program?</td>
<td>Personality, perception and work stress</td>
</tr>
<tr>
<td>How were the responsible for the SPI activities selected? How were the activities conducted?</td>
<td>Individual decision making</td>
</tr>
<tr>
<td>Which is your perception on the SPI program leadership?</td>
<td>Leadership effectiveness, Perception</td>
</tr>
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</table>

In order to address ethical needs, we created a free consent term to inform about research procedures and confidentiality. The interviews took place in the interviewees’ offices and the researcher did not rush the interview so that the interviewee could express his/her opinion effectively.

We conducted two periods of data collection and analysis. Each analysis was held after each data collection phase. Readers must take note that the sampled practitioners within the analyzed organizations are representative of practitioners as a whole. The main reason for this assumption is that the five collaborators that we selected for the interviews were in charge of the SPI activities. In addition, the data was collected from software organizations that were tackling real SPI implementation issues on a daily basis. Therefore we have high confidence in the accuracy and validity of data.

B. Data Analysis

Before initiating the analysis, each document’s content was verified. We explain how we used the GT stages to perform the data analysis.

Grounded Theory (aka Data Grounded Theory) uses a set of systematic data collection and analysis procedures to generate, prepare, and validate substantive theories on essentially social phenomena, or on wide social processes [14]. Glaser and Strauss [14] state that there are two basic types of theories: formal and substantive. The substantive type is specific to a given group or situation, and does not aim at
generalizing away from its substantive area. Although the purpose of the GT Method is the construction of substantive theories, its use does not necessarily need to remain restricted only to researchers who have this research goal. According to Strauss and Corbin [7], the researcher may use only some of its procedures to meet one’s research goals.

The Grounded Theory is based on the coding idea which is the process of analyzing the data. The coding process can be divided into three stages: open, axial, and selective coding. The open coding involves the data’s breakdown, analysis, comparison, conceptualization, and categorization. Figure 1 shows how we carried out the open coding stage.

The selective coding allows the identification of the core category, with which all others are related. We decided not to elect a core category yet (postponing the selective coding phase), because this cannot be done until the theoretical saturation is reached [7]. After the analysis, two others researchers verified those codes and categories created in order to audit the coding process.

IV. OUR RESULTS

In Santos et al. [15], they discussed primary findings about some human aspects, specially motivation, learning and work stress. That paper showed that work stress can create a delay on execution of SPI activities. In this section we discuss our results from the qualitative research on critical human aspects on SPI. We discovered major findings for some of the human aspect presented on Section II. Our implications from these results are described as follows.

Motivation: We encountered some causes that make professionals motivated: (a) organizational innovation (they were the first two organizations that achieved one level of the MPS.BR model in the Amazonas state); (b) achieving the level proposed in SPI model evaluation; (c) professionals’ integration activities; and (d) gaining new SE knowledge. The quotation from interviewee 3 shows and example of cause ‘d’:

“We are talking about the software engineering and information technology areas. We are having professional growth, we are earning knowledge, and therefore, this has motivated us.”
-Interviewee 3

According to other interviewee, just achieving the level in the SPI model without obtaining the comprehension about the benefits of SPI can create de-motivation. Other identified de-motivating factors are: the feeling of obligation related to SPI activities; the lack of reward system; or, the lack of professionals’ acknowledgment by senior management. This is illustrated in the following quote.

“In order to motivate the professionals, I think it is necessary that senior management praises professionals that had more dedication, giving some bonus for instance.”
-Interviewee 1

Personality: Our research identified the personality characteristics as: (a) proactivity (see the following quote); (b) capability to motivate other professionals (one professional said he motivated his colleagues and stated this was important for the SPI program); and (c) responsible professional examples (responsible professionals have to be the first to complete their activities).

“I’ve always taken initiatives. This has contributed so much for the success of the activities.”
- Interviewee 5

Perception: The perception about the SPI program showed that the professionals and senior managers understood its real benefits. This aspect makes collaborators have a better understanding about the whole process and motivates the identification of problems during the activities execution.

