The Impact of Software Process Improvements in Small and Medium Scale Enterprises

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Abstract*—Most of the software development companies around the globe are small and medium scale enterprises. These organizations are considered as the back-bone of the world economy (In the year 2008, more than 85% of the companies in US, China, India, Finland, Ireland etc are small and medium scale enterprises). These small and medium firms have realized that improving their process and working methods are crucial for their business, but they are lacking in the knowledge and resources to implement it. Successful software process improvement implementation is a herculean task for these small and medium enterprises since they are not capable of investing the cost of these programs. There is insufficient knowledge about which innovations are effective, and which factors influence the adoption of software process improvement in small and medium enterprises. There is enough evidence that the majority of small software organizations are not adopting existing standards as they perceive them as being oriented towards large organizations and studies have shown that small firms' negative perceptions of process model standards are primarily driven by negative views of cost, documentation and bureaucracy. In this paper, we present the current significant software process improvement methodologies for small and medium enterprises comparisons, and a proposed methodology for future studies.

Keywords*—Software quality, Small and Medium Enterprises, Software Process Improvement, Software Process Improvement Methodology.

I. INTRODUCTION

It is well aware that the software quality is mostly dependent on the process that is used to create it. The software Small and Medium Enterprises (SMEs) plays an important role in software production. It was individual SMEs or they were involved in large companies or projects [1]. For many years from now, Software Process Improvement (SPI) has been recognized as an efficient and effective way for firms to improve their quality of the software they develop and the productivity with which they work with. V.M. Paula et al [19] states that the existing process models do not support informational and behavioral aspects of the software development process. To ensure the quality of the product, reduce costs and maximize productivity, every software firms need a well-understood and managed software development process.

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But there is enough evidence that the majority of small software organizations are not adopting existing standards as they perceive them as being oriented towards large organizations and studies have shown that small firms' negative perceptions of process model standards are primarily driven by negative views of cost, documentation and bureaucracy [10]. This paper discusses the above issues and proposes new software process model that can be used in small and medium enterprises. A new model is proposed based on the traditional software process development models such as Capability Maturity Model (CMM), Capability Maturity Model Integration (CMMI), and International Organization for Standardization (ISO) and Software Process Improvement Capability Determination (SPICE). There are basically large gains to be made within the industry by the wider implementation of SPI, but as yet the use of models such as CMM within small organizations has been limited. There is a general agreement that they cannot be applied unmodified to small organizations [6]. Many researches were carried out in order to determine what modifications must be made to the model, to make it effective and efficient in these development environments. According to Johnson and Broadman [6], tailoring is needed in specific areas, such as documentation, management, review, resources and training. Major improvements can be achieved by improving the technical issues of the process rather than organizational issues [9], and proposed a model that integrate CMM with the ISO 9001 and ISO 9000-3 models.

Even though these results are encouraging, many questions remain unanswered. Generally, SMEs operate on strict financial constraints. So SMEs require low-risk strategies that relatively show results quickly for any kind of investment of resources. Among the studies, which generic model provides the most reliable way to achieve these results? Can risk assessment and minimization be factored into the SPI model? How can SPI be used to the organization's business goals? How can a software measurement be used effectively within the SPI programme? How can we assess the effectiveness of the SPI programme, so that the management can see the return on their investment? A proposed model will provide an answer for all these existing issues.

II. SOFTWARE PROCESS

Software Process is defined as a set of tools, practices and methods to produce software products according to a specific plan [19]. Providing a suitable organizational stability and good control are the main objectives of the software process. Even though there are a number of software process definitions, all these definitions have the same aim of helping the software engineers to develop a software of high quality.

According to R.S.Pressman [15], the software process is a framework of tasks to built high quality software.

Somerville [9] stated that the software process is a structure of activities to develop software systems and pointed out that software process consists of the four activities: (1) Software Specification; (2) Software Design and Implementation; (3) Software Validation; (4) Software Evolution.

III. SOFTWARE PROCESS IMPROVEMENT TRADITIONAL MODELS

Any software process improvement plan requires a true and qualified statement about the current status of software development in the organizations and a description of strengths and weaknesses used to identify the areas of improvement. On the basis of previous studies, we have selected five SPI methodologies that have been already implemented in SMEs. The following section discusses general information about the models:

A. Capability maturity model

The Capability Maturity Model (CMM) was developed by the US Department of Defense at Software Engineering Institute (SEI). The model's objective is to improve the existing software development processes, but it can also be used to other processes. It was originally developed as tool for objectively assessing the ability of government contractors' processes to perform a contracted software project. Even though the model comes from the field of software development, it is also used as a general model to aid in business processes globally. The main focus of this model is on managing the process and to develop a process maturity framework to help the organization to improve their software process by using the following five maturity levels (initial, repeatable, defined, managed and optimized levels).

