Software Process Improvement in Small and Medium Sized Software Enterprises in Eastern Finland: A State-of-the-Practice Study

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Abstract. Software Process Improvement (SPI) has been proven to increase product and service quality as organizations apply it to achieve their business objectives. Improvement needs of small organizations are same as larger organizations, i.e. they want to achieve better results in software projects, product quality, and customer satisfaction and put an end to the project overruns and failures. However the resources of the small company for SPI-work are often limited and external support seems to be essential. Companies are lacking experience and knowledge how to define and implement appropriate improvement plans and actions. The paper presents current results of software process assessment and improvement work done at University of Joensuu in cooperation with small and medium-sized software companies.

1 Introduction

Software process assessment and improvement is widely acknowledged as one of the most important means for achieving competitive and effective software industry. Different organizations have published and supported state of the art approaches like ISO 15504 [12], CMMI [4] and Bootstrap [18]. One of the goals of these models is to support transition of best practices into software industry. However, among the small and medium-sized organizations the awareness of these models has been weak and even if a small company knows the models and recognizes the improvement needs, their resources - both financial and personnel related - are often limited. Typically small companies are also lacking experience and knowledge on how to define and implement appropriate improvement plans and actions. They encounter difficulties applying these models to their software process improvement (SPI) work because models reflects the software practices of large software organizations [2]. Thus appropriate tailoring of these models is needed [2].

During the years many SPI models for small businesses have already been developed (see, for example [1,2,10,16,20,23]) but the implementation of software process improvement itself is often difficult. Many studies have reported success factors and implementation issues for SPI (e.g. staff and management commitment, business orientation, measurement) in large organizations (see, for example, [6, 21, 22, 26]) and also in small organizations (see, for example [6]).

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A number of studies have also investigated the state of the practice of software development work and impacts of software process improvement. A good general overview of the state of the practice of software engineering, mainly in large software businesses, can be found on IEEE Software (November/December 2003), special issue for software engineering state of the practice [11]. Also many large organizations have reported their experiences of SPI (see, for example, [5, 7, 8, 17]) and a number of studies have reported experiences of SPI work in small companies (see, for example, [3, 9, 15]).

This article presents the process and results of an empirical study of software process assessments in tSoft-project [25]. The goal of the tSoft-project is to improve the productivity and competitiveness of small and medium-sized software companies in Eastern Finland by assisting them to improve their software engineering processes and working practices. tSoft offers SPI-consultation, education and technology watch services for the participating companies. The focal areas of consultation are software process assessments, assistance in improvement planning and implementation of new practices and processes. Other project's major areas, technology watch and education, are targeted to support process improvement and implementation by updating personnel skills and knowledge on software engineering methods and technologies. The project is managed by the department of computer science at University of Joensuu. Industrial partners are small and medium-sized software companies from Northern Carelia region in Eastern Finland. At the moment the project is at the end of its first phase and participating companies are implementing their planned improvement actions according to their software process improvement plans.

The rest of this paper is as follows: In Chapter 2 we will describe the profiles of the participating companies and in Chapter 3 we will present the assessment process used. Then in Chapter 4, we will present assessments' main findings and study the software process strengths and improvement opportunities for the participating companies. Finally in Chapter 5 we will draw some conclusion and present future directions for the tSoft-project.

2 Profiles of the Participating Companies

Altogether eight software enterprises participated in the assessments during the year 2003. Following background information is collected by using questionnaire forms which company representatives independently filled and returned to the authors.

The companies represent different sizes, ages and application domains of software industry. Six of the companies were small independent software houses and one was a unit of larger software organization. The eighth participant was a software department of an industrial manufacturer. The total number of software work-related employees in participating companies was 92. The smallest software personnel was 3 and the largest company had 35 employees in software. The average number of software workers was 11.5. In 2002 the total revenue of the organizations was circa EUR 9 million excluding the industrial manufacturer. The total average revenue per company was circa 1.5 million EUR.

In the year 2002 companies had typically 5 software projects and the average team size of the projects was 3-5 employees. Most of the organizations and projects had one physical location. The total percentages of production activities of organizations were as follows: new development 40%, maintenance 32 % and other 28 %.

