Improving Software Development Process Implemented in Team Project Course

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Abstract. The paper presents an assessment approach to software development process used within students' team project. The assessment is based on exemplary Process Assessment Model given in ISO/IEC 15504-5 standard. The results of the assessment suggest the area of improvement in our software development process realization. The history, context and basic assumptions established and proposed for the future improvements in the course are given.

Keywords: team project, software development, process assessment model.

1 Introduction

Software engineering (SE) is a discipline of developing and maintaining software systems that behave reliably and efficiently, are prepared for future enhancement and modification, and satisfy the requirements that customers have formulated for them. Students of SE during their program of study should participate in the development of software of real-world software.

To fulfill the industrial postulate of incorporating professional practice into the curriculum, since 1998 we have been offering a Software Development Course (SSD). During this course students work in teams on design and implementation of projects that involve consideration of real-world issues including safety, efficiency, and suitability for the intended users.

Usually every educational course after several editions is a subject to change. It is especially true for software area because of the rapid changes in the field of software engineering. Similarly to software development, the course development can be divided into four phases: specification, design, implementation, and assessment. Even though a course specification is stable and is performed only once, design and implementation of the course is not a one-time process but rather a "work in progress" i.e. it can be seen as an iterative process. In order to conduct the next course iteration one should know the results from the assessment of the previous one.

The main aim of the paper is:

- to present an assessment carried out for the existing software development process implemented in project course; the assessment process is based on the assessment model as it is proposed in ISO/IEC 15504-5 [3] standard,

- to figure out the elements which could be changed in order to reach the higher quality of this process, and
- to propose a technical tool aiding of new quality-oriented activities.

We expect that due to more formal process assessment of course implementation we will get a strong rationale for the course modification.

The paper consists of four sections. Section 2 presents briefly a model of process assessment as defined in [2], [3]. Section 3 describes an assessment of the taught process and gives some suggestions how it could be change for better quality. Section 4 summarizes the paper.

2 Model of Process Assessment

An assessment of software development process can be conducted according to ISO 15504-2 standard [2]. Process Assessment Model (PAM) is used as a common basis for performing assessments of software engineering process capability. PAM is a two-dimensional model of process capability. The considered dimensions are:

1. the process dimension, where processes are defined and classified into process categories; further these categories are decomposed into groups.
2. the capability dimension, where a set of process attributes grouped into capability levels is defined; these process attributes provide the measurable characteristics of process capability.

In the process dimension there are distinguished three categories of processes: primary, supporting and organizational. An individual process is described in terms of process name, purpose, and outcomes [1]. For example in Table 1 *Software construction* process is described.

In PAM every process is extended with additional information in the form of:

- a set of base practices for the process providing a definition of the tasks and activities needed to accomplish the process purpose and fulfil the process outcomes; each base practice is explicitly associated to a process outcome (see Table 1 the line named Base Practices);
- a list of input and output work products associated with each process and related to one or more of its outcomes; each work product has some characteristics associated.

PAM is based on the principle that the capability of a process can be assessed by demonstrating the achievement of process attributes on the basis of evidences related to assessment indicators. There are two types of assessment indicators: process capability indicators, that can be applied to capability levels 1 to 5, and process performance indicators, that can be applied exclusively to capability level 1 .

Process capability indicators are as follows:

- Generic Practice (GP);
- Generic Resource (GR);
- Generic Work Product (GWP).

These indicators concern significant activities, resources and or results associated with the process. The existence of these indicators provides evidence of process capability.

Table 1. Exemplary process description in PAM (the source: [3])

Process ID	ENG.6
Name	Software construction
Purpose	The purpose of the Software construction process is to produce executable software units that properly reflect the software design.
Outcomes	As a result of successful implementation of Software construction process: 1) verification criteria are defined for all software units against their requirements; 2) software units defined by the design are produced; 3) consistency and traceability are established between software requirements and design and software units; and 4) verification of the software units against the requirements and the design is accomplished.
Base Practices	ENG.6.BP1: Develop unit verification procedures. Develop and document procedures and criteria for verifying that each software unit satisfies its design requirements. The verification procedure includes unit test cases, unit test data and code review. [Outcome: 1] ENG.6.BP2: Develop software units. Develop and document the executable representations of each software unit. Update test requirements and user documentation. [Outcome: 2] (...)

In Table 2 the examples of mapping from the defined generic practices (GP x.y.z) to the relevant process attributes (PA.x.y.z) are given.

