Which Process Model Practices Support Project Success?

Marion Lepmets

Institute of Cybernetics at Tallinn University of Technology
Akadeemia 21, Tallinn
Tel.: +372 2 620 4198
Marion.lepmets@ttu.ee

Abstract. In this research the relevance of the guidance of software process models to industry was studied - more precisely, how relevant are the basic project management practices to the industry projects and to the success of these projects. The focus of the research is on project management and its related practices - the processes that support the achievement of capability levels 1 and 2 in CMMI and ISO/IEC 15504. These project management practices can also be viewed as best practices, the application of which can lead to project success. We aimed to discover whether the implementation of basic project management practices supports project success. There is evidence that higher process capability supports increased project performance. The question remains about the significance of basic project management practices to project performance.

Keywords: Software Process Improvement (SPI), project management, project success, process models, CMMI, ISO/IEC 15504.

1 Introduction

This research is related, on one hand, to the field of project management and, on the other hand, to the field of software process improvement. The field of software process improvement has evolved from quality thinking in manufacturing [1]. Project management, often seen as having no explicit underlying theory, is argued in [2] to be based on the theory of project and the theory of management.

In this study we focused on ISO/IEC 15504 and CMMI as they are widely used in software industry for process assessment purposes. ISO/IEC 15504 is the only international standard for process assessment at the moment. CMMI, whose underlying ideas have endured over time, has evolved from the concepts of software maturity framework that was developed by Software Engineering Institute already in 1986 and is used extensively today. Both ISO/IEC 15504 and CMMI provide guidance for process assessment to software development organisations in their attempt to map activities against the best practices of the chosen model. For companies new to software process assessment and improvement, one of the most important questions is the relevance of the process model guidance to its activities, i.e. how well do model practices correspond to industry best practices [3].

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In studying the process model practices we have limited the study to project management (PM) and its related practices. We aim to answer the following question: What is the relationship between implementing basic project management practices and the success of software projects?

In order to attain the aim of the study, project management practices were first derived from process models of CMMI for Development V1.2 [4] and ISO/IEC 15504 [5]. Additional project management practices not described in these process models were added from the Project Management Body of Knowledge (PMBoK) from PMI [6] and project management literature. This set of project management practices is called the basic project management (PM) practices throughout this study. These basic PM practices were then evaluated against the industry software development projects. Metrics were developed and the data was gathered through a survey questionnaire from software project managers. The data was analyzed through triangulation of data, using correlation, factor analysis and self-organizing maps on the same set of data. The survey also described project success factors that provide the data for measuring the relationship between implementing the basic PM practices and the project success.

2 Related Research and Motivation

Although this research is related to quality management in general, there are three narrow areas of research that relate closely to this study: a) research conducted about SPI and process models; b) research conducted about Project Management and its practices that lead to project success; c) process capability and project success.

In the first area there is a lot of research conducted on SPI, improvement methods [7], [8], [9] and models [10] that are related to it. There are many case studies published about the implementation and adoption of process models in industry, mostly illustrating the industry success stories [11], [12], [13], [8]. There has also been much comparison of different Capability Models and SPICE, both by Software Engineering Institute (SEI) and European Software Institute (ESI), primarily mappings of terminology and concepts [14], [15], with few analyses of conceptual relationships between the models [16]. Much research in SPI is focused also on the SMEs and how they can benefit from process models originally created for the needs of large organizations. [17], [18], [19], [20], [21].

Most of the research in the second area is empirical, aiming to find the industry best practices as well as project success factors. An extensive survey of PM practices of 122 in-house software development projects in US organizations that rely heavily on software was described in [22]. The study claims that the project manager's clear vision of the project, good requirements and adequate information for delivery were the most important factors of project success. Similar study was carried out in Australia where 42 software development or maintenance projects were studied, described in [23]. The results confirm the findings of the Verner and Evanco study.

Goldenson and Herbsleb surveyed 61 CMM appraisals through contacting 167 individuals in USA and Canada over a one-year period. The study [24] concludes that the higher organizational maturity increases the organizational performance. In their study, performance was defined in terms of six variables: customer satisfaction,

ability to meet budget commitments, ability to meet schedule commitments, product quality, staff productivity, and staff morale. El Emam and Birk have used the same variables in [25] that were defined in [24].