Types of software systems and applications the organizations were developing varied. Most companies (6) developed application software for others, but five of the organizations had also distinct software products of their own and/or they developed commercial software for open markets. The more detailed breakdown (%) is as follows: Company representatives were able to select as many application types as adequate for company development work.

- Application software for other companies (75 %)
- Commercial software for open market (63 %)
- Application software for internal customers (50%)
- Application software for own purposes (38 %)
- Embedded software for own system products (38 %)
- Embedded software for customer's system products (25 %)
- Subcontractor (13%)
- Other (13 %)

Typically the companies' key customers operated in the sectors like education, municipal services and construction industry, but companies had also markets from state authorities, agriculture and food products, military and customer services (retail) sectors. The typical number of production versions of companies' software was one (in four companies) but some of the companies had also more production versions (three companies had 2-5 versions). The most typical development model used was rapid prototyping and incremental or evolutionary model, but also classic waterfall model existed widely. Most used tool of the tool usage in software development were related to documentation (all of the companies used) and project management (in 7 out of 8 companies). Only one of the companies used tools for testing.

3 Assessment Process

In order to study current state of processes and practices in the participating companies, we conducted software process assessments. Process assessment examines the processes used by an organization to determine whether they are effective in achieving their goals [13]. The results of assessments may be used either to drive process improvement activities or process capability determination. This is done by analyzing the results in the context of the organization's business needs and identifying strengths, weaknesses and risks inherent in the processes.

In our case the main goal of the assessments was to find out improvement needs of the organizations and support their process improvement work. The assessment process contained five basic activities: planning, data collection, data validation, process rating, and reporting. A set of templates were also prepared for assessment process including an assessment plan, kick-off presentation, assessment report, presentation of the assessment results and feedback form. Assessment forms used during

on-site assessment sessions were acquired from Finnish Software Measurement Association [24]. In the planning phase of the assessments, survey-forms were also used to study improvement needs and priorities of the companies. Assessments consisted two different parts. In the first part the organizations made self-assessments using KYKY model, and in the second part SPICE-assessments were conducted by trained assessors (authors) in co-operation with software professionals of the companies. The assessments were run during spring 2003.

The *KYKY* model is an overview of organizational or project level quality and process management practices. The model is developed by STTF [19] using ISO9001, SPICE, CMM 1.1 and various other sources. It covers seven process areas and contains 46 questions. Each question were assessed by company representant using a SPICE scale of N (not achieved, <15 %), P (partially achieved, 15 %-50 %), L (largely achieved, 51%-85%), and F (fully achieved, >85 %). The process areas are:

- Process oriented operation (8 questions)
- Customer-supplier processes (6 questions)
- Software engineering processes (6 questions)
- Project management processes (7 questions)
- Support processes (6 questions)
- Organizational processes (5 questions)
- Process improvement (8 questions)

We used the model as an overview study of software company's quality and process management practices at an organizational level. We asked the representative of an organization to fill in the KYKY form. Then we analyzed the answers and wrote a report which included also a comparison with the other participating companies. The KYKY assessments were done before the SPICE-assessments and it helped also to set constraints for the SPICE assessments.

SPICE (ISO 15504) [12] is an international standard for process assessment. We used SPICE-conformant assessment method from Finnish Software Measurement Association in our assessments. The method used is based on the technical report version of the SPICE standard [13,14] published in 1998. The SPICE-assessments produced both an analysis of current capability level and improvement opportunities. A total of 24 people from the companies participated in the SPICE-assessments during the spring 2003. Main data collection methods during assessments were document reviews, interviews and discussions with companies' software professsionals. Because we didn't want to consume too much of the company time, we set out to perform assessment in one day, we had to restrict the assessment scope. We selected five key processes as follows: project management (MAN.2), software requirements analysis (ENG.1.2), configuration management (SUP.2), quality management (MAN.3), and subcontractor management. As a rough guidance for process selection we used level 2 processes from staged CMMI model [4] for software because it provides a good roadmap for improvement. Another constraint for assessment was the capability level of the processes. We performed questions and ratings relating only to levels 1 and 2 although ISO-15504 provides rating levels from 0 (incomplete) to 5 (optimizing).

