Software Process Improvement Implementation: Avoiding Critical Barriers

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This article seeks to identify perceptions and experiences of practitioners about critical barriers (CBs) that can undermine the implementation of Software Process Improvement (SPI) programs. The objective of this study is to summarize CBs and provide guidelines about how to avoid them. The results of this article provide advice to SPI managers and practitioners on what and how to address CBs when developing SPI implementation initiatives.

There are three major elements involved in SPI initiatives: SPI appraisal, process definition, and process deployment [1]. The SPI appraisal consumes a larger percent of the budget and resources, as it requires money to hire lead appraisers, time away from work for staff to be interviewed, and time away from work for the internal appraisal team. Process defining requires model knowledge, process definition knowledge/skills, and knowledge of the organization/company. Many organizations, however, do not have the model knowledge, the process definition knowledge, or the skills. Often, deployment is not only multi-project, but multi-site and multi-customer type. The whole SPI initiative is a long-term approach and it takes time to fully implement.

A Software Engineering Institute (SEI) report shows the number of months (see Figure 1) required to move from one maturity level of CMMI® to the next [2]. The SPI approach is often considered as an expensive approach for many organizations [3] because, in order to fully implement an SPI initiative, an organization needs to invest enough resources for a long time. This problem is exacerbated if the SPI initiative does not achieve the desired results. Even with the large advances in SPI approaches, the SPI initiatives failure rate is very high (i.e., 70 percent) [4]. This is one of the reasons that many organizations are reluctant to embark on a long path of systematic process improvement.

Thorough literature review revealed that many standards and models exist for SPI, but little attention has been paid to their effective implementation. The chaotic implementation process is the most common cause of SPI implementation failure [5]. Attention to a defined SPI implementation process is essential for the success of any SPI initiative.

This article presents the empirical findings of what can undermine the implementation of SPI initiatives. To focus this study, I investigated the following research questions:
- What barriers can undermine the SPI-implementing initiatives?
- How can one avoid these barriers?

The objective of addressing these research questions is to provide advice to SPI managers and practitioners on what and how to address CBs when developing SPI implementation initiatives.

Research Methodology

This study uses data from interviews with 34 Australian SPI practitioners (15 percent of the requested participants). The target population in this research was those software practitioners who have participated in SPI implementation initiatives. The invitation letter included a brief description of the research project and the nature of the commitment required. In return, I offered to make the research findings available to the participating practitioners.

Software practitioners have cited those barriers that have undermined SPI implementation initiatives within their organizations. Based on their SPI implementation experiences, the practitioners have also suggested guidelines regarding how to avoid SPI implementation barriers. It is worth mentioning that the data was collected from practitioners who were involved in tackling real SPI implementation issues, on a daily basis, in their respective organizations.

Interviews were conducted with three groups of practitioners:
- The first group was made up of designers/testers/programmers/analysts.
- The second group was made up of team leaders/project managers.
- The third group was made up of senior managers/directors.

All the interview transcripts were read to identify the major themes of CBs. These themes were noted and compared to the notes made during the interviews in order to reassure that the transcripts being analyzed are indeed a true reflection of the discussion in the interviews. This two-step process also verifies that the transcription process has not changed the original data generated in the interviews. Different themes were grouped together under one category. For example, poor response (a user unwilling to be involved, etc.) were grouped together under the CB category *lack of support*. Each category represents a CB for the implementation of SPI initiatives.