The research conducted in the third area aims to discover whether the higher capability of a certain process or process area has positive effects on project performance. The study of Goldenson and Herbsleb in [24] claims that the higher organizational maturity increases the organizational performance. The results appear to be unaffected by the type and size of the organizations involved.

El Emam and Birk investigated the relationship between the capability of software requirements analysis (SRA) process as defined in the ISO/IEC TR 15504 and the performance of software projects in [25]. Their results indicate that improving the SRA process may potentially lead to improvements in productivity of software projects in large organizations.

Jiang describes a study [26] that examined the relationship between SW-CMM software process development activities and project performance. As a result of their study they conclude that the higher process maturity is positively associated with the project performance while the basic project management process activities were not significant to project performance.

As a result of analyzing the related research, we can argue that there is evidence from literature [25], [26] that higher process capability supports better project performance. There remains a question, however, about whether the implementation of basic practices of process models increases the project performance. The findings from the related research have motivated the author to study the relevance of the basic PM practices of process models to industry projects and to the success of these projects. The benefits of SPI are stated to rise as a consequence of implementing combinations of practices that relate to one area as opposed to the implementation of an individual process [25]. We studied a combination of related processes instead of studying the relationship of an individual process capability and project success. The project success factors used in the study reflect the six success variables described in [24] and applied in [25].

3 The Basic Project Management Practices

In order to find out the relevance of process model practices in industry, we first derived the set of basic PM practices that later served as the basis for data collection through a survey questionnaire. This set of the PM practices were derived from process models CMMI and ISO/IEC 15504 and the pertinent PM practices from literature and the PMBoK.

The basic PM practices of process models are made up of the project level practices of CMMI and ISO/IEC 15504, which is a set of specific practices (from CMMI) and base practices (from ISO/IEC 15504) of project management and project management related processes (areas). Also, the generic practices and generic practice indicators that support the achievement of generic goals/process attributes of Capability Level 2 are a part of the basic PM practices in this study. This should indicate that the processes that have been implemented in the industry project described in the survey are performed according to a plan and their performance is controlled against that plan as opposed to being accidental.

Additionally, project management practices from various sources of project management literature and the PMBoK [6] were also collected into the set of basic PM practices.

The set of the basic PM practices was reached in four steps. First, the basic PM related practices were selected from the two process models. Second, these practices were grouped together on the practice level. Third, the practices of the PMBoK were analyzed against the model practices and the pertinent ones added to the final set of basic PM practices. Project management literature was reviewed and the PM best practices compared to the set of basic PM practices of process models and the PMBoK and the pertinent practices were then added to the final set.

3.1 Process Model Practices

The project management related practices were drawn from the process models and grouped into categories for the survey questionnaire. Each category consists of a set of specific/base practices that are evaluated through the survey against industry projects. There were altogether 13 categories of basic PM practices derived from the process models that correspond to 96 survey questions.

Table 1 describes the basic PM practices derived for the study from CMMI and ISO/IEC 15504 and grouped into categories for the survey questionnaire App. 5 in [3].

Table 1. Basic PM practices derived from process models

Basic PM model practice categories:	**CMMI specific practices from:**	**ISO/IEC 15504 base practices from:**
Project Planning	Project Planning	Project Management
Project Estimation	Project Planning	Project Management
Project Monitoring and Control	Project Monitoring and Control	Project Management
Requirements Management	Requirements Management	Requirements Elicitation
Supplier Tendering		Supplier Tendering
Change Request and Configuration Management	Configuration Management	Change Request Management
Supplier Agreement Management	Supplier Agreement Management	Contract Agreement
Risk Management	Project Planning	Risk Management
Problem Resolution Management		Problem Resolution Management
Quality Assurance		Quality Assurance
Measurement and Analysis	Measurement and Analysis	
Process Performance Management	GP 1.1-2.10	GPIs of PA 1.1, 2.1
Process Work Products Management		GPIs of PA 2.2

Each of the categories listed in Table 1 consists of a set of model practices. These practices needed to be grouped for evaluation purposes. Since integrating practices of different models is an approach that lacks objectivity, we used the differentiation of known and unknown factors [27]. This differentiation helps to see the similarities and differences between the two process models. It also allows an easier industry practice comparison to practices of only one of the process model. [3]

Additional project management best practices were analyzed and added to the final set of the basic PM practices derived from the process models. These pertinent practices together with the model practices were then formulated into survey questions that were used for data collection in software industry. [28]

3.2 Pertinent Project Management Practices from the PMBoK

There are five groups of processes related to project management described in the PMBoK [6]. Each group consists of core and facilitating processes that are comparable to the selected practices of the process models. Most processes described in the PMBoK have already been derived for the study from either one or both of the process models. The only PMBoK practices that are not described in process models come from the project closing process group and are added to the set of basic project management practices.