“I perceive the improvement program as a process to help us in software development and help with a better understanding on: what are we doing, how are we doing the activities (...)”
- Interviewee 1

Learning: Our outcomes show that learning occurs when professionals practice the new knowledge gained in the SPI program. Previous knowledge about software process helps in learning the new SPI related activities. On the other hand, when the professionals only take the SPI courses, the knowledge earned is low. We also indentified that the difficulty to assimilate some concepts about SPI has consequences: delay to complete and deliver the work products. The possible cause of this delay can be associated with the insufficient knowledge in Software Engineering (SE):

“The process took us more time, mainly because we needed to learn how to do the activities.”
- Interviewee 1

Individual decision making: The aspect associated with individual decision making of SPI programs shows that the decisions about SPI judgments should be taken consciously. The reasons need to be analyzed, evaluated and discussed with the responsible(s) for the SPI program. If necessary, these decisions should also be discussed with certain collaborators before they are reported for the entire organization. This is illustrated in the following quote.
“We understood everything together before we communicated with other professionals. If I had done a mistake in documentation, she would have corrected me.”
- Interviewee 5

**Employee Selection:** The employee selection aspect should consider some professional experiences. In one organization, the professionals were selected just due to the fact that they were already allocated for the projects designated for the SPI program. In other organization, the professional competence in previous activities was evaluated:

“To select professionals, we observed their previous performance in other projects.”
- Interviewee 2

Due to space limitations, we have summarized the other identified human aspects in Table III. In addition Table III also shows some suggestions for treating human aspects based on the analyses made on this research.

**TABLE III. OTHER IDENTIFIED HUMAN ASPECTS IN THIS RESEARCH**

<table>
<thead>
<tr>
<th>Human aspect</th>
<th>Findings</th>
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<tbody>
<tr>
<td>Training</td>
<td>It is necessary to develop training about the SPI activities. Training can support the definition of professional roles. Also, this aspect can contribute to professional development.</td>
</tr>
<tr>
<td>Leadership effectiveness</td>
<td>We suggest senior managers to verify the professional leadership capabilities. Exclusive professional dedication to coordinate the SPI program inside organization can guarantee the SPI activities success.</td>
</tr>
<tr>
<td>Job Satisfaction</td>
<td>Collaborator benefits, like work time flexibility, can increase job satisfaction during the execution of SPI activities.</td>
</tr>
<tr>
<td>Performance appraisal</td>
<td>Our results suggest the evaluation of professionals to identify improvement performance points. Performance depends on the type of activity performed by collaborators.</td>
</tr>
<tr>
<td>Work stress</td>
<td>Senior managers need to evaluate the events that can cause stress on professionals. It is necessary to guarantee a better performance.</td>
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</tbody>
</table>

**V. COMPARING OUR RESULTS WITH PREVIOUS RESEARCH ON LITERATURE**

In this Section we compare our findings with the results of previous studies about SPI. The most relevant comparisons are described as follows. Readers must take note that other comparisons regarding human aspects are shown in Table IV.

**A. Comparison Findings**

**Comparison about Motivation:** The motivational factors: to organize the process, to obtain new knowledge, to achieve the level on SPI model; are also presented in [16][17][18][19]. We have confirmed the statement in [16][17][18][19], which indicates the importance of analyzing the motivational factors described on Section IV to improve professionals’ commitment. Moreover, we also observed that senior managers could not motivate all professionals due to the lack of a reward system. In the literature we found similar affirmation [16]: “the motivation is connected to incentives as reward and group acceptance”.

We observed the professionals’ integration activities as a different motivational factor regarding the literature factors. Integration activities can create professional motivation because they increase the interaction between the collaborators and senior managers.

**Comparison about Learning:** About the learning aspect, Dybå [1] points out that it is important to explore new knowledge. During our research one professional said that new knowledge is fundamental to the execution of SPI activities, because they do not have enough knowledge about Software Engineering. This statement corroborates our findings as we managed to observe the importance of previous and new knowledge in the interviews.

We found out that most SPI activities were new in both organizations. Therefore, it was necessary to guarantee enough knowledge about software process and software engineering concepts. Rocha et al. [20] described that the most relevant problem in SPI programs is the insufficient team capability in Software Engineering concepts. We found out a similar outcome as our results show that professionals have to practice the new knowledge in order to absorb the new concepts.

