

# Teaching Process Improvement by establishing Process Modeling Profile to drive Process Improvement – The PRO2PI-WORK4E Method

Clenio F. Salviano  
Centro de Tecnologia da Informação Renato Archer  
Rodovia D. Pedro I, km 143.6, CEP 13069-901  
Campinas, SP, Brazil  
clenio.salviano@cti.gov.br

## Abstract

A method has been defined and used to guide teaching and learning on Software Process Improvement (SPI) courses. This method is a customization for education of a method for initiating a process improvement cycle in an organization. This method had been used in twenty-three SPI courses. During the classes, each student learns basic concepts of Software Process Improvement and selected reference models, related these concepts and models with his or her actual work environment and work processes, and constructs a proposal for a process improvement.

## 1. Introduction

Around 2003, a group of Software Process Improvement (SPI) specialists created a specialization postgraduate courses *lato sensu* on SPI. The objective was to disseminate its concepts, techniques, methods and reference models to professionals all over Brazil. This type of course has minimum load 360 hours and only allow the admission of graduates of higher education. It is an alternative to a master degree. The specialization course was offered as distance e-learning from the Federal University of Lavras (*Universidade Federal de Lavras – UFLA*) with eight specific courses. For each specific course, support materials were produced, including a reference book and exercises. Each specific course lasted one month. Each specific course was completed with a four hours classroom

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lecture at UFLA Campus in the city of Lavras once a year. The specialization course was completed with a monograph.

For this specialization course, I was responsible for the specific course of Software Process Assessment and Improvement with ISO/IEC 15504-5 model. The actual objective of this specific course was to introduce SPI. I thought over SPI, teaching and learning processes and how the teach SPI.

Teaching SPI is a challenging effort. When we extend SPI from software related processes to knowledge working related process, we understand that teaching SPI can be considered as SPI. Knowledge worker, as defined first by Drucker, is a worker that thinks for a living [Dru59]. Software related worker is a knowledge worker. Teaching is a knowledge worker activity. Therefore teaching SPI is a process that, using the concept of process capability, should be performed, managed, established, predicable and improved. Hence, a teacher teaching SPI should follow a method for teaching process.

Conversely, during a course, the students are in a learning process. In order to guide the learning process, a constructivist-based process can be used. Constructivism is a psychological theory of knowledge (epistemology) that argues that humans construct knowledge and meaning from their experiences. Paulo Freire, a Brazilian educator, declared in his *Pedagogy of Freedom* that “knowledge cannot be transferred, knowledge must be constructed” and therefore “to teach is not to transfer knowledge but to create the possibilities for the production or construction of knowledge” [Fre98]. Therefore to teach SPI we need to create the possibilities for the production or construction of SPI knowledge.

Therefore, I decided to create this possibility by relating the teaching process with my experience in

helping organizations to perform process improvement cycles and the learning process with the students' actual experiences in their work processes.

The students in SPI courses are Information Technology professionals. They should learn SPI by a combination of studying and doing SPI. Hence, to teach SPI we customized a SPI Method in order to improve both teaching and learning. The method guides the students in a SPI experience related with starting a SPI cycle in their actual work.

From the experiences of the process used in this specific course, a method was consolidated to guide new editions of this specific course. The objective of this article is to share the experiences on using this method.

The customized method is named as PRO2PI-WORK4E. It is part of an innovative process improvement methodology: PRO2PI (Process Modeling Profile to drive Process Improvement) [Sal04] [Sal09a]. A methodological element of PRO2PI is a PRO2PI-WORK method. This method guides a workshop to establish a Process Modeling Profile in order to start a process improvement cycle. PRO2PI-WORK4E (*"for education"*) is a customized version of this method to be used to teach process improvement.

This article is organized in six sections. This Section 1 is an introduction and a contextualization of the article. Section 2 provides a brief overview of PRO2PI Methodology. Section 3 introduces the PRO2PI-WORK4E method. Section 4 presents information about applications of this method in SPI courses. Section 5 presents further work. Finally Section 6 presents conclusions.