But this model is having certain disadvantages: (1) When organizations use CMM, they look at each level as a target, they make their goal to reach the next level up, this can be a dangerous thought because if you become fixated on reaching the next level, you may forget the real goal, that is to improve the processes; (2) The CMM does not specify a particular way of achieving these goals. In order to achieve the goals, one needs to think in a flexible way, the goal will only be achieved if the organizations processes are taken into account, as each organization is different so that the steps needed for process improvement will also be different; (3) CMM only helps if it is put into place early in the software development process, that is, if there is a process that is in a crisis, then CMM will not help overnight, it cannot be used as an emergency method for recovering from a difficult position; (4) finally, CMM is concerned with the improvement of management related activities, not giving importance to the process related activities.

B. Capability maturity model integration

Capability Maturity Model Integration (CMMI) can be used to guide process improvement across a project, division, or an entire organization. Under this methodology, processes are rated according to their maturity levels, which are defined as initial, repeatable, defined, qualitatively managed and optimized. The model was created by Software Engineering Institute by combining the CMM models (SW-CMM V2.0, Integrated Product Development (IPD), and System Engineering CMM (SE-CMM) [15]. The purpose of CMMI is that it helps to integrate the different organization functions.

The disadvantages of CMMI are (1) may not be suitable for every organization; (2) it may add overhead interms of documentation; (3) may require additional resources and knowledge required in smaller organizations to initiate CMMI-based process improvement; (4) may require a considerable amount of time and effort for implementation and (5) require a major shift in organizational culture and attitude.

C. Software process improvement and capability determination (SPIC E)

International Organization for Standardization and The International Electrotechnical Commission jointly developed the Software Process Improvement and Capability Determination (SPICE). It is developed to support the development of an international standard for Software Process Assessment. SPICE is also known as ISO/IEC 15504. The main objective in its development is to provide the software industry with gains in productivity and quality.

D. International organization for standardization (ISO)

The purpose is to guide the software development and maintenance. The first edition of ISO 9000 Quality System Standards was published in 1987 and revised this model in 1994 and 2000. ISO 9000 series is the standard used to provide the guidance of quality management (ISO 9000 & ISO 9004) and quality assurance (ISO 9001, 9002, 9003) [11].

E. Bootstraps

The methodology developed in the ESPRIT (the European strategic Programme for Research) in Information Technology project from October 1991 to February 1993. The main goal of this is to speed up the use of technology in European software industry.

IV. SOFTWARE PROCESS IMPROVEMENT CRITICAL SUCCESS FACTORS

Most researchers introduced the concept of Critical Success Factors (CSFs) to identify the areas where close attention must be focused. Since the introduction of the concept by Rockart [11], CSFs studies have been shown to be useful in the analysis of the implementation and use of information systems and management practices. There are lots of classifications of these critical success factors. Even though, Hall et al [18] grouped these critical factors into four as follows:

A. SPI economic factors

It is not easy to measure the value of process improvement in terms of lower risk, staff monthly productivity, improved quality, or customer satisfaction [14]. Many earlier researches in the past have claimed to have determined the Return on Investment (ROI) for process improvement.

B. SPI people issues

The process determines the success of the outcome of the software project, and that all personnel must be interested in the process [15]. Some researchers pointed out these people issues as following: (1) Management commitment and

SPI leadership, (2) Staff involvement, (3) Mentors, (4) Training and expertise, and (5) Motivation.

C. SPI Organizational Factors

Many researchers have derived these factors into six (human, political, cultural, goals and change management). However, Aileen [14] distributed these factors to three dimensions, which focused on communication between the employees and the availability of resources to achieve all needed improvement.

D. SPI implementation factors

There are a variety of implementation factors which can cause well-planned SPI initiatives to result in failure suc as setting realistic objectives, SPI infrastructures, evaluation and readiness [18].

V. SMALL AND MEDIUM ENTERPRISES (SMEs)

These are companies whose personnel numbers fall below certain limits. SMEs are also said to be responsible for driving innovation and competition in many economic sectors. SMEs represent a high proportion of firms in most countries all over the world. They represent more than 85% of all firms in the US, Canada, China, India, Finland, Ireland and many other countries [2]. Depending on the study conducted by Hofer in Australia [4], the size of small firms is between 10 to 50 employees. The characteristics of small and medium enterprises according to Hofers [4] are given in table 1.

