

# Towards a Model for Managing Success Factors in Software Process Improvement

Joseph Trienekens

Eindhoven University of Technology Den Dolech 2  
5600 MB Eindhoven The Netherlands

**Abstract:** Existing software engineering and management literature argue for many different ways of looking at success factors that influence Software Process Improvement (SPI). This study investigates success factors identified in a number of research projects and proposes a model for managing these factors in a structured way during different phases of an SPI program. It also aspires to describe a model that reflects the cyclical influences of factors in a continuously progressing SPI program.

## 1 Introduction

Many factors seem to influence the effectiveness of Software Process Improvement (SPI) activities. These factors can be of different types, such as organizational (e.g. commitment of management), human (e.g. resistance), technical (e.g. lack of tools), financial (restricted budget). Over the years various papers have been written about success factors of organizational change in SPI.

Although many articles look at factors that drive success in Software Process Improvement activities, they look at them from different perspectives and with different definitions [2]. Some articles look at the factors as prerequisites “written in stone”, while other articles describe them as factors that are possible to influence through various management actions. There is consequently a form of chaos prevalent in the area, and a lack of overview of what drives success in organizational change under SPI. The opportunity to try to create an overview of this field is the area of research that this article will focus on. The purpose of this study is to enhance the understanding of SPI implementation success by investigating various sets of factors found in literature that are argued to have an impact on the outcome of organizational change. Many research projects have dealt with this topic but there is not a high degree of similarity between all these studies [3].

For this paper we selected four articles [1], [4], [5], [6], looking at various aspects of successful SPI. The articles are based on case studies as well as a large number of surveys. The surveys in these articles also contain interviews of managers and practitioners. Several factors have been found and these factors can be used as guideline in the SPI program.

This paper is divided in two parts. Firstly we compare and conclude to the success

factors that are found in surveys and related literature. In the second part we present a model for SPI success factors that reflects the cyclical influences of factors in a continuously progressing SPI program.

## 2 Approach

Articles have been selected that reflected upon different aspects of drivers for success when implementing Software Process Improvement. The paper collection is based on literature, articles, surveys and experiences from different scientific databases. The four papers that have been analyzed address respectively success factors:

- that affect organizational change [6].
- on different levels of maturity [4].
- in large and small organizations [1].
- that affect software processes [5].

This paper will address first the key findings of the different articles and the most important coherences as well as contrasts between the articles. Secondly, a model will be introduced for managing success factors during SPI implementation. The paper's conclusions can be considered as suggestions for companies to decide whether or not an organization is ready to embark on a journey of Software Process Improvement, and if not, what criteria must be improved in the organization if it should have any significant change of becoming successful in the improvement process.

## 3 Investigating SPI success factors

### 3.1 Success factors that affect organizational change

In [6] ten factors are described, which can either positively or negatively affect organizational change in Software Process Improvement (SPI). The article is based on surveys in 56 software organizations that use an ISO 9000 quality system or the Capability Maturity Model (CMM) as a basis for process improvement. A ranking of the ten factors was created based on the frequency of them being mentioned in published experience reports and case studies. The factors ranked in order of decreasing importance are as follows:

#### *Management Commitment and Support*

This factor concerns the degree to which management in all company levels sponsor the change.

#### *Staff Involvement*

Staff involvement addresses the amount of staff members that participate in improvement activities.

#### *Providing Enhanced Understanding*

The degree to which knowledge of current software processes is acquired and diffused across the organization is addressed by this factor.

#### *Tailoring Improvement Initiatives*

This factor is based on the need to customize and adapt a SPI program for local

needs as well for the departments' own strengths and weaknesses.

*Managing the Improvement Project*

This concerns how effectively the improvement efforts are planned and controlled.

*Change Agents and Opinion Leaders*

This factor addresses the people that initiate and support the improvement activities at corporate level, and those who are opinion leaders at the local level.

*Stabilizing Changed Processes*

Once improvement has taken place, this factor describes the organization's ability to maintain the improved state and not fall back into old habits.

*Encouraging Communication and Collaboration*

This factor concerns how communication efforts between different teams and departments are important for SPI activities.

*Setting Relevant and Realistic Objectives*

The subject is how goal setting must both be realistic and for the overall benefit of the organization.

*Unfreezing the Organization*

The lowest ranked factor concerns the inner resistance in an organization that SPI activities must face before embarking on a SPI program.

As a conclusion the paper states that neither ISO 9000 nor CMM in itself provide adequate support on how to implement the elements of an SPI program. Further it is recommended that the success factors should be used as guidelines to prepare an organization for a Software Process Improvement initiative.