## 2. PRO2PI Methodology

PRO2PI (Process Modeling Profile to drive Process Improvement) is a methodology for software and other knowledge worker process improvement driven by Process Modeling Profile with elements from multiple reference models.

A Process Modeling Profile is a set of specification and descriptive models of knowledge worker processes. Each model is from one of three types of models: Process Capability Profile, Process Enactment Description and Process Performance Indicator. As the inclusion of Process Enactment Description and Process Performance Indicator are research proposals, for teaching purpose, only Process Capability Profile is used. Therefore, from now on, Process Capability Profile is used instead of Process Modeling Profile.

There are two types or representations of reference models for SPI: staged and continuous.

Staged reference models define maturity levels. Continuous defines processes or process areas and capability levels. A Process Capability Profile is a set of processes or process areas in capability levels. A maturity level is an example of a Process Capability Profile.

PRO2PI is defined as a methodology following the meaning of the term methodology used by Schreiber et al [Sch00] in Knowledge Engineering. Schreiber et al presents the elements and their relationships of a methodology as a pyramid with feedbacks cycles. A methodology is a sequence of feedbacks cycles with a worldview based on a set of principles that form the baseline of a methodology. This worldview is grounded in theories that provide the essential concepts for establishing the methodology. The methods (and models, meta-models and other methodological components) and tools provide the key to enable the practical application of the methodology. The use of this methodology (the experiences) produces feedback that feeds the other "layers" of the methodology and enables the evolution of the methodology.

As a multi-model methodology, PRO2PI supports process improvement using elements from multiples process capability models and other sources. These elements are selected or defined and are integrated as a Process Capability Profile. A Process Capability Profile that drives a process improvement under PRO2PI methodology is also named as a PRO2PI.

The current version of PRO2PI methodology has four groups of methodological elements:

- Process Modeling Profile Metamodels,
- PRO2PI Quality Models,
- Process Improvement Methods, and
- Method Framework for Process Models.

Process Improvement Methods is centered in PRO2PI-CYCLE. PRO2PI-CYCLE is a method to guide a process for process improvement cycles including a function to define and use a PRO2PI. PRO2PI-WORK defines six phases. The first phase is Prepare for improvement cycle. It starts after a decision and commitment for improvement. The second phase is Establish improvement references. The third phase is Prepare for improvement actions. The fourth phase is Implement improvement actions. The fifth phase is Prepare improvements institutionalization. The sixth phase Institutionalize improvements produces an Improved organization. In the first phase, a first version of a PRO2PI is defined. Then, in each one of the following phases, the PRO2PI can be revised and updated and its current version is always used to drive the actions. An article presents detailed information and examples about this cycle as a modeling view of SPI driven by a PRO2PI [Sal11].

For small organizations, I realized that the improvements actions should starts as soon as possible and should produce visible results soon. In order to start improvements action (the fifth phase) I defined a specific method (PRO2PI-WORK) to implement the first four phases as a workshop. This workshop lasts two or three days.

Therefore PRO2PI-WORK is a method for workshop to establish a PRO2PI. This method has been developed to be used in traditional process improvement cycle methods, as, for example, IDEAL and ISO/IEC 15504 cycle, or in a PRO2PI-CYCLE process improvement cycle. PRO2PI-WORK method is composed of four phases: Preparation, Analysis, Consolidation and Conclusion.

There are two customized variations of PRO2PI-WORK method. One of them is PRO2PI-WORK4A (PRO2PI-WORK for Assessment) for a workshop with emphasis in the assessment of current practices. The other one is PRO2PI-WORK4E (PRO2PI-WORK for Education) for a workshop with emphasis in education on process improvement.

### 3. PRO2PI-WORK for Education

PRO2PI-WORK4E is method to guide SPI teaching and learning processes during a classroom or distance-learning course.

During the classes, each student learned basic concepts of Software Process Improvement in general, including its history, objectives and definition, process assessment, process enactment description and reference models for SPI, as, for example, CMMI-DEV [Cmm10] and ISO/IEC 15504-5 [Iso06]. Each student also related these topics with the work environment and work processes, and construct a proposal for a process improvement of his/her work processes. This proposal is documented as an article.

