CHAPTER 1 Software Process Improvement (SPI) Concepts and Principles

LEARNING OUTCOMES

By the end of this chapter, you should be able to:

1. Explain the relationship between software and software process improvement.
2. Identify and explain common models used in software process improvement.
3. Describe the benefits of software process improvement and elaborate how it could help companies to achieve their strategic goals.
4. Explain the software process improvement initiatives and suggestions to monitor the effectiveness.

INTRODUCTION

Software is at the heart of modern business and is pervasive throughout society. New technologies and mobile phones have transformed our lives, and software is an integral part of these technologies.

Companies also have changed the way of doing business to take advantage of new technologies. The success of business today is highly influenced by the functionality and quality of the software it uses. It is essential that the software used is safe, reliable, of a high quality and fit for purpose.

Today, concern for quality has become an international movement. Examples:-

- England requires quality programs to be certified and audited.
- Europe offers certification for software development companies that meet the standards described in ISO 9000 (International Standards Organization number 9000) [Arter92].
- Japan has awarded the Deming Prize for years [Masaaki86].
- In the United States, the Department of Commerce and NASA give major awards, such as the highly Baldridge Quality Award coveted Malcolm [Garvin91], for quality improvement.

Many companies have begun to implement quality improvement or total quality management (TQM) programs throughout the company, not just in software development.

Quality

- A key issue in the field of software engineering
- Popular view: Difficult to define and measure
- Professional view: quantifiable, controllable, manageable, improvable
- Definition: Conformance to requirements

Conformance to requirements – Managerial aspects
During the production, measurements must continually be taken to determine conformance to those requirements:-

- Measurement model
- Project tracking and oversight
- Validation criteria
- Quality assurance system
- Plans, commitment to improvement

Conformance to requirements – Technical aspects
Requirements must be clearly stated such that they cannot be misunderstood:-

- Complete
- Unambiguous
- Verifiable
- Precise
- Concise
- Consistent

Software process improvement (SPI) initiatives are aligned to business goals and play a key role in helping companies achieve their strategic goals. It allows companies to solve key issues to eliminate quality problems. It helps companies to critically examine their current process to determine the extent to which it meets their needs, as well as identifying how process can be improved and where waste can be minimized or eliminated.

SPI allows companies to identify the root causes of problems and to determine appropriate solutions to the root causes of problems. The benefits of successful process improvement include the consistent delivery of high-quality software, improved financial results and increased customer satisfaction.

Since most problems are caused by defective processes rather than by people, SPI initiatives lead to a focus on the process and on ways to improve the process. A focus on the process helps to avoid a blame culture that occurs when blame is apportioned to individuals rather than the process. The focus on the process leads to a culture of openness in discussing problems and their solutions and in instilling process ownership in the process practitioners.

SPI allows companies to mature their software engineering process and to achieve their business goals more effectively. It helps software companies to deliver the agreed software on time and on budget, as well as improving the quality of the delivered software, reducing the cost of development, and improving customer satisfaction with the software.

1.1 DEFINITION AND CONCEPTS

What is Software?

"The programs, documentation and operating procedures by which computers can be made useful to man"

(Grubb & Amstrong 2003 p.6)

- Software includes apart from the source and object code, documentation of all the aspects of the program and procedures in order to get the program running and operating.

- The documentation usually exists of requirements analysis, design documents and systems and user manuals.

What is Maintenance?

"The act of keeping an entity in an existing state of repair, efficiency, or validity; to preserve from failure or decline"

(Grubb & Amstrong 2003 p.6)

- Maintenance takes place in multiple places in the society and is important for keeping technical artefacts functioning.
- It would be a material disaster if no maintenance work was performed. Maintenance is needed for the many technical artefacts in our surroundings.

Software Maintenance

"The modification of a software product after delivery to correct faults, to improve performance or other attributes or to adapt the product to a modified environment"

(Pankaj 2004 p.1)

- The maintenance phase starts after the delivery of the software system to the organization who ordered it and that maintenance is all about modifications.
- Maintaining work exists in the context of an existing running system which set limitations on changes can be done.
- Software maintenance can be thought of in two different settings:-
    - Maintenance during the development phase
    - Maintenance after the software is implemented

- It is essential for software maintenance to be considered during the development phase – when the ground is laid and decisions at this time are crucial for the entire life time of a software system. However, the maintenance work is done after the implementation.
- Both aspects are important for the overall picture of software maintenance.