### **3.2 Success factors on different levels of maturity**

Many researchers have studied factors that influence Software Process Improvement (SPI) positively or negatively. However not much attention has been given to the impact of success factors at different levels of maturity. In [4] 16 factors have been identified, respectively "inspections"; "reviews"; "standards and procedures"; "project post mortems"; "metrics"; "risk assessment"; "estimating tools"; "automation"; "training and mentoring"; "reward schemes"; "internal leadership"; "internal process ownership"; "executive support"; "experienced staff"; "external consultants"; and "stringent controls". The factors "reviews", "standards and procedures", "training and mentoring" and "experienced staff" have, according to the authors, a major impact on SPI success. For two factors, "estimating tools" and "reward schemes", the majority opinion was that these factors do not have an impact on SPI success. Two factors "reviews" and "training and mentoring" in both lower and higher mature companies have a major impact on SPI success. For differences in factors relating to SPI success, only the factor "training and mentoring" was mentioned.

To summarize, the most prominent factor is "training and mentoring". Respondents think that "reviews", "standards and procedures", "training and mentoring" and "experienced staff" have a major impact on SPI success. "reviews" and "standards and procedures" are related to process. "Training and mentoring" and "experienced staff" are related to skills. Therefore, the authors suppose that an important element of SPI is process improvement in conjunction with skill

development.

### 3.3 Success factors in small and large organizations

Presumably there are differences between small and large organizations regarding the way they implement software process improvement (SPI) programs in order to advance their businesses. However in [1] it is shown that there is no difference in the level of success between small and large software organizations. More important is that large successful and small successful organizations differ fundamentally in their approach to SPI, especially with respect to participation and the preferred mode of learning. In small successful organizations the employers participate and explore new knowledge more than in large successful organizations. The main difference between small and large software organizations is the way in which they react to unstable and changing stimulus situations. Small software organizations in turbulent environments require learning strategies that are more closely aligned with explorative behavior. So, this kind of SPI strategy is based on improvisation. Large software organizations relied on learning from experience to prepare future rather than exploring new possibilities. They kept doing what they did well, rather than risk failure. But on the other hand, software businesses must be able to turn unexpected problems and failure into learning opportunities; successful SPI requires tolerance for failure.

The size of the organization does not limit its potential for SPI success. This means that software companies of any size can advance their businesses by practicing a critical set of SPI elements. Small companies can and do implement SPI elements as effectively as large organizations and achieve high performance. Large successful software organizations emphasize exploitation of their best practices through formal procedures, process models, guidelines, rules and checklists in order to manage and improve their software process. Small successful organizations pay more attention on exploring new possibilities, making the most of diversity and creativity of the human resources involved in software process. To be successful, formal processes must be supplemented with informal, inter-personal coordination about practice.

### 3.4 Success factors affecting software processes

Even though numerous studies have been done there is still a great deal of variability in the success of SPI programs and often it is so that specific success factors don't offer an explanation. The aim of the research in [5] is to get insight into the factors that practitioners think to affect software processes. This study includes many surveys of practitioners' opinions and the investigation was primarily focused on the research question: What factors, as identified by case studies, affect or don't affect software processes?

According to this study two main reasons exist which relate to variability of success with SPI. These main reasons are the factors that affect software processes and the research strategies that are used to investigate these factors. The importance for seven factors that affect software processes was investigated across a survey study and multiple cases study. These seven factors are respectively: "executive support", "experienced staff", "internal process ownership", "metrics", "procedures", "reviews" and "training". In accordance with the study there were two factors, respectively

“reward schemes” and “estimating tools”, which were shown not to be relevant to SPI. Four factors were identified by the survey, but not by the case studies. These factors are: “inspections”, “internal leadership”, “standards” and “mentoring”. In the next section we use Table 1 to compare dimensions and viewpoints on success factors for SPI.

Table 1: Comparing dimensions and viewpoints on success factors for SPI

	Stelzer and Mellis (1999)	Rainer and Hall (2002)	Dybå (2003)	Rainer and Hall (2003)
Problem Area Backgrounds	Neither CMM nor ISO 9000 provides support on how to implement organizational change in SPI	There was not yet any study performed about the impact of factors at different levels of maturity.	There has been no attempt to verify whether small and large organizations implement SPI programs differently in order to advance their businesses	Despite of many studies, there is still a great variability in the success of SPI programs, whose reasons cannot be explained
Article Objectives	Give help on how to implement SPI through identifying success factors, comparing to previous research and examining the generality of the factors	Determine factors that have an impact either positively or negatively on SPI of low and high maturity companies	Investigate whether an organization's size affects its SPI implementation strategy and the degree of SPI success	Get insight into the factors that practitioners think affect software processes Consider research strategies used to study these factors
Research Methodologies	Factors were identified by the authors Empirical research of factors mentioned in case studies for ranking purposes Interviews with German software managers	16 factors were identified. Through the use of a questionnaire, the impact of each factor was determined.	Empirical research through the use of a questionnaire sent to 120 software and quality managers in 55 companies	Empirical research through usage of case studies and interviews with practitioners Usage of quantitative and qualitative analyses