Characteristics	**Approximately ratio in small firms (%)**
Internal project meetings are held regularly	90%
Serve mainly regular customers	65%
Projects often last longer than planned	50%
Employees often work overtime	73%
Marketing is an important part of the company philosophy	75%
Investing in training of employees	78%
Quality management is important	87%
Continuous documentation of all tasks	6%
Traditionally structured company	52%
Teamwork is important	99%
Customer involvement all the time	80%
Develop software for many different domains	50%
Always newest technology	80%
Dynamic and flexible company	94%
Customer support is important	95%
Often use new methods and techniques	75%

Table 1: Characteristics of Small Software Firms, by Hofer [19]

VI. SOFTWARE PROCESS IMPROVEMENT IN SMALL AND MEDIUM ENTERPRISES

The intention to carry out the process assessment and improvement activities is to collect information as to what needs to be changed and to establish how to pursue the improvements in order to minimize development cost and maximize the quality of products. Existing software engineering literature states that there are fundamental operational differences between small and large organizations. Small organizations are concerned with practice and large organizations with processes. Abbott [1] identified six key points to software process improvements in small and medium enterprises and they are: (1) Senior management support; (2) Adequate staffing; (3) Applying project management principles to process improvement; (4) Integration with ISO 9001; (5) Assistance from process improvement consultants; (6) Focus on providing value to projects and to the business. Johnson and Broadman [6] identified seven small organization challenges:

- Handling requirements
- Generating documentation
- Managing projects
- Allocating resources
- Measuring progress
- Conducting reviews
- Providing training

Larsen and Kautz [12] viewed that these organizations afraid of the initial expenses which they assume are large both with regard to direct costs for process assessment, training and tools, but also due to indirect costs for personal and time resources when implementing improvement actions. It is quite difficult for any small SMEs to select an improvement approach, and to apply it in their organization without the external help from the consultants. Some of the shortcomings faced by SMEs are: Excessive documentation, Extensive number of Specific Practices (SP), Requirement of extensive resources, High training costs, Practices independent of project type, Lack of guidance in satisfying project and development team needs and Many of the smaller companies oppose the CMMI model due to the expensive compliance effort, both in time and money [9]. There is insufficient knowledge about which Innovations are effective, and which factor influence tha adoption of SPI in SMEs. It is important to understand the processes currently used and to evaluate the effectiveness of process improvement programs, or investments in SPI are wasted [17] .

VII. DISCUSSION

All the above mentioned SPI methodologies are divergent in characteristics; it is required to find out some significant and common attributes so that we can find a comparative view of all the selected approaches. Kautz et al [12] concluded in their findings that primary lesson for the small organizations, which wish to perform improvement activities, is that it makes sense to use a structural model to organize the process. They further suggests the secondary lesson is that the model should be adjusted to the particular conditions of the organizations and the third lesson is that it make sense to perform the improvement activities as a project with clearly assigned and documented roles, responsibilities and resources. He further pointed out the significance of factors to be studied further like management support and commitment, project planning

and organization, education and training, assessment, monitoring and evaluation, staff involvement, support and knowledge transfer by external consultants, usability and validity of the introduced changes and cultural feasibility for process improvement in software SMEs.

VIII. FUTURE WORK

After verifying all the problems with the existing software process improvement methodologies, we come to a conclusion that the proposed methodology can be used for future work which is aimed at helping small and medium enterprises to implement and improve their software processes. To help small and medium scale industries, we need to analyze and find the characteristics of these enterprises depending on the literature reviews conducted earlier since most of the enterprises (small and medium) are having the same or similar characteristics. To check the software process improvements success factors, we need to determine the software process activities. To improve the software business processes, select the most appropriate software process models that are used in SMEs. Select the most suitable SPI traditional models, Compare these models with the software process models and figure out the missing activities. Then, modify the software process activities to attain all process areas of SPI model depending on the activities of other SP models. After the completion of these modifications, determine the new SP model requirements and conduct administrative questionnaires on small and medium enterprise to check whether the new modified model meets their requirements. We will get an overall idea after the analysis of the questionnaires. Then we can finalize the final requirements needed for implementing the SPI model for the small and medium enterprises. The following figure shows the development stages of the SP model for small and medium firms.