**Comparison about Individual Decision Making:** The results in [20] indicate that the process of individual decision making had difficulties and created delays whenever it was necessary to consider several opinions. However, according to our results, this was seen as a positive factor because the professionals enjoyed to discuss a better decision about SPI activities before executing it.

**TABLE IV. OTHER HUMAN ASPECTS COMPARISON**

<table>
<thead>
<tr>
<th>Human aspect</th>
<th>Comparison Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>In [16] and [21], the authors agree that it is important to increase and maintain the professionals’ capabilities. Our work findings showed that training gives sufficient knowledge to professionals to execute the SPI activities.</td>
</tr>
<tr>
<td>Leadership effectiveness</td>
<td>Rocha et al. [20] affirm that “the inexistence of a responsible professional to coordinate a SPI program with exclusive dedication was a critical factor to implement the SPI program”. The leader capabilities contribute to increase the activities success.</td>
</tr>
<tr>
<td>Job Satisfaction</td>
<td>About job satisfaction Rocha et al. [20] verified that the changes on traditionally “ad hoc” activities were difficult to be accepted by software developers. We observed that some professionals were not satisfied with the SPI program due to the cultural change.</td>
</tr>
<tr>
<td>Performance appraisal</td>
<td>Different performance levels of the professionals can create internal conflicts that have an impact on SPI programs [20]. The participation of all professionals is essential for the success of the SPI program [22]. Nevertheless, in our study, the different levels of performance did not influence enough to compromise the SPI program success.</td>
</tr>
<tr>
<td>Work stress</td>
<td>Baddoo and Hall [16] show that the work stress aspect can influence the professionals in a negative way. In our findings we observed that pressure can create work stress. There was a pressure about the deadline for activities conclusion because the organizations had a date for the SPI evaluation.</td>
</tr>
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</table>

We found out that personality, perception and employee selection aspects were also significant to SPI program success. However, we did not find anything similar to make comparisons in the consulted literature.

**B. Comparison Outcomes, Benefits and Research Gaps**

Our findings regarding the influence of human aspects on the SPI programs carried out in Amazonas state (Brazil) have
relevant similar results compared with previous studies. The consistencies in our results with previous research in different organizations, teams, and countries suggest that these results are true for software engineering in general. However we found some differences due to the context of software organizations:

- We found a different motivation factor, not yet listed in previous studies: professionals' integration activities. In future studies, researchers shall observe if these activities help motivate professionals in different SPI contexts;
- The fact that individual decision making process caused delays was perceived as a positive factor, because the professionals prefer to discuss before making decisions.

It is relevant to conduct other studies to obtain more findings about the influence of other aspects, such as emotions, attitude measurement and work design. These aspects involve several variables that can also influence SPI programs.

VI. CONCLUSIONS

This paper has presented how human aspects can influence SPI programs from the point of view of the professionals involved in such efforts. We interviewed five people from two companies that achieved the level G of Brazilian SPI Model (called MPS.BR [12]) in the state of Amazonas, Brazil.

We found out that the following aspects influence SPI programs: learning process, training, motivation, job satisfaction, personality, leadership effectiveness, making individual decisions, work stress and perception. The analysis of the results of this qualitative study can help practitioners and researchers in successfully implementing SPI programs.

We presented a comparison between our findings and previous studies outcomes in order to analyze the different contexts. This comparison verified that our findings were similar to the results of previous studies. However, we observed that the personality, perception and employee selection aspects were also significant to SPI program success.

These aspects can influence SPI activities by solving SPI problems, increasing the perception of SPI program benefits and using professionals' characteristics for employee selection.

Each qualitative study contributes to advancing the state of art in a research area, providing evidence and hypothesis that can be later tested using quantitative methods. We aim to continue contributing with the creation of a body of knowledge about SPI human aspects by validating our findings in a new SPI program. This validation will allow us to understand the extent to which our results can be generalized, and identify which other contextual factors affect the human aspects we identified.

ACKNOWLEDGMENT

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