Software Process

"A set of practices or tasks performed to achieve a given purpose. It may include tools, methods, material and people"

(Gerard O'Regan 2011 p.3)

- A software development process is the process used by software engineers to design and develop computer software. It may be undocumented ad hoc process or it may be a standardized and documented process used by various teams on similar projects.

- The process employed in software development include:-
  - Processes to determine the requirements;
  - Processes to design and develop the software
  - Processes to verify that the software is fit for purpose
  - Processes to maintain the software

- When software systems are installed and running in an environment, sooner or later new requirement emerge. To continue being useful a system needs to be able to change and/ or add functionality for these new requirements.

- For software to be maintainable it needs to be adaptable to changes in a cost-effective way that does not increase the probability of errors.

- The quality of a product is largely determined by the quality of the process used to build it and the quality of the software process used for developing and maintaining it.

  - ***Quality (process) ⇒ Quality (product)***

- To improve the quality of a software product, the process for producing it must also be improved
- The majority of software problems or the causes of software crisis (e.g. budget overrun, lack of quality, late delivery) are managerial, not technical (Humphrey, 1989)

- The Software Engineering Institute (SEI) believes that there is a close relationship between the quality of the delivered software and the quality and maturity of the underlying processes employed to create the software. The SEI adopted and applied the principles of process improvement employed in the manufacturing filed to develop process maturity models such as the Capability Maturity Model (CMM) and its successor the Capability Maturity Model Integration (CMMI).

1.2 WHAT IS SOFTWARE PROCESS IMPROVEMENT?

"A program of activities designed to improve the performance and maturity of the organization's software processes and the results of such a program"

(Gerard O'Regan 2011 p.4)

- Software process improvement (SPI) is concerned with practical action to improve the processes in the organization to ensure that they meet business goals more effectively.

- The origin of the SPI field go back to the manufacturing sector and to Walter Shewhart's work in the 1030s on statistical process control. His work later refined by Deming and Juran and they argued that high-quality processes are essential to the delivery of a high-quality product. The argument was that the quality of the end product is largely determined by the processes used to produce and support it which needs to be an emphasis on the process as well as the product.

- The work of Deming and Juran was later applied to the software quality field by Watt Humphries and others at the SEI leading to the birth of the software process improvement field.

- SPI initiatives support the organization in achieving its key business goals such as delivering software faster to the market, improving quality, reducing or eliminating waste.

- The objective is "to work smarter and to build software better, faster, and cheaper than competitors".

- SPI is concerned with defining the right processes and following the consistently. It involves training all staff on the new processes, refining the processes, and continuously improving the processes.

1.3 BENEFITS OF SOFTWARE PROCESS IMPROVEMENT

Many organizations have problems with developing high-quality software consistently on time to their customers due to:-

- Budget and schedule overruns
- Late delivery of the software
- Spiralling costs
- Problem with the quality of the delivered software
- Customer complaints with the functioning of the software
- Staff morale

Software process improvement can assist in dealing with these problems. It requires an investment but there are cost benefits and it provides a return on the investment made. The benefits from software process improvement include:-

- Improvements to quality
- Reductions in the cost of poor quality
- Improvements in productivity
- Reductions to the cost of software development
- Improvements to on-time delivery
- Improved consistency in budget and schedule delivery
- Improvements to customer satisfaction
- Improvements to employee morale.

The Software Engineering Institute (SEI) has found that there are benefits that organizations can achieve from using CMMI. It has measured the improvements in several categories: cost, schedule. Productivity, quality, customer satisfaction and the return on investment (ROI) which collected from 25 organizations. Table 1-1 shows result from 25 organisations and are from publicly available conference presentations, published papers and individual collaborations.