A capability level is a set of process attribute(s) that provide a major enhancement in the capability to perform a process. There are defined six process capability levels: 0–incomplete, 1–performed, 2–managed, 3–established, 4–predicable, 5–optimizing. Every capability level attribute is described in structured, standardized form [3]. An example of such a description for the attribute of process performance indicator of the 1st level is presented below:

Level 1: Performed process

PA 1.1 Process performance attribute

The process performance attribute is a measure of the extent to which the process purpose is achieved. **As a result of full achievement of this attribute:**

a) the process achieves its defined outcomes.

Generic Practices for PA 1.1:

- Achieve the process outcomes;
- Perform the intent of the base practices;
- Produce work products that evidence the process outcomes;

Generic Resources for PA 1.1:

- Resources are used to perform the intent of process specific base practices [PA 1.1 Achievement a]

Table 2. Exemplary relationships between generic practices and process attributes ([3])

GP	Practice Name	Maps to
PA 1.1: Process performance attribute		
GP 1.1.1	Achieve the process outcomes.	PA.1.1.a
PA 2.1: Performance management attribute		
GP 2.1.1	Identify the objectives for the performance of the process.	PA.2.1.a
GP 2.1.2	Plan and monitor the performance of the process to fulfill the identified objectives.	PA.2.1.b
GP 2.1.3	Control the performance of the process.	PA.2.1.c
GP 2.1.4	Define responsibilities and authorities for performing the process.	PA.2.1.d
GP 2.1.5	Identify and make available resources to perform the process according to plan.	PA.2.1.e
GP 2.1.6	Manage the interfaces between involved parties.	PA.2.1.f
PA 2.2: Work product management attribute		
GP 2.2.1	Define the requirements for the work products.	PA.2.2.a
GP 2.2.2	Define requirements for documentation and control of work products.	PA.2.2.b
GP 2.2.3	Identify, document and control the work products.	PA.2.2.c
GP 2.2.4	Review and adjust work products to meet the defined requirements.	PA.2.2.d

Generic Work Products for PA 1.1

- Work products exist that provide evidence of the achievement of the process outcomes [PA 1.1 Achievement a]

All process attributes for all capability levels are given in Table 3. In this table it is also defined what attribute ratings are required for a process to be categorized as being on the appropriate level of capability.

Table 3. Process Capability levels and their attributes

Capability level	Process attribute	Attribute rating
Level 0: Incomplete	Incomplete	N/P
Level 1: Performed	Process Performance	L/F
Level 2: Managed	Level 1+	F
	Performance Management, Work prod. Management	L/F
Level 3:	Level 2+	F
Established	Process Definition, Process Deployment	L/F
Level 4: Predictable	Level 3+	F
	Process Measurement, Process Control	L/F
Level 5:	Level 4+	F
Optimizing	Process Innovation, Continuous Optimization	L/F

where symbols of attribute rating are interpreted as follows:

<i>N</i>	Not achieved	i.e. 0 up to 15% attribute achievement
<i>P</i>	Partly achieved	i.e. > 15% up to 50% attribute achievement
<i>L</i>	Largely achieved	i.e. > 50% up to 85% attribute achievement
<i>F</i>	Fully achieved	i.e. > 85% up to 100% attribute achievement

3 Improvement of Software Development Process Implemented in SSD Course

3.1 Historical Background

The considered software development process is implemented within team project classes offered since 1999. Initially students followed USDP [6] methodology, but since 2004 we have introduced RUP process [7]. The previous editions of SSD course are described in [4], and [5].

As this project corresponds to the concept of the *capstone course*, it has three common elements of capstone programs:

- 1) students are divided into teams of typically 4 to 6 students each; one of them plays a role of the project manager and the lecturer plays a supervisor/auditor role;
- 2) each team is given a real-world project or problem to solve;
- 3) this project takes 30 weeks to complete (it is continued along two semesters – 60 class-hours, offered within 7th and 8th semesters for about 120 students every year).

The project constitutes a part of a subject called System Software Development.

Before attending the course we require the students have finished the courses of object-oriented programming, UML [8], fundamentals of databases. In parallel the students are offered software project management and database design courses.

Design and implementation of software system belongs to the important activities within project. We suggest students to use multi-tiers architecture as well as component techniques. The target system architecture should be distributed between at least two tiers. Client-server is the most often selected system architecture.

3.2 Assessment of Current Software System Development Process

The students are obliged to use customized RUP approach while developing software system within SSD project. Comparing attributes of our implemented development process to these given in [3], we can recognize that our process is at least on the 1st capability level.