4 Assessment Findings

In this section the main findings from the assessments, both KYKY and on-site SPICE assessments, are reported but first we present the results from the survey which was done before assessments. These results describe the strengths, weaknesses, improvement priorities and risks of the organizations in their own opinion and experience.

Before the assessments company representatives were asked to fill a questionnaire which inquired which three processes or activities were most important strengths and weaknesses of the company. Figure 1 presents the most frequently mentioned issues of the survey. The competency of company personnel was a critical strength of the companies. Project management activities were also considered as well as technical know-how of the personnel. Three most important weaknesses were in the areas of testing, product management and project management. The improvement opportunities the companies were interested in were related to testing, requirements management and customer cooperation. The three main risks were unsatisfied customers because of defects, schedule and cost overruns and possible changes in personnel.

Strengths	**Weaknesses**
– Know-how of the personnel (experience and education) – Project management (planning and follow-through) – Technical know-how	– Testing – Product management (e.g. documentation and change management – Project management (resources and milestones, customer management)
Improvement ideas	**Risks**
– Requirements management – Customer cooperation – Testing	– Personnel changes – Cost and schedule overruns – Unsatisfied customers because of defects, schedule and cost overruns

Fig. 1. SWOT-chart of the tSoft companies

In the KYKY assessment the strongest process areas were customer supplier processes, project management and software engineering processes. Most of the assessed practices got grade F or L in these process areas, but there were differences between companies. According to the KYKY results, the main improvement opportunities were support processes, process improvement and process oriented operation. In the above mentioned process areas most of the questions were assessed to P or N. For example in support process, improvement opportunities were noticed in documentation and release practices.

Table 1 summarizes the SPICE assessment's main findings. To preserve confidentiality, companies are referred to as Company A, B, C etc. in Table 1.

In the SPICE assessments the following key strengths and weaknesses were identified at participating companies.

Table 1. Capability levels of the companies process instances

	Company							
Process	A	B	C	D	E	F	G	H
Project management	1	1	1	1	2	1	2	2
Software requirements analysis	1	1	2	0	1	1	2	-
Configuration management	1	1	1	0	1	1	0	2
Quality management	0	0	0	0	1	0	1	2
Subcontractor management	-	1	0	-	-	-	1	-
Levels: 0 incomplete, 1 performed, 2 managed, - not assessed								

Project management process was performed at level 1 in all companies. One of the main strengths was that a project plan was generated in every assessed project. Generally the scope of work and the main achievements of the project were well defined and also a development strategy was described in the project plan. Software lifecycle model for the project was mainly iterative or incremental in nature, but also classic water fall model was used. Responsibilities of the project's tasks were normally well defined both internally and externally.

Although the project management process was performed at level 1 in all companies, some improvement opportunities were identified. Project's workload and time estimates were normally based on solely project manager's experience and no formal methods e.g. for product size estimation were used. Also project's activities and their associated tasks were often described very roughly. Generally there were no formal procedures for project's risk or quality management and project's quality and risk plans were missing in most cases. Also project's monitoring practices need more attention because of e.g. comparization between planned and used mandays or calendar time were rarely done. Communication and human resource management were among of the most mentioned improvement areas during different assessments.

Software requirements management process vary from one company to another. Three of the companies had formally defined requirement management process, but the rest of the companies gather and manage requirements more or less unsystematically. One of the companies didn't have any kind of requirements specification. Generally companies had some kind of requirement documents and especially functional requirements of the software were often defined. Requirement baseline documents were also reviewed together with the customer. However, in this process there were generally many things to improve in assessed projects except those three companies who followed their described process. First, requirements, like performance, usability and interface were rarely documented. Second, requirements change management was poorly organized in most of the companies. Often requirements document was not updated after first accepted version and sometimes incoming changes were stored only in the email or yellow notes. Third, tracebility of the requirements were also poor because of lack of documentation and tool support of requirements change management.