As a customization of PRO2PI-WORK Method, PRO2PI-WORK4E is composed of four phases:

- Preparation,
- Analysis (in this case by teaching SPI and Models with an analysis of an Organizational Unit to prepare for improvement),
- Consolidation (in this case by teaching Process Assessment and Improvement with a consolidation of a PRO2PI) and
- Conclusion.

PRO2PI-WORK4E is defined with four phases and twenty-one activities:

#### Phase 1: Preparation

- A.1.1 Analyze information about the specific course
- A.1.2 Select process areas from reference models

#### A.1.3 Select and customize teaching materials

#### Phase 2: Analysis

- A.2.1 Introduce the specific course
- A.2.2 Present an introduction to SPI
- A.2.3 Identify an Organizational Unit (OU) <W>
- A.2.4 Describe a current macro OU process<W>
- A.2.5 Identify business factors and goals <W>
- A.2.6 Present selected process areas
- A.2.7 Identify process areas relevance <W>
- A.2.8 Review work and propose PRO2PI <W>

#### Phase 3: Consolidation

- A.3.1 Present process capability and assessment
- A.3.2 Present examples of capability levels
- A.3.3 Estimate process capability <W>
- A.3.4 Present improvement cycle methods
- A.3.5 Propose improvement goals/actions <W>
- A.3.6 Review work and PRO2PI <W>
- A.3.7 Present research directions on SPI
- A.3.8 Each student presents proposed PRO2PI<W>

#### Phase 4: Conclusion

- A4.1 Conclude PRO2PI and article <W>
- A4.2 Conclude specific course

In the activities identified with <W> the emphases is in the practical work by the students with presentation with concepts, examples and orientation for the practical work.

For each activity, there are artifact templates and examples. One of them is a template and guidelines for the article with a correspondence between each section and each practical work result. The article is from 6 to 12 pages long. In addition to title, authors names, authors affiliation, abstract and introduction, in the beginning, and the references in the end, the article should contains the following sections:

- Section 1. Introduction to the article
- Section 2. Context, with a description about the organizational unit;
- Section 3. Conceptual references, with a introductory view on software process improvement, the selected model and the method used;
- Section 4. Related work, with identification and comments on related work to this work;
- Section 5. Process used, with a description of how the work was developed;
- Section 6. Business factors, and business goals of the organizational unit;
- Section 7. Description of the macro process of the organizational unit;
- Section 8. Statement about the relevance and risk for selected process areas for the organizational unit;

Section 9.	Process Capability Profile for process improvement
Section 10.	Improvement goals and improvement actions for the organizational unit;
Section 11.	Conclusions.

This article is constructed during the classes, using specific techniques and templates for each practical work activity.

In Activity A.2.2 - Present an introduction to SPI, the SPI manifesto is used to communicate the values and principles of SPI [Pri10]. In Activity A.2.4 - Describe a current macro OU process, the instructor presents objectives, concepts, notations and examples of process enactment descriptions. Then each student identifies and describes a macro process to be improved. In Activity A.2.5 - Identify business factors and goals, instructor presents objectives, concepts, the SWOT (Strengths, Weaknesses, Opportunities, Threats) technique [Hum04] for business factors, and the approach by Potter and Sakry [Nei02] for business goals definition. Then each student identifies business factors and describes business goals.

In Activity A.2.6 - Present selected process areas, the instructor presents each selected process area with: the concept behind it; its definition from its model; general comments about it; symptoms that are often seen when its practices are missing; and reasons why it may be important. The idea and examples of presenting symptoms and reasons are from a presentation by Garcia et al [Gar08].

In order to guide the understanding of each presented process area, each student relates it to his/her work environment and defines their relevance for process improvement. Hence, in Activity A.2.7 - Identify process areas relevance, for each presented process area, each student defines:

- a) How it is performed in the OU, including an identification of the actual process or group of processes that correspond to the process area presented, and information about how it is performed;
- b) What is the relative importance of this process area for the business goals, expressed in a three-value scale: low, medium and high; and
- c) What is the relative risk for the organization if it continues to perform this process area as it is now, expressed in a three-value scale: low, medium and high.