According to [2] the process is performed when it fully achieves its performance attribute due to achieving its defined outcomes. In Table 4 there are presented selected implemented workflows (GP), required work products (GWP) and some of resources used in process (GR).

To establish how far is our process from the 2nd level of capability we have to point out that our performed process is implemented in a managed fashion (planned, monitored and adjusted) and its work products are appropriately established, controlled and maintained (see Table 3).

We have decided to performed such assessment for limited numbers of attributes, which, in our opinion need to be improved. The same approach to assessment might be conducted for all attributes defined in [3] for managed process.

Table 4. Software system development work products

RUP discipline	Work products	Notes	Tools
Requirements	Vision, Glossary	Sketches of GUI-interface, screen shots or executable GUI prototype.	Requisite Pro Rational Rose
	Supplementary Specification		
	Use Case Model		
	Use-Case specifications		
	User-interface prototype		
Design	Design Model		Rational Rose SoDa
	Deployment Model		
	Data Model, SAD		
	Deployment Model		
Test	Test plan, Defects list		Test Factory (option) Clear Quest
	Test evaluation summary		
	Defects list		
Project management	Iteration Plan	Software Development Plan was elaborated by a teacher. Risk list is limited to use-case priorities.	
	(from 2 nd iteration)		
	Iteration Assessment		
Environment	Use-case priorities	Design guidelines Programming guidelines.	
	Project specific guidelines		
	(option)		

Table 5 gathers information about performance management attributes for assessment – they are described by letters from A to D. Particular indicators are evaluated subjectively – in 0-5 point scale – basing on our expectations and experiences. Some comments about each element rate are put below. The process in considered area is partially achieved (42%).

Ad. A) Better monitoring of the project progress and tasks realization is needed. Now each team prepares weekly reports for team supervisor. The control over the project from the supervisor's perspective is relatively small. Tasks to be performed within a concrete iteration should be communicated in a readable way.

Ad. B) More flexible treatment of iteration content is needed. The disciplines performed within the project should be carefully selected, e.g. in many cases full business modeling is spared.

Ad. C) Easier access to templates and examples of artifacts used during software development is needed. The artifacts should be clearly described; now they are distributed as packed zip archives.

Ad. D) Improved communication inside the development team as well as between the development team and the supervisor is needed; now, the direct contact between the supervisor and a team is usually limited to 30 min a week; it is often too short, so additional information is exchanged by e-mails or printed documents; the feedback is rather low and late.

Table 6 gathers information about attributes needed for assessment of work product management attributes (row E). Some comments about each element rate are put below the table. The process in considered area is partially achieved (30%).

Table 5. Assessment of performance management attributes

ID	Attribute	Indicator	Element to be assessed	Assessment [0-5] scale
A	Performance of the process is planned and monitored	GP	a.1) Process performance is monitored to ensure that planned results are achieved	2 (rarely, manual)
		GR	a.2) Workflow management system	0 (none)
		GWP	a.3) Contains status information about corrective actions; schedule and work	2 (incomplete, not up to date)
B	Performance of the process is adjusted to meet plans	GP	b.1) The plan(s) are adjusted, as necessary, b.2) Rescheduling is done when necessary.	3 (very rarely)
		GR	b.3) Facilities and infrastructure resources are available	2 (very rarely)
		GWP	b.4) Process definition describes the way of plan controlling and adjusting	0 (fully manual)
C	Resources and information necessary for performing the process are identified, made available, allocated and used	GP	c.1) The human and infrastructure resources necessary to performed the process are defined, made available, allocated and used.	2 (not formalised)
		GR	c.2) Information and/or experiences repository.	4 (distributed as zip files)
		GWP	c.3) States results achieved or provides evidence of activities performed in a process.	3 (zip files)
D	Interfaces between involved parties are managed (...)	GP	d.1) Communication between the involved parties is effective	2 (not up to date)
		GR	None	3 (weekly meetings)
		GWP	None	
Summary				23/55 (42%)

Table 6. Assessment of work product management attributes

ID	Attribute	Indicator	Element to be assessed	Assessment [0-5] scale
E	Work products are appropriately identified, documented, and controlled	GP	e.1) Change control is established for work products.	2 (manual)
			e.2) The work products are made available through appropriate access mechanisms.	0 (not for supervisor)
			e.3) The revision status of the work products may readily be ascertained.	3 (contact with supervisor is needed))
		GR	e.4) Configuration management system.	0 (none)
			e.5) Document identification and control procedure.	3 (manual)
		GWP	e.6) Records the status of documentation or work product.	2 (not up to date)
			e.7) Contains and makes available work products and/or configuration items.	0 (not for supervisor)
			e.8) Supports monitoring of changes to work products.	2 (often not up to date)
Summary				12/40 (30%)

Ad. E) There is a need for introducing commonly used change and version control mechanisms for artifacts (especially documents). Now, a team is responsible for assuring both mechanisms. The supervisor has limited access and thus not complete knowledge on about the document versions, their authors, and the reasons of changes.