Project completion practices from the PMBoK:

- Information to formalise project completion is gathered and disseminated;
- The project is evaluated after closing;
- The lessons learned are compiled for future projects

3.3 Pertinent Project Management Practices from Project Management Literature

An extensive literature survey was conducted to find project management practices that are not described by the selected practices of process models [3]. The purpose of these pertinent PM practices in the research is to find out whether there are practices that industry implements and regards as vital for success but are not described in process models on the project level.

Most practices from project management literature had similar practices already described in the process models (project planning, estimation, monitoring and control, human resource and risk management) or in the PMBoK (project completion). Practices about directing people were added to this study as a result of the literature survey conducted.

Project directing practices from project management literature:

- Give directions to the project team;
- Supervise the project team;
- Motivate the people in the project team;
- Coordinate the interaction between the people in the project team;
- Explain the reasons behind the decision-making to the project team;
- Resolve the conflicts within the project team.

4 Data Collection

The set of the basic PM practices was then developed into a survey questionnaire. The survey questions were formulated into closed-ended questions and an intensity scale provided to find out how well these practices were implemented in industry projects.

There were altogether 105 questions corresponding to the set of basic PM practices of which 96 were from process models, six from project management literature and three from the PMBoK. [28]

The basic PM practices can also be viewed as best practices, the application of which can lead to project success. Thus, the industry projects described in the survey had to be successful as well. The questionnaire was addressed to software industry project managers, who then described a recent successfully completed project that they managed by rating the questions provided in the survey [3]. There were nine questions in the survey aiming to find out how successful was the project that the project managers described.

At the beginning, simple random sampling was used where the survey was sent to 118 Finnish software companies. Only one response was received from this sample. We concluded that the companies most likely to respond to the survey are the companies interested in quality-related issues in software development and the non-probability sampling was used instead. Companies in Finland were contacted through a national SPI expertise centre FiSMA and a national software companies association in Estonia. It is impossible to determine the companies interested in software quality or software process improvement, which makes determining the sample from that population equally impossible. The non-probability sampling method used in the research allows us to generalize the results of the data analysis only to the respondents of the survey. There were altogether 29 responses to the survey, of which 11 came from Estonia, 16 from Finland and two remained anonymous as to the origin of the respondent company. [3]

The internal validity of the results was increased in the study through data triangulation, where the findings of the data analyses were confirmed by three different methods. The data analysis results using different analysis methods were compliant with each other, indicating that using any other method will not provide new results of the received data.

5 Data Analysis

The data received were analysed through triangulation. While correlation is the most straightforward form of relations between two variables, we cannot easily find clusters of variables from correlation tables. Factor analysis is of help here - we can find clusters of variables that have similar trends of behaviour. Still, the reasons behind classifying variables under a certain component are not explained through factor analysis. Here, we used self-organising maps [29], which also visualise clusters of multi-dimensional data in diagrams and in addition, explains the reasoning behind clustering of different variables. [3]

To answer our research question: What is the relationship between implementing basic PM practices and the success of these projects?, the correlation between project success and basic PM practices was looked for. The highest correlations between practices and success are described in Table 3. There was only a moderate correlation between project success and performing the basic PM practices. Significant correlations were found between project planning, stakeholder involvement planning, positive project environment, where staff responded to supervision and people in the project were motivated.

Table 3. Highest correlations between project success and basic PM practices

Basic PM practices:	Project success
project's staff interaction was well coordinated	0.78
people in the project were motivated	0.75
stakeholder involvement planned	0.71
the project was carried out in positive environment	0.69
the project was well planned	0.61
base practices were performed	0.49

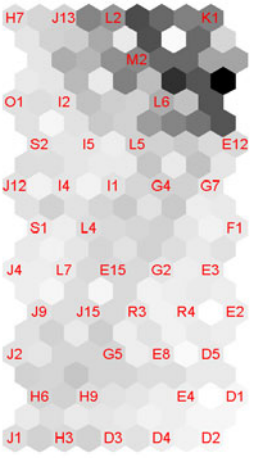
Factor analysis (Table 4) tells us that the success of the project depends highly on project being on schedule, on budget, where people are directed and motivated, well coordinated staff interaction, reasons for decision-making well understood by staff and project was carried out in a positive environment. Successful project was also accurately estimated, where stakeholder involvement was planned. The factor analysis of the entire data set can be viewed here [30].