Improvements	Median	#Data points	Low	High
Cost	20%	21	3%	87%
Schedule	37%	19	2%	90%
Productivity	62%	17	9%	255%
Quality	50%	20	7%	132%
Customer Satisfaction	14%	6	-4%	55%
ROI	4.7:1	16	2:1	27:1

Table 1 - 1 Benefits of Software process improvement (CMMI)

1.4 MODULES USED IN SOFTWARE PROCESS IMPROVEMENT

A process model provides a place to start an improvement initiative and it provides a common language and shared vision for improvement. It provides a framework to prioritize actions and allows the benefits of the experience of other organizations to be shared.

A process model defines best practice for software processes in an organization. It describes what the processes should do rather than how they should be done. This allow organization to use professional judgement to choose the most appropriate process implementation to meet its needs. The process model will need to be interpreted and tailored to the particular organization.

There are several popular process models used in software process improvement including:-

- Capability Maturity Model Integration (CMMI)
- ISO 9001 Standard
- ISO 15504 (also known as ISO SPICE)
- Personal Software Process (PSP) and Team Software Process (TSP)
- Six Sigma
- IEEE Standards
- Root Cause Analysis
- Balanced Scorecard

CMMI

- It was developed by the Software Engineering Institute (SEI) and is the successor to the older software CMM which was released in the early 1990s.
- The latter was specific to the software filed and was influenced by Watt Humphreys work at IBM.
- The CMMI is a suite of products used for improving processes, ant it includes models, appraisal methods, and training material.
- The CMMI models address three areas of interest:-
    - CMMI for Development (CMMI-DEV)
    - CMMI for Services (CMMI-SVC)
    - CMMI for Acquisition (CMM-ACQ)

- The CMMI Development model is the vehicle used for software process improvement and a framework that allows organizations to improve their maturity by improvements to their underlying processes.
- It provides a structured approach and allows the organization to set improvement goals and priorities.

- It provides a clearly defined roadmap for improvement and it allows the organization to improve at its own pace. It also allows the processes to evolve from ad hoc immature activities to disciplined mature processes.
- The CMMI practices may be used for the development, acquisition, and maintenance of products and services. A SCAMPI appraisal determines the process maturity of an organization and allows it to benchmark itself against other organizations.

ISO9001

- An internationally recognized quality management standard and is customer and process focused. It applies to the processes that an organization uses to create and control products and services, and it emphasizes continuous improvement. This standard is designed to apply to any product or service that an organization supplies.
- The implementation of ISO 9001 involves understanding the requirements of the standard and how the standard applies to the organization. It requires the organization to identify its quality objectives, define a quality policy, produce documented procedures, and carry out independent audits to ensure that the processes and procedures are followed.
- An organization may be certified against the ISO 9001 standard to gain recognition to its commitment to quality and continuous improvement. The certification involves an independent assessment of the organization to verify that it has implemented the ISO 9001 requirements properly.
- It will also verify that the processes and procedures defined are consistently followed and that appropriate records are maintained.

ISO 15504 (also known as ISO SPICE)

- An international standard for process assessment. It includes guidance for process improvement and for process capability determination, as well as guidance for performing an assessment.
- ISO/IEC 15504 can be used in a similar way to the CMMI and its exemplar models (for either software or systems life cycles) may be employed to implement best practice in process definition. Assessments may be performed to identify strengths and opportunities for improvement.

PSP and TSP

- The Personal Software Process (PSP) is a disciplined data-driven software development process that is designed to help software engineers understand and to improve their personal software process performance.
- It was developed by Watt Humphrey at the SEI, and it helps engineers to improve their estimation and planning skills and to reduce the number of defects

in their work. This enables them to make commitments that they can keep and to manage the quality of their projects.

- The Team Software Process (TSP) was developed by Watt Humphrey at the SEI and is a structured approach designed to help software teams understand and improve their quality and productivity.
- Its focus in on building an effective software development team, and it involves establishing team goals, assigning team roles as well as other teamwork activities. Team members must already be familiar with the PSP.

