



A process capability based assessment model for software workforce in emergent software organizations

Ö. Özgür Tanrıöver^{a,*}, Onur Demirörs^{b,1}

^a Computer Engineering Department, Ankara University, Gölbaşı 50.yıl Yerleşkesi Bahçelievler Mh., 06830 Ankara, Turkey

^b Informatics Institute, Middle East Technical University, İnönü Bulvarı, 06531 Ankara, Turkey

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ABSTRACT

Software process improvement frameworks for software organizations enable to identify opportunities for improving the processes as well as establishing road maps for improvement. However, software process improvement practice showed that to achieve a sustained, leveraged state, software organizations need to focus on the workforce as much as the process. Software process improvement frameworks address the people dimension indirectly through processes. To complement process assessment models/methods, there is a need of mechanisms that address the problem of “how to assess, identify and prioritize detailed skill and knowledge improvement needs in relation to roles and processes of software organizations”. In this study, we developed a Software Workforce Assessment Model (SWAM) for emergent software organizations to perform role based workforce skill assessment aligned with software processes by coupling SW-CMM and SWEBOK models. SWAM is developed in accordance with the widely accepted assessment and evaluation theory principles. It is composed of an assessment baseline for software roles, criteria and scales for assessment. A SWAM based assessment process uses specific techniques such as Euclidian distance and dendrogram diagrams to obtain useful results from data obtained from assessments. Through a case study, SWAM is shown to be applicable and the results are valuable for an emergent software organization. Specifically, the assessment enables the organization to identify priority knowledge units, to decide the extent of trainings for groups of individuals, to effectively assign project roles, to identify improvement priorities for the practitioners related to their roles and finally facilitates enactment and improvement of the software processes.

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1. Introduction

The software process is a set of activities, methods, practices and transformations that software engineers and users use to develop and maintain software products [1]. During the last two decades, a number of software process improvement frameworks including software process assessment methodologies and underlying process reference models have been developed. Among these, Software Capability Evaluation (SCE) [2], Standard Capability Maturity Model Integrated (CMMI), Appraisal Method for Process Improvement (SCAMPI) [3,4] and Software Process Improvement and Capability Determination (SPICE) [5,6] have been widely used.

Software process improvement frameworks enable software organizations to identify opportunities for improving the processes as well as establishing road maps for improvement [7]. However, software process improvement practice showed us again and again that to achieve a sustained, leveraged state, software organizations need to focus on

people more than anything else [8–11]. Software process improvement frameworks address the people dimension indirectly through processes. The underlying process model describes roles and associated practices defined in each process area and accordingly software practitioners should be trained in accordance with the roles they are assigned.

To improve software practitioner skills with the methods based on execute–evaluate–change cycle P-CMM [12,13], Personal Software Process (PSP) [14], to guide practitioners to build a self-directed teams Team Software Process (TSP) [15,16] and to guide organizations in managing and developing their workforce People Capability Maturity Model (P-CMM) [12,13] have been developed. However, these models/methods, do not specifically address the problem of “how to the organization will identify detailed improvement opportunities of software practitioners according to organization's software processes”.

In this study, we have developed a Software Workforce Assessment Model (SWAM) for emergent software organizations. The aim of SWAM is to perform role based personnel skill assessment aligned with software processes. SWAM is developed in accordance with the assessment and evaluation principles. It is composed of an assessment baseline for software roles, criteria and scales for assessment. A SWAM based assessment process uses specific techniques such as Euclidian distance and dendrogram diagrams to obtain useful results from data obtained from

* Corresponding author. Tel.: +90 3122033300; fax: +90 3124841095.

E-mail addresses: ozgurtanriover@yahoo.com (Ö.Ö. Tanrıöver), demirors@metu.edu.tr (O. Demirörs).

¹ Tel.: +90 3122103741; fax: +90 3122103745.

assessments. SWAM couples the process and workforce aspect and is an enabler to identify and prioritize specific and concrete improvement and training needs in relation to software processes and roles. Its outputs can be effectively used for training programs at individual and organizational levels. Specifically, the knowledge profiles and dendrogram diagrams for roles generated help to identify top priority knowledge units for the organization, to decide the type of the trainings for determined groups of individuals, to effectively assign project roles, and to identify improvement priorities for the practitioners related to their roles in the projects. In this respect, SWAM assessment is complementary to mostly used software process assessment methods (SCE and SCAMPI) as well as people capability maturity models (PSP, P-CMM and TSP).

In the following sections, first existing assessment models, and their positions related to workforce assessment are summarized. Then, the development of software workforce model in accordance with the evaluation principles is given. Thirdly, the SWAM based assessment process coupled with a case study to validate the model and findings of the conducted case study is presented. Finally, possible improvement directions and limitations of the study are given.