In addition to interviews, I have analyzed published experience reports, case studies, and articles in order to identify factors that can play a negative role in the implementation of SPI programs. Each

Figure 1: *Number of Months Required to Move Between CMMI Maturity Levels*
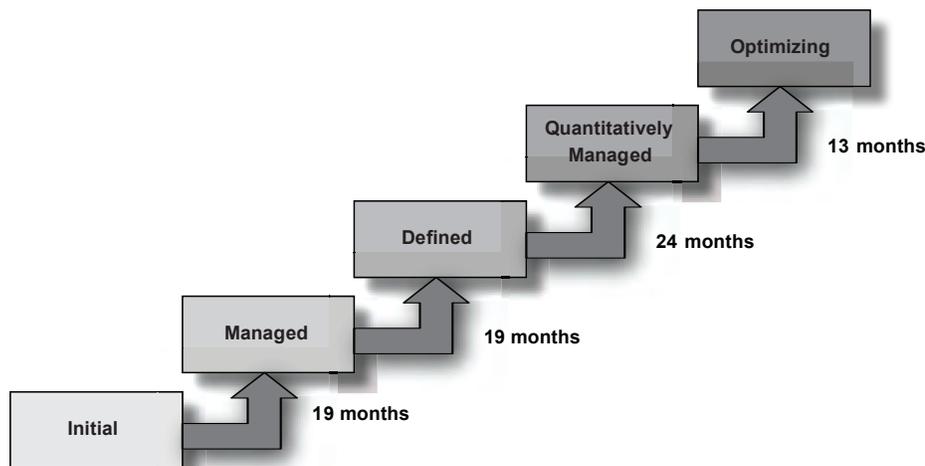
paper was reviewed carefully and a list of barriers was generated.

There were three categories of papers. The first category included papers in which the authors have described their SPI implementation experiences with lessons learned (i.e., why their SPI implementation program was not successful, etc.). It was fairly easy to identify SPI barriers because often authors provided a summary of barriers in the lessons learned. The second category included papers in which SPI implementation was discussed but authors did not provide any summary of barriers. In this case, I have had to read each paper carefully to identify the SPI barriers. The third category included a few papers that I analyzed where the results of empirical studies were described.

In order to reduce researcher bias, I have conducted inter-rater reliability evaluation during this process. Three research papers were selected at random and a colleague, who was not familiar with the issues being discussed, was asked to identify SPI barriers that appeared in the papers. The results were compared with previous results and no great disagreements were found.

For analyzing the data, I used frequency analysis, which is usually the most commonly used approach for similar studies by other researchers [6]. The presentation of data along with their respective frequencies is an effective mechanism for comparing and contrasting within or across groups of variables. In order to analyze the CBs, I recorded the occurrence of a CB in each interview transcript and research article and calculated the relative importance of each barrier.

Findings

Seven CBs were identified that can undermine SPI implementation initiatives: inexperienced staff, lack of defined SPI implementation methodology, lack of SPI awareness, lack of support, lack of resources, organizational politics, and time pressure.

In the following section, these seven CBs are described. For each, guidelines are provided, suggesting how to avoid these CBs.

Inexperienced Staff

In the SPI literature, many authors have described inexperienced staff as a barrier for SPI:

- Kautz and Nielsen describe why implementation of SPI was not successful in one company: " ... the staff and technical director had no prior experience with SPI and its potential benefits" [7].

- Moitra describes the problems and difficulties of managing change for SPI and identifies inexperienced staff as one of the barriers for SPI: "the quality and process improvement people are often quite theoretical—they themselves do not understand quite well the existing software development processes and the context in which they are used" [8].

Software practitioners said in the interviews that the experienced staff should be involved in SPI initiative because they have detailed knowledge of, and first-hand experience with, SPI implementation. With experienced staff, less rework of the documentation items is required and real

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issues can be resolved. The practitioners said that SPI initiatives can only be successful if staff members have a thorough understanding of the entire SPI process and related business. For inexperienced staff, practitioners emphasized training in SPI skills in order to achieve mastery of its use. This involves equipping the practitioners with the knowledge of the critical technologies (for example, how to measure a process) required for SPI initiatives. The overall objective of this training should be to transfer knowledge to inexperienced staff of SPI activities and interrelated business activities and objectives.