After the identification of relevance of all presented process areas, each student constructs a

three by three bi-dimensional matrix with relative importance and relative risk.

In Activity A.2.9 - Review work and propose PRO2PI, each student first identifies in the result of previous activity, the process areas that are in higher importance and higher risk for the OU, analyze the business factors and goals, and then select two or three process areas that could guides an improvement cycle in this OU. These process areas are the first version of the proposed PRO2PI. The instructor provides further orientations and examples for this activity.

In Activity A.3.3 - Estimate process capability, each student first estimate the current process capability level of each process area in the proposed PRO2PI and then propose a level to be achieved after the improvement cycle. The proposed levels became part of the PRO2PI. In Activity A.3.5 - Propose improvement goals/actions, each student proposes improvement goals and actions to achieve these goals and include these goals and actions in the PRO2PI. The approach by Potter and Sakry [Nei02] for define compelling improvement goals and improvement actions is used.

In Activity A.3.6 - Review work and PRO2PI, each student revises again the activity results and consolidates a version of the PRO2PI.

#### 4. Using PRO2PI-WORK4E

In the last twelve years, I used PRO2PI-WORK4E method to guide twenty-three SPI teaching experiences. Table 1 presents data on these twenty-three applications of PRO2PI-WORK4E Method.

In Table 1 each application of PRO2PI-WORK4E Method is characterized by an identification, from C01 to C07, of the course in which a specific course was teach, the month and year when it was teach, the number of students and the number of articles produced. Usually the number of articles is smaller than the number of students because some articles were produced by groups of students.

C01 is the specific course "Introduction to SPI using ISO/IEC 15504-5 (SPICE)" of "Software Process Improvement" Specialization pos-graduate course at Federal University of Lavras (*Universidade Federal de Lavras – UFLA*). The specific course is 36 hours of distance e-learning with material, orientations, exercises and chats using the Moodle software system during one month. The specific course is completed with 4 hours of a classroom lecture at UFLA Campus in the city of Lavras.

C02 is the specific course "Standards for Software Process - ISO/IEC 15504-5 (SPICE)" of "Quality Software Development" Specialization pos-graduate course at SENAC School of Exact Sciences and

Technology (*Faculdade SENAC de Ciências Exatas e Tecnologia*). The specific course is total of 40 hours with 10 classroom lectures at SENAC Campus in the city of São Paulo.

Table 1 – Twenty-three applications

ID	Course	Year/month	#students	#articles
01	C01	2004/05	18	18
02	C02	2004/09	22	10
03	C01	2004/11	37	31
04	C02	2005/02	11	4
05	C01	2005/05	27	20
06	C03	2005/06	31	13
07	C03	2005/06	24	9
08	C01	2005/10	42	32
09	C04	2005/11	22	17
10	C05	2006/11	27	10
11	C01	2006/03	30	11
12	C01	2007/05	32	20
13	C01	2007/10	36	20
14	C01	2008/05	32	19
15	C01	2008/11	25	18
16	C06	2008/06	28	8
17	C06	2009/06	20	10
18	C05	2010/11	24	12
19	C05	2011/11	22	4
20	C05	2012/11	14	4
21	C07	2013/09	46	17
22	C08	2014/09	22	17
23	C07	2015/04	36	10
		<b>TOTAL</b>	<b>628</b>	<b>334</b>

C03 is the specific course “Software Process Quality” of “Software Engineering” Specialization pos-graduate course at São Judas Tadeu University (*Universidade São Judas Tadeu - USJT*). The specific course is total of 12 hours with 4 classroom lectures at USJT Campus in the city of São Paulo.

C04 is the specific course “Introduction to SPI with CMMI” of “Capability Maturity Model Integration” Specialization pos-graduate course at Federal University of Lavras (*Universidade Federal de Lavras – UFLA*). The specific course is 36 hours of distance e-learning with material, orientations, exercises and chats using the Moodle software system during one month. The specific course is completed with 4 hours of a classroom lecture at UFLA Campus in the city of Lavras.