In *configuration management process* base practices of the companies varied mostly. The companies seemed to understand the basic activities of the configuration

management (i.e. version control, change management and release management) but the implementation of these activities were between ad hoc and performed in most of the assessed projects. Only two of the assessed process instances achieved level 1 base practices fully, four largely (just) and two of the processes were at level 0 because the results were only partially achieved. One strength of the configuration management process in most of the companies were the code version control which was handled by version control tool (e.g. cvs). However, in most of the cases, the tool was not used for the documents, which were handled manually. For change management purposes some of the companies had developed their own tool which was used for managing customer requests and defects. In all assessed projects some kind of project folders and files hierarchies was created, but the naming and the structure of the folders and files were often unsystematic. Delivery of the products was handled well in all cases.

The key weaknesses of the process were related to the following issues. First, the identification of the components which belonged under product management. In many cases it seemed that it was not clearly decided which of the work products (specifications, plans etc.) should be under version control and maintenance. Second, the instructions and guidelines for configuration management were lacking and members of the project group had shortage of information how to handle, for example release of the product. Third, the change management of different components was often poorly handled. Especially documents were seldom updated and the version history of them was lacking or defective. Also the responsibilities in the area of configuration management should have been assigned more clearly.

Results of *quality management process* were mostly at ad hoc level and base practices of level 1 only partly achieved. One of the assessed process instances achieved level 2, two achieved level 1 and the rest were at level 0. One of the assessed company has a ISO 9001 certification, but others were not largely aware about software quality aspects and there were no formal procedures for quality management. Despite of the non-systematic quality management process companies did perform informally some quality activities like testing and reviews (e.g. for code). However, these activities were not systematically planned and requirements for the quality of the work products were lacking. The following improvement opportunities were identified. These improvement opportunities do not concern the ISO9001 certified company.

At the first, companies should start to think, what quality means to them and to set general goals for quality management and assurance. After that they should think what are the quality goals for products and processes at the project level and start tailoring the quality goals according the project. To achieve this it means that companies should start the planning for quality. Also the activities of how the project will meet the required goals should be planned and implemented. E.g. checklists for different purposes and reviews at the right places of the project life cycle could help to meet goals. Well-planned and implemented testing is also one of the key activities for good product quality. After that, the continuous monitoring of quality situation should be arranged.

Subcontractor management process was assessed only in three companies and the results include only three process instances. Two of these instances achieved level 1

and one had partly achieved rating. General strengths of the process were definition of the scope of work and the evaluation and selection of the partners. The selection of the partners were often made based on former experience of partner and no formal capability evaluations were used. The needed contracts were well handled. Some risks and improvement opportunities were also identified. The systematic practices for checking and acceptance of work were lacking. For example, testing, versioning, virus control and checking against specification, could help. The practices for monitoring the subcontractors work and progress were insufficient. Progress report templates or reporting tool for this purpose could help. Also the specification of work and risk management practices should improve.

Conclusions

In this paper we have described software process assessment work and results at tSoft-project with 8 small and medium sized software organizations in Eastern Finland. We conducted software process assessments to examine the processes used by an organization to determine whether they are effective in achieving their goals and the results were used to drive process improvement activities.

Most of the current processes and practices in participating organizations are far from being well defined and systematically implemented and managed. We found out that competency of company personnel was a critical strength of the companies and therefore the personnel changes are a great risk for small organization.

Identified weaknesses were, for example, systematic project's work load and time estimation practices that were lacking, requirements change management was poorly organized and organizations were not largely aware about software quality aspects and there were no formal procedures for quality or configuration management. However organizations performed many of the base practices of the assessment model in different processes and achieved level 1 in several assessed process instances. Especially project management practices were generally handled well in assessed projects. Also functional requirements of the software system were often defined and version control tool for code was in use.

We believe that after assessments the organizations are now more aware of software process improvement topics and the work towards culture of quality has began. As a result of the assessment process, key findings were selected for improvement and constituted the basis for SPI projects of the companies. SPI projects were kicked off in companies during autumn 2003 and spring 2004. At the moment companies are implementing planned improvement projects and we have already seen the first results. We follow and support these improvement actions very closely and we hope to report the more detailed results later. We believe that this study provides an interesting insight into the state of the practice of small software enterprises in presented process areas.

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