Table 4. Classification of basic PM practices with project success

Basic PM Practices:	Project success
the project staff committed well to directions	0.656
project's staff interaction well coordinated	0.647
project was carried out in positive environment	0.590
stakeholder involvement in project was planned	0.577
project quality goals well estimated	0.575
people in project were motivated	0.571
reasons of decision-making understood by staff	0.545
project was accurately estimated	0.456

During SOM analysis we viewed the clustering of basic PM practices together with project success. On a U-matrix, the light colour corresponds to a small distance between two map units, i.e. a group of data that are similar and behave in the same way and dark colour corresponds to a bigger difference. The light area on the right low corner of the u-matrix on Figure 1 is represented also in the table next to it, illustrating the basic PM practices clustered closely together with project success. High values of project success are clustered closely together with people management, requirements management and accurate project estimation.

As a result of the data triangulation, we cannot argue that implementing the basic PM practices are significant for a project to succeed. At the same time, we can say that directing and managing people and their interactions well in the project is crucial for project success. We can also conclude that the basic PM practices that most affect the success of the project were requirements management, project planning and accurate estimation with defining the project scope, planning of the project resources and stakeholder involvement.



J1	H3	D3	D4	D2
J3		E10	D6	D9
J5		F4	D8	P1
J6		H1	F5	P2
J7		H2		P3
		H4		P5
				P6
				P7

Fig. 1. Clustering variables of project success and basic project management practices

6 Discussion

In our research, we evaluated the basic PM practices in industry. We studied the relationship between the implementation of the basic PM practices in industry projects and the success of these projects.

The only significant relationship between PM practices and project success comes from the PM literature. Directing and managing the people in the project team through motivating and supervising them, and co-ordinating the interaction between team members were described as the most important PM practices supporting the project success.

There were only few process model practices moderately related to project success. The project management related practices of project planning and estimation selected from process models were the only practices described as important for the project success. The project resource and stakeholder involvement planning, and estimation of project attributes are the prerequisites for good project planning and accurate project estimation, respectively.

This finding suggests that the organisations improving their processes with the help of process models may not experience much benefit to their improvement work until the processes reach a higher capability level than level 2 [3]. The basic PM practices may form the necessary foundation for project success, but their implementation alone did not deliver observable benefits based on this study.

These results confirm the findings in [21], [22], both of which described the crucial factors of project success through managing the project team in terms of motivating the team members, co-ordinating the communication of team members and relating well to the team. Similarly to [31] our results illustrate that the behavioural and organisational issues, as opposed to the technical issues, are the primary drivers of project success. O'Suillebhain et al. state in [32] that most process improvement experts neglect the reality that human factors, skills and social and teamwork

competencies have significant influences on success. This is contrary to the belief of many process people who feel that processes can make the company independent of people.

Based on the results of the research reported in [32], process models could also contain best practices about directing and managing people in the project teams. A project manager has to motivate the team members, co-ordinate their interaction and supervise them when necessary to create the positive environment for the development that supports the overall project success.

7 Summary

As a result of the research, we can conclude that the practices related to managing and directing people in the project developing team were most important from the standpoint of the project success. Planning the project resources and stakeholder involvement, and estimating the project accurately were also relevant to project success. The more complicated practices related to project data measurement and analysis; risk control and post-mortem reviews through project closing were rarely implemented in the projects studies in the research.

The findings also suggest that the basic PM practices may form the necessary foundation for project success but their implementation alone did not deliver observable benefits based on this study. Organizations improving their processes may not experience benefits of their improvement work until the processes reach higher capability level than level 2.

Even though the higher project management process capabilities are likely to increase project success, it is clear that the human aspects of the project management and process improvement are vitally important for their success. Successful process improvement relies heavily on human factors, skills and teamwork competencies. A project manager has to motivate the team members, coordinate their interaction and supervise them when necessary to create the positive environment for the development that supports the overall project success.

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