Results of the Articles	Ten factors that affect organizational change in SPI. Factors are the same for both CMM and ISO 9000. Similarities in factors between all industries	Factors that have a major impact and factors having no impact on SPI were found. Four broader themes emerge: people, process, skills and leadership.	The size of an organization does not limit its potential for success. Small should capitalize on employee participation and exploration of new knowledge	Factors that contribute to successful SPI implementation. A multi-strategy approach is necessary for an improved understanding of SPI
Application of the Results	Although factors may seem self-evident, they can be used as a guideline before implementing SPI	Offer recommendations to practitioners of different maturity level companies on SPI.	Provide new understandings and enhance relative strengths for managers of software companies	Give practitioners a set of success factors they can use when implementing an SPI program

### 3.5 Discussion on the investigated success factors

Table 1 indicates the main points of the articles for the aspects: problem area backgrounds, article objectives, research methodologies, results of articles, and possible application of the results. In the next subchapters a discussion of the differences and similarities is provided for each of the aspects of the articles.

**3.5.1 Differences in problem area backgrounds.** As can be seen the backgrounds for the articles differ substantially. In [6] research has as starting point an idea that neither CMM nor ISO 9000 provides enough support on how to implement organizational change in SPI. In [4] a lack of description is identified of what drives success within SPI for different levels of maturity of the organization. In [5] the authors argue that there still is too much variability in the success of an SPI program that cannot be accounted for. In [1] a totally different approach is followed by making a distinction between success factors for large and for small organizations.

**3.5.2 Differences in objectives.** In [6] the objectives were to investigate how to implement SPI though identifying success factors. In [4] research strategies are considered, which can be used to study these factors. In the research they determined factors that have an impact either positively or negatively on SPI implementation success of companies with both low and high levels of maturity. The authors also in their second article [5] want to get insight into factors, which practitioners “in real life” think to affect software processes. In [1] the author seeks to investigate among



others whether an organization's size affects its SPI implementation strategy and the degree of SPI success.

**3.5.3 Differences in research methodologies.** In [6] the authors identified factors in their survey by themselves. They used empirical research of factors mentioned in case studies for ranking purposes. They also interviewed German software managers for background information. In [4] a questionnaire has been used to provide the researchers with data on factors influencing SPI implementation success. The authors identified 16 factors based on previous research. The impact of each factor was determined from the results of the questionnaires. Their second article [5] used quantitative and qualitative analyses, and they compared results of the case studies with the results of the surveys.

**3.5.4 Differences in research results.** In [6] the research resulted in 10 factors that affect organizational change in SPI. The factors found were the same for SPI programs based on both CMM and ISO 9000. They also noticed that there are similarities of factors in all industries. In [4] the authors found factors that have either a major impact or no impact on SPI implementation. In their second article [5], they found many factors, some of these were based on survey and case studies and others were not. They found two main reasons that exist which relate to variability of success with SPI, namely: factors that affect software processes and the research strategies that are used to investigate these factors. They got 26 factors as results that potentially affect SPI. They also noticed that a multi-strategy approach is necessary for an improved understanding of SPI. In [1] the author investigated organizations and found as results that the size of an organization does not limit its potential for success. Small organization should capitalize on employee participation and exploration of new knowledge.

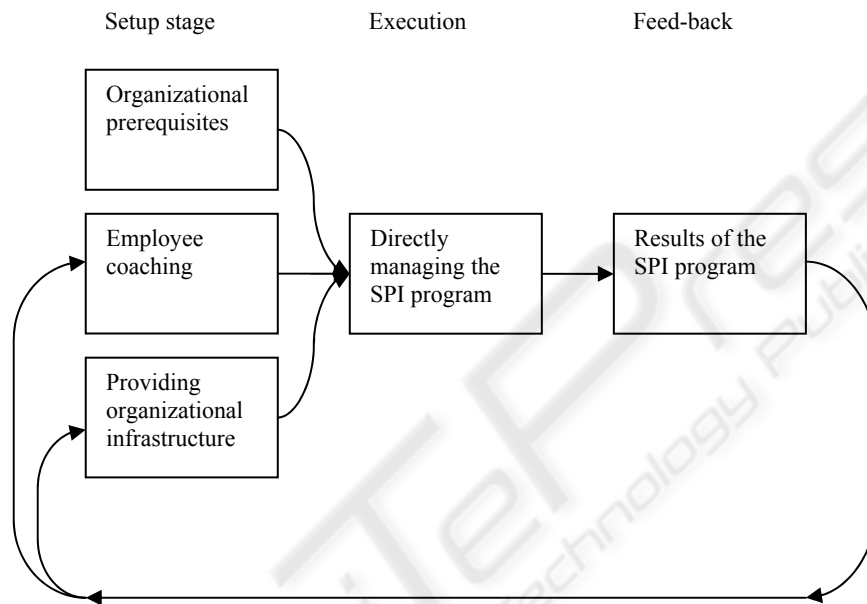
**3.5.5 Application of the results.** In [6] the authors underline that although factors may seem self-evident, they can be used as a guideline before implementing SPI. In [4] also recommendations are offered to practitioners of different maturity level companies on SPI. Based on [5] practitioners are able to get a set of success factors they can use when implementing an SPI program. In [1] the author also offers new understandings and enhance relative strengths for managers of software companies.