IX. CONCLUSION

In small and medium enterprises, software process improvement deployment approaches require special concerns due to some constraints regarding material and human resources. Although numerous SPI standards and models have been proposed, their adoption among small organizations is hard due to some size mismatches and to lack of experienced process engineers, which force them to hire external consultants.

Small and medium enterprises need to have suitable software process models that can achieve all the activities of a selected SPI traditional model. This paper discussed this problem and how it can be solved. It purely depends on the comparison between software process models and the characteristics of small software firms, as well as and getting the features required by small and medium firms on SPI model. Then the new SP model will be developed based on these requirements.

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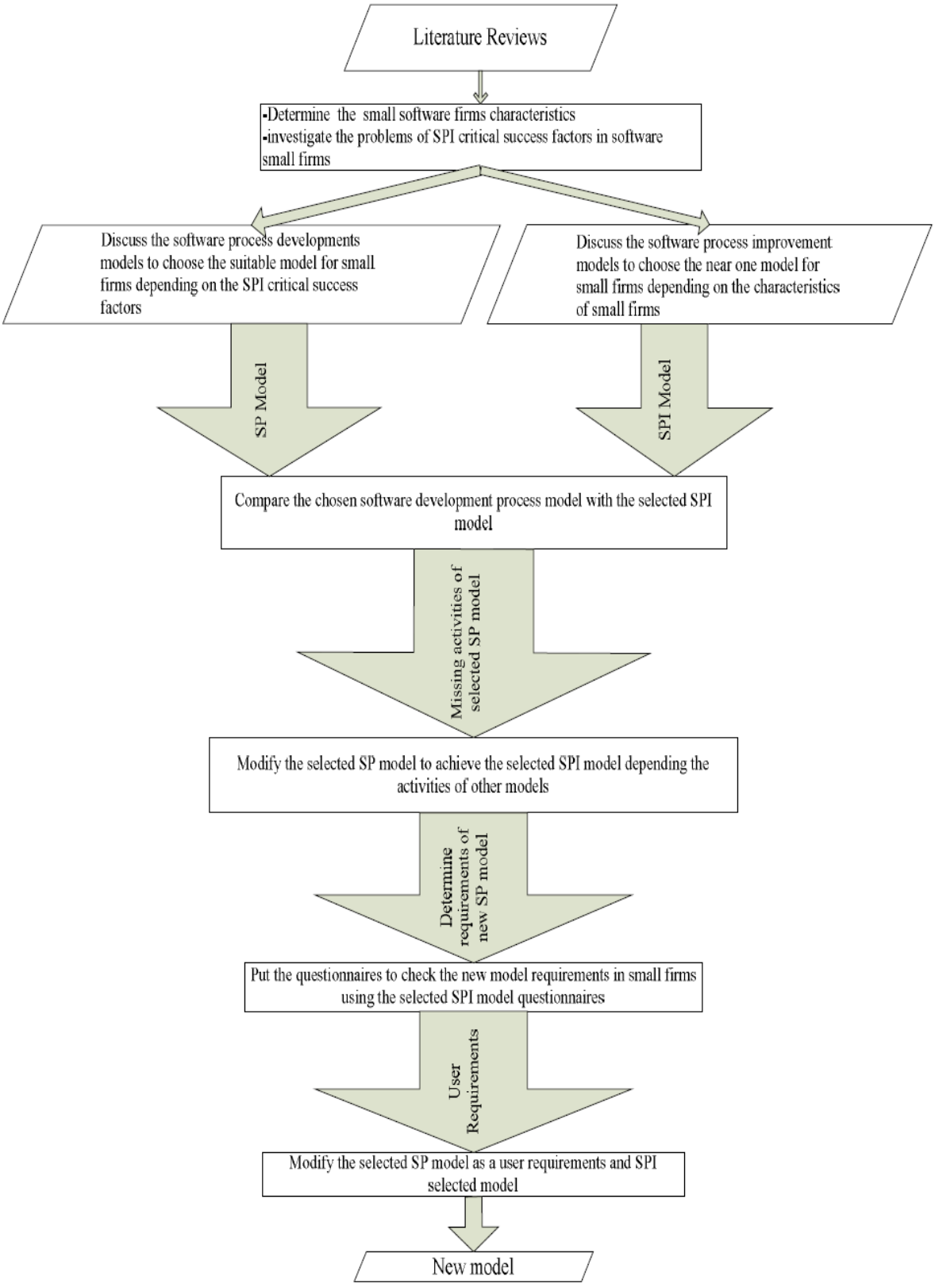

Figure 1 Development Stages of SP Model for SMEs