Six Sigma

- It was developed by Motorola as a way to improve quality and reduce waste. Its approach is to identify and remove the causes of defects in processes by minimizing process variability.
- It uses quality management techniques and tools such as the 5W, business process mapping, statistical techniques, and the DMAIC and DMADV methodologies.
- There are several roles involved in six-sigma initiatives such as Champions, Black Belts, and Green Belts, and each roles requires knowledge and experience and is awarded on merit subject to training and certification.
- Sponsorship and leadership is required from top management to ensure the success of a Six-Sigma initiative.
- A six-sigma project follows a defined sequence of steps and has quantified targets. These targets may be financial, quality, customer satisfaction, and cycle time reduction.

1.5 PROCESS MAPPING

The starting point for improving process is first to understand the process as it is currently performed. This involves participation from the process stakeholders to reach a common understanding of how the process is actually performed and to identify how it may be improved.

The process as currently performed is then sketched pictorially, with activities and their inputs and outputs recorded graphically. This graphical representation is termed a "process map" and is an abstract description of the process "as is".

The process map is an abstraction of the way that work is done, and it may be critically examined to determine how effective it really is and to identify weaknesses in the process. The process thinking by the process practitioners leads to modifications to the definition of the current process. The proposed definition is sketched in a new process map to yield the process "to be".

Once the team has agreed on the new process the templates required to support the process become clear from an examination of the input and output of the various activities. Procedures or guidelines will be documented to provide details on how the process is to be carried out.

1.6 PROCESS IMPROVEMENT INITIATIVES

The need for a software process improvement initiative often arises from the realization that the organization is weak in some areas in software engineering and that it needs to improve to achieve its business goals more effectively.

The starting point of any improvement initiative is an examination of the business goals of the organization including:-

- Delivering high-quality products on time
- Delivering products faster to the market
- Reducing the cost of software development
- Improving software quality.

There is more than one approach for the implementation of the CMMI. A small organization usually has fewer resources available and team members involved in the initiative. Larger organizations may be able to engage dedicated people on the improvement activities.

Once the organization needs have been identified the improvement initiative commence:-

- Conducting an appraisal to determine the current strengths and weaknesses of the processes
- Analysing the results to formulate a process improvement plan
- Implementing the plan
- Piloting the improved processes and verifying that they are effective
- Rolling out the new processes.

The improvements are monitored for effectiveness and the cycle repeat which are:-

- The improvement initiative should be based on business needs.
- Improvements should be planned based on an objective understanding of the strengths and weaknesses of the current processes in the organization.
- The improvement need to be prioritized.
- The improvement should be planned and managed as a standard project.
- The results achieved to be reviewed at the end of the period and a new improvement cycle started for continuous improvement.
- SPI requires people to change their behaviour and so organization culture needs to be considered.
- Process Champion is required to drive the process improvement initiative in the organization.
- Senior management need to be 10% committed to the success of the initiative.
- Staff need to be involved in the improvement initiative and there needs to be a balance between project needs and the improvement activities.

1.7 BARRIERS TO SUCCESS

Software process improvement initiatives are not always successful. Occasionally an improvement initiative is abandoned. Reasons for failure are:-

- Unrealistic expectations
- Trying to do too much at once
- Lack of senior management sponsorship
- Focusing on a maturity level
- Poor project management of the initiative
- Not run as a standard project
- Insufficient involvement of staff
- Insufficient time to work on improvements
- Inadequate training on software process improvement
- Lack of pilots to validate new processes
- Inadequate rollout of new process

It is essential that a software process improvement initiative to be treated as a standard project with a project manager assigned to manage the initiative.

Senior management need to be 100% committed to the success of the initiative. They need to make staff available to work on the improvement activities. All staff must be made clear on the priority of the improvement initiative. Appropriate training on software process improvement and the maturity model process to be provided to all staff.

SUMMARY

Software process improvement plays a key role in helping companies to achieve their strategic goals. It allows companies to focus on fire prevention rather than firefighting and examine their processes to determine the extent to which they meet their needs.

Software process improvement initiatives lead to a focus on the process and the focus on process thinking is important since most problems are caused by defective processes rather than by people.

Software process improvement allows companies to mature their software engineering processes and to achieve their business goals more effectively. It help software companies to deliver the agreed software on time and on budget, as well as improving the quality of the delivered software, reducing the cost of development and improving customer satisfaction.

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