The following guidelines were suggested by the practitioners to avoid this barrier:
1. People should be selected for SPI activities who have a track record of different SPI projects.
2. The organization should develop a written training policy for SPI to meet its training needs.
3. Responsibilities should be assigned to each staff member regarding SPI implementation activities (e.g., process design, process testing, and process deployment).
4. A mechanism should be established to monitor the SPI progress of each staff member (e.g., staff members are meeting the deadlines).
5. A mechanism should be established to collect and analyze the feedback data from each staff member and to extract the main lessons learned (e.g., data generated during process testing and results of pilot implementation).

Lack of Defined SPI Implementation Methodology

Practitioners stressed the need to design an implementation methodology that contains an SPI implementation plan as well as SPI activities, practices, responsibilities, and procedures to be used during the implementation process. Often, the SPI projects have no specified requirements, project plan, or schedule [9]. It was recommended by the practitioners to treat SPI as a real project that must be managed like any other project.

Lack of defined SPI implementation methodology has emerged as a CB for successful SPI implementation. This is because little attention has been paid to the creation of an effective SPI implementation methodology. Studies show that 67 percent of SPI managers want guidance on how to implement SPI activities, rather than on what SPI activities to actually implement [10].

The following guidelines were suggested by the practitioners in order to avoid this barrier:
1. SPI implementation methodology should be developed using current technologies (e.g., software tools for planning, tracking, and reporting projects).
2. SPI implementation methodology should be tried and tested in pilot projects.
3. Staff members should be satisfied with the performance of the methodology in the pilot projects.
4. Training should be provided for developing the skills and knowledge needed to successfully use a methodology.
5. Work should be done to continuously improve a methodology with the aim of using it in the whole organization.

Lack of SPI Awareness

Practitioners felt the need for awareness of SPI programs (i.e., return on investment and impact) in order to fully understand the benefits of SPI. Practitioners said that since SPI implementation is the process of adoption of new organizational practices, it is very important to promote SPI awareness activities and share knowledge among different stakeholders. In addition, SPI is an expensive and long-term approach and it takes a long time to realize the real benefits. Hence, in order to get the support of management and practitioners and to successfully continue SPI initiatives, it is extremely important to provide sufficient awareness at the very beginning. SPI implementation is not as beneficial without sufficient awareness of its benefits. With this in mind, practitioners suggested involving all of the staff members in these awareness programs.

The following guidelines were suggested by the practitioners in order to avoid this barrier:
1. The benefits of SPI should be promoted among the staff members of the organization before implementation.
2. Higher management should be aware of the investment required and long-term benefits of the approach before implementation.
3. Staff members should be aware of their roles and responsibilities (e.g., through training and coaching) during the implementation of SPI within their unit of work.
4. Planning should be done to organize and continue SPI awareness events within the organization.
5. Planning should be done to make the SPI a part of the organization's culture.

Lack of Support

Lack of support is one of the barriers that many practitioners think can undermine SPI implementation initiatives. Often, SPI initiatives are not treated as real projects, get low priority, and are easily replaced. As well, management often doesn't support SPI because they do not understand how SPI initiatives can help in their daily work. The practitioners stressed the need to provide sufficient support for SPI initiatives.

The following guidelines were suggested by the practitioners in order to avoid this barrier:
1. Management should show strong leadership and support for SPI.
2. Management should be committed to provide all of the required resources.
3. A procedure should be established to facilitate staff members during implementation.
4. Staff members and higher management should be aware of the benefits of implementation.
5. A mechanism should be established to monitor the SPI progress of each staff member.

Lack of Resources

Management often agrees to SPI without sufficient knowledge of the investment required. In some organizations, management assumes that an SPI initiative will occur with very little investment. In others, management does not consider an SPI initiative as a real project and hesitate to allocate resources.

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In addition to the findings from the 34 interviews, the following studies have identified lack of resources as one of the barriers for SPI implementation:
- Florence [11] discusses the lessons learned in unsuccessfully attempting CMM Level 4 at The MITRE Corporation. He states that they achieved CMM Level 3 because sufficient resources were provided, but failed to achieve Level 4 because sufficient resources were not provided.
- Kautz and Nielsen describe why implementation of SPI was not successful because " ... the project managers were hesitant to use resources from their own projects on any improvement activity" [7].
- In the experience of Oerlikon Aerospace, Laporte and Trudel [12] describe five elements for successful implementation of SPI and state that it is important to estimate and provide resources. Otherwise, frustration will end the organization's readiness to adopt the SPI program.