2. Related assessment models

The most frequently used process assessment methods by the software community are SCE [2] and SCAMPI [3]. These methods are based on the Capability Maturity Model for Software (SW-CMM) and CMMI, developed by the Software Engineering Institute (SEI). The SEI's models describe five levels of process maturity. An organization willing to improve its software process must evolve through all these levels. Moreover, (in SW-CMM and staged version of CMMI) each maturity level is composed of a set of key process areas (KPA), and each KPA consists of key practices that accomplish the goal of the process areas. In addition to evaluation to KPAs, SCAMPI includes evaluation of technology and experience level of the software development personnel to a certain extent. The underlying process model describes roles and associated practices defined in each process area and accordingly software practitioners should be trained in accordance with the roles they are assigned. However, training needs assessment of software workforce and role assignment mechanism based on capability profile of practitioners is not explicitly defined.

In addition to organizational process oriented approach of CMMI, Humphrey [12,13] suggested PSP as a self-improvement framework defined in terms of a set of large-system software methods and practices. In essence, the PSP provides a software engineer with the tools necessary to improve his skills using an execute–evaluate–change cycle. As a complementary to PSP, the TSP extends and refines the CMMI and PSP methods to guide engineers in their work to build a self-directed team and to perform as an effective team member. Humphrey [16] argues that, the CMMI, PSP, and TSP provide an integrated three-dimensional framework for process improvement. However, neither PSP nor TSP provides a concrete and explicit model to assess the workforce of software development from the abstraction level of an organization.

It has been agreed in many studies that human resource management practices are among the indispensable critical success factors for quality software processes [17,11]. In order to complement the above approaches, SEI developed the P-CMM [12,13] to guide organizations in managing and developing their workforce. P-CMM uses the same principles and structure as the CMMI. P-CMM has four KPAs that address training issues: one at level 2 and three at level 3. However, the P-CMM does not bring an organizational focus to training at level 2. In fact, the “Training” KPA resides at level 2 and describes the training program for the unit or project as in the case of ISO 15504. Only, at level 3 the “Knowledge and Skills Analysis” KPA focuses on the identification of the core competencies of the organization and the knowledge/skills required to perform the processes. Even if the P-CMM was to be tailored

to be implemented according to the needs and capabilities of small organizations, it does not suggest an assessment baseline or best target profiles for roles in accordance with enacted software development processes. It only provides the roadmap for a generic human resource management process and in fact could be applied to any organizations of other domains.

Differently from SW-CMM and CMMI (Staged Model of CMM), ISO/IEC TR 15504's model is based on two dimensions: a process and a process capability dimension. A software organization is assessed in the process dimension against the process attributes in the capability dimension. ‘Human resource management process’ defined in ISO/IEC TR 15504 is aiming to provide the organization and projects with individuals who possess skills and knowledge to perform their roles effectively and to work together as a cohesive group. If this process is successfully implemented, firstly the roles and skills required for the operations of the organization and the project will be identified through timely review of the organizational and project requirements; secondly training will be identified and conducted to ensure that all individuals have the skills required to perform their roles and finally individuals with the required skills and competencies will be identified and recruited by using objective mechanisms, or they will be trained as appropriate to perform the organizational and project roles. Although, it is clear that in order to reach these objectives an assessment for workforce is needed, ISO 15504 does not explicitly define or suggest a methodology for this purpose. Furthermore, ISO 15504 suggests that the trainings must be performed mostly on project bases when needed. However, the ISO/IEC TR 15504 base practices themselves require knowledge and skills in certain areas irrespective to any project domain. The issue of how necessary training will be identified to perform these is not addressed.

Finally, ISO 9001 2000 [18] model provides organizations with guidance to achieve compliance with this standard. The quality system compliance with the standard requirements confirms that the company has achieved such a maturity level that it is capable of defining the processes and performing them according to the definitions [19]. However, the model says nothing about which methods organizations should use to meet these requirements or what kind of knowledge and skill are required for the practitioners of these activities. The method is left completely to the particular organization. For instance, if an item in the ISO model demands that the organization define and set up the procedures for staff training, in fact it is assumed that the organization has a defined training scheme and documented procedures for identifying training needs with respective contents.

Current improvement paradigms define *why/how* an identified process is to be performed in the context of the goals, objectives and constraints of a project or organization. For improving the quality of software production, process dimension has been the main aspect used and in addition to organizational wide assessment models, even process standards for specific software life-cycle phases are developed [20]. The basic assumption is that process assessment scores are positively related with organizational effectiveness. They do not, however, provide the necessary details to assess the capabilities of workforce to enact these processes. Especially, in small organizations, the quality of workmanship involved in the software process is as important as the process. Thus an explicit and detailed method is also needed for assessing the workforce component especially for emergent software organizations.

3. SWAM: software workforce assessment model

SWAM is developed based on general evaluation and assessment principles [21–23] which are widely used in education field. In essence five main steps must be considered for an evaluation:

1. Determination of the *object* under assessment.
2. Elicitation of the *characteristics/criteria*.
3. Determination of the ideal characteristics of the object attributes to be compared to: the *assessment baseline*.

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