C05 is the specific course “Software Process Quality” of “Software Engineering” Specialization pos-graduate course at Piracicaba Methodist University (*Universidade Metodista de Piracicaba – UNIMEP*). The specific course is total of 24 hours with 4 classroom lectures at UNIMEP Campus in the city of Piracicaba.

C06 is the specific course “Software Process Improvement” of “Software Quality Management” Specialization pos-graduate course at Paulista Informatics and Management School (*Faculdade de Informática e Administração Paulista - FIAP*). The specific course is total of 24 hours with 6 classroom lectures at Aclimação Campus in the city of São Paulo.

C07 is the specific course “Software Process Models” of “Information Technology Governance” Specialization pos-graduate course at Unicamp Technological School (FT Unicamp). The specific course is total of 24 hours with 4 classroom lectures at FT Unicamp Campus in the city of Limeira.

C08 is the specific course “Software Process Models and Assessment” of “Software Process Improvement” Specialization pos-graduate course at Vale dos Sinos University (*Universidade do Vale dos Sinos – Unisinos*). The specific course is 24 hours of distance e-learning with material, orientations, exercises and chats using the Moodle software system during one month. The specific course is completed with 4 hours of a classroom lecture at Unisinos Campus in the city of São Leopoldo.

In spite of the different names of each specific course, all of them are about an Introduction to Software Process Improvement. In each of them, a specific Reference Model is presented and other models are also commented. Given the dissemination in Brazil, four reference models are used: the ISO/IEC 15504-5 Exemplar Process Assessment Model (ISO/IEC 15504-5) [Iso06], Capability Maturity Model Integration for Development (CMMI-DEV) [Cmm10a] and for Services (CMMI-SRV) [Cmm10b], Brazilian Software Process Improvement Reference Model (*Modelo de Referência da Melhoria de Processo do Software Brasileiro – MR-MPS.BR*) [Mon09]. In a more recent application, at Vale dos Sinos University, CERTICS

Reference Model for Assessment (*Modelo de Referência para Avaliação da CERTICS*) [Sal14] was also used as reference.

## 5. Further Work

For each application, I get feedback from the students and analyses the results. Minor adjustments have been made for each application to implement minor improvements. Although there are 23 applications in 12 years with participation of 628 students and production of 334 articles, PRO2PI-WORK4E is a work in progress because I neither analyze these data in a systematized fashion nor transfer this method to another instructor. Slides, templates and results, including articles from students, for each specific course are registered. A further work is to analyze these results.

Another further work is to identify an appropriate pedagogical reference and to analyze and improve PRO2PI-WORK4E from this reference. A candidate reference is andragogy. According to the article Malcolm Knowles an American practitioner and theorist of adult education, andragogy as “the art and science of helping adults learn”. Knowles identified the six principles of adult learning as: (a) Adults are internally motivated and self-directed; (b) Adults bring life experiences and knowledge to learning experiences; (c) Adults are goal oriented (d) Adults are relevancy oriented; (e) Adults are practical; and (f) Adult learners like to be respected. A preliminary analysis of these principles indicated that they are relevant for PRO2PI-WORK4E.

PRO2PI-WORK4E is described in Portuguese language as all slides and other support materials because all applications are in Brazil. There is an English version of slides for a tutorial on PRO2PI-WORK (and PRO2PI-WORK4E) that has been presented in international conferences, as, for example, Euromicro SEAA 2012, SPICE 2008 and EuroSPI 2009 [Salb09]. These tutorials and now this article increase the dissemination of PRO2PI-WORK4E.

## 6. Conclusions

This article presented a method and a balance about experiences with constructivist-based education on Software Process Improvement. The education experiences were guided by PRO2PI-WORK4E method. The twenty-three post graduate courses, the participation of 628 students in those courses, the production of 334 articles with proposals for process improvements for the actual work processes, and the positive feedbacks from them, gives us confidence that this is a valid experience and

it deserves to be disseminated. Due to limitations, the experiences were more in identify and planning process improvement actions then actually implement them. Some students continued these experiences after the classes, completing the process improvement cycle.

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