## **4 A model for managing success factors in software process improvement**

This section will present a model for managing factors that influence the outcome of SPI efforts. First of all, the factors presented in the different articles have a tendency to be based on different viewpoints. Articles have looked upon the success factors as organizational prerequisites, which, if not fulfilled, make the SPI program pointless. Other articles have looked at the factors that can actually be influenced by the management. Therefore a combination of these two main dimensions is suggested, and the model will present the factors grouped into different "areas of influence". The graphical representation of the model is depicted in Figure 1.

Many of the factors influence the SPI program efforts in such a way that the

output of the SPI program in its turn will influence the factors again. This argues in favor of a cyclical model, where the initial factors need to provide the SPI efforts with the necessary momentum to succeed. In the following sections, the various factors found under each area of influence will be described and discussed. Since this is a model of drivers of SPI program success, a network structure has been created to explain influences rather than by providing a checklist of factors to check against the organization in focus.



**Figure 1:** The cyclical model for managing success factors in an SPI program

The arrows represent influence between different stages both in requirements of what has to be done before taking on the next step, but also in what conditions the later steps have to be adapted to.

#### 4.1 Organizational prerequisites

The organizational prerequisites are a set of factors that are very difficult to manage directly for the firm and are also not subject to change as of influence from previous cycles in this model. Some of these factors can make embarking on a SPI program extremely difficult. An example of such a factor is “experienced staff” by Rainer et al, see [4], [5].

Other factors might merely affect in what way management tackles a situation. An example here is “the size of the organization”, by Dybå [1], which affects what strategy to use and what organizational strengths to build the processes on.



## **4.2 Employee coaching**

Factors found under the domain of employee coaching are “staff involvement”, “change agents and opinion leaders”, “unfreezing the organization” and “setting relevant and realistic objectives”, see e.g. [6]. Another factor is “training and mentoring”, introduced by Rainer et al [4], [5]. The reason behind this is that their main goal is to give the employees the right momentum to embark on a SPI program.

## **4.3 Providing organizational infrastructure**

These factors include “providing enhanced understanding”, “tailoring improvement initiatives”, and “encouraging communication and collaboration”, see e.g. [6]. Other factors are “reviews”, and “standards and procedures”, in [4], “internal process ownership”, “metrics” and “procedures”, in [5]. The factors all provide the main prerequisites to be performed for the employees to be able to take on the SPI initiative and perform the improvement tasks well.

## **4.4 Directly managing the SPI program**

The most important factor is “management commitment and support”, which in its turn affects all the other domains more or less directly. This factor is emphasized in multiple reports [6], [5]. The outcome of the previous steps of the setup phase also results in the factors of how specifically to “manage the improvement project” and how to “stabilize the changed process”, see e.g. [6].

## **4.5 Making use of the results of the SPI program**

The outcome of the SPI program can be measured in various ways, and these results can directly provide a guideline on both what factors to try to improve, but also indirectly affect such things as “employee commitment”, since, if the program proves successful, this is likely to increase the initial support given. Although the factors in the setup stage have to be influenced prior to embarking on a SPI program, they remain important after the program has started. The cyclical model constantly revolves and there is a continuous flow of influences between the stages.

# **5 Conclusions**

Because empirical studies on success factors and their results tend to flow together and overlap, representative articles have been selected for discussion. These articles have been discussed from different dimensions and viewpoints. Subsequently a cyclical model for managing success factors influencing a software process improvement has been presented. This model provides a structured way to handle success factors while also dealing with the relationships between these factors. In this model, four sets of factors have emerged, respectively Organizational Prerequisites, Employee Coaching, Providing Organizational Infrastructure and Directly Managing the Software Process Improvement Program. Next steps in our research will focus on

the validation of the presented cyclical model for success factors in practice, in particular regarding the management of SPI programs and the development of strategies for SPI implementation.

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