3.3 Proposed Solution

This section presents how the generic elements, identified and described in section 3.1, are to be instantiated within software system developing process. The solution will be implemented during following semester. The main element of the solution is Office SharePoint Server 2007 [9] that is used within the Institute of Applied Informatics as a LMS e-learning platform and as a portal for document management.

SharePoint supports business life cycle of design documents. All documents prepared by a particular team are stored and versioned by SharePoint server. Creation of new documents is simplified due to possibility of using templates.

In SharePoint a document can be in one of four states: draft, pending, approved, rejected. The document is in draft state after creation. Within this state document can be modified and updated many times. History of document revisions is available for both the team and the supervisor. The team can change the state of document to pending – see fig. 1. That means, that the document is ready to be checked. If the document verification is successful the supervisor changes its state to approved, otherwise – to rejected state. The team is obligated to prepare a new version of rejected document – the life cycle of such document begins once again. The information about the authors/updaters of each document could be easily obtained (realization of c.3, d.1, e.3-e.8 – tables 5 and 6).

	Słownik biznesowy	Student First	Approved
	Słownik systemowy	Student Two	Draft
	Zgłoszenie tematu	Student First	Pending

Fig. 1. Information about work product state

SharePoint supports monitoring of design tasks and design progress. Iteration plan for 1st iteration is prepared by team supervisor. Plans of subsequent iterations are prepared by team managers. The plan is visualized by Gantt’s graph – see fig. 2 (realization of a.1, a.2, a.3).

Any plan rescheduling has to be agreed with the supervisor. After that a team manager is allowed to introduce changes into iteration breakdown (realization of b.1, b.2, b.3). Each week the supervisor controls project progress according to the plan. Usually the supervisor asks for reasons of noticed delays and, if they are important he/she talks over the possible corrective actions and/or about the rearrangement of schedule (realization of b.4).

Discussion forum and wiki pages enable knowledge transfer between all stakeholders within the process, i.e. students, domain experts, IT experts etc. (realization of c.2). Table 7 presents assessment of a current process (CSA) and a priori assessment of proposed solution (FSA). We hope the process will move to fully achieved 2nd capability level in the considered area.

Fig. 2. Iteration process breakdown

Table 7. A priori assessment of planned improvements

Element	CSA	FSA	Element	CSA	FSA
	[0-5]	[0-5]		[0-5]	[0-5]
a.1)	2	4 (planned and documented)	e.1)	2	5
a.2)	0	5	e.2)	0	5
a.3)	2	4 (omits corrective actions)	e.3)	3	5
b.1)	3	5	e.4)	0	5
b.2)	2	5	e.5)	3	5
b.3)	0	5	e.6)	2	5
b.4)	2	5	e.7)	0	5
c.1)	4	5	e.8)	2	5
c.2)	3	4 (acceptance procedure is needed)			
c.3)	2	5			
d.1)	3	4 (communication not guaranteed)			
Summary	49/55	89%	Summary	40/40	100%

4 Summary

The aim of the paper was to show how to evaluate a process capability level and point out these task and activities in a process implementation improving of which would rise up a capability level. The assumption is that the process should be capable in terms of ISO/IEC 15504-2 assessment model.

Up to now the software development process was at least at 1st performed capability level. It results from the fact that it is a customised version of RUP methodology. The RUP disciplines: Configuration, and Change Management and Project Management need improvement in our opinion. The elements of these two disciplines were assessed to fulfil requirements defined for the managed level (according to Process

Assessment Model described in [3]). The solution aiming at improvement of the software development process in considered area and moving the process from partially achieved to fully achieved attributes was also described.

The key element of the solution is based on application of Office SharePoint 2007 Server. The solution is fully developed by the students attending the course. It is planned for deployment during the following semester. Its *a posteriori* assessment will be possible in six months.

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