The following guidelines were suggested by the practitioners in order to avoid this barrier:
1. Planning should be done to provide all the required resources (funds, tools, and people) for SPI implementation (e.g., a typical project management activity in which a project manager does cost estimation and allocates required resources for a project).
2. Staff members should be allocated time for SPI efforts.
3. Staff members should agree to the allocated time (i.e., extra time should be allocated for SPI activities).
4. A procedure should be established to avoid *time pressure* (staff members having very little time to complete their tasks).
5. A mechanism should be established so that SPI will not get in the way of day-to-day work (e.g., SPI must be considered as a real project and software practitioners must not be expected to do SPI in addition to their daily software development activities).

Organizational Politics

Many practitioners argued that organizational politics is one of the major barriers in SPI implementation. This is because the SPI is considered a change in the organization and often people resist this change.

Organizations are made up of groups and individuals who have differing values, goals, and interests. The SPI initiative may fit into one group's goals but not into another's. There are many factors that can trigger organizational politics, such as reallocation of resources, promotion opportunities, low trust, time pressures, and role ambiguity.

There are several studies that describe organizational politics as a barrier for SPI implementation. For example, Moitra describes the problems and difficulties of managing change for SPI and identifies organizational politics as one of the barriers for SPI: " ... politics in organizations is probably one of the principal reasons why change management efforts for process improvement initiatives fail" [8]. The writers of [13] conducted a study of 14 companies, investigating some of the important success factors and barriers for SPI; they identified organizational politics as one of the barriers for SPI.

The following guidelines were suggested by the practitioners in order to avoid this barrier:
1. Management and staff members

should provide strong support for SPI.

2. Planning should be done to make the SPI a part of the organization's culture (e.g., awareness training).
3. The benefits of SPI should be promoted among the management and staff members of the organization.
4. All of the key stakeholders should be involved in SPI implementation initiatives.
5. A conflict resolution plan should be established.

Time Pressure

Time pressure is often in the form of meeting project deadlines and getting the product within budget. Practitioners stressed the need to avoid time pressure of staff members during SPI implementation. As discussed in the Lack of Resources section, practitioners suggested that in order to avoid time pressure, SPI must be considered as real work and software practitioners must not be expected to do SPI in addition to their day-to-day software development activities.

There are several studies that describe time pressure as a barrier for SPI implementation. A few of the key studies observed the following:

• In [14], time pressure is identified as one of the obstacles to SPI: " ... operational management feel that in the absence of all other obstacles, lack of time seems to be the overriding obstacle to SPI success in companies."
• Paulish and Carleton [15] describe case studies for SPI measurement and illustrate time restriction as one of the SPI implementation problems.

The following guidelines were suggested by the practitioners in order to avoid this barrier for time pressure:

1. Staff members should be allocated time for SPI efforts and staff members should agree to the allocated time.
2. A procedure should be established to avoid staff from having time pressure (i.e., inadequate time to complete tasks).
3. A mechanism should be established so that SPI will not get in the way of day-to-day work (i.e., SPI should be added to daily activities).
4. The SPI implementation effort should be staffed by people who indicated interest and commitment in the effort.
5. A procedure should be established to facilitate (e.g., to avoid time pressure) staff members during SPI implementation.

Conclusion

The empirical study of CBs with 34 SPI practitioners is presented in this article. Seven CBs that can undermine the SPI implementation effort were identified. The identification of CBs in this study can act as a guide for practitioners when designing SPI implementation initiatives, making it easier to avoid the barriers that have been identified by SPI practitioners who are dealing with these issues on a daily basis. It is suggested that organizations should address these CBs when developing SPI implementation initiatives. This article also provides advice to SPI managers and practitioners on how to address CBs when developing these initiatives.◆

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