Performance Evaluation of Software Development Project Team

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Abstract. The necessity of finding the connection between the planning, decision making, actions and results create project management interest to an evaluation of the project team performance. By analyzing the team performance, determining successful projects and assessing results, members of such project will have the necessary information to avoid failures, to monitor the progress, to compare similar projects and move to defined goals.

The objective of this paper is to provide guidelines for evaluation of the project team performance in the software development project. This paper summarizes measures for evaluation of the team performance, an evaluation objectives and it benefits as well as factors that may have an influence on the team performance. Demonstration example of the guideline usage has been provided.

Keywords: Software development project management, human resource management, project team performance, sociometric method.

I. INTRODUCTION

Almost every of us is oriented to archive some goals (in work or life) or successful outcomes and want to keep track progress of achievements and results. Similarly, also software development (SD) organizations, project managers, and team members would like to evaluate a performance of projects and project teams [1]. Finding of connections between planning, decision-making, actions and results creates interest of organizations and project management to an evaluation of the project team performance [2].

The SD project mainly includes cross-functional team-intensive work that creates new software products [3]. The most part activities in these projects have been based on people so the team development, evaluation, and management activities are important.

An objective of this paper is to provide a guideline for evaluation of the project team performance in the SD projects. The guideline has been created based on a literature review about the team performance, the project success and an evaluation measures (qualitative, technical and social) and demonstrated with an example. The main contribution of this research is the evaluation of the qualitative team performance together with technical and social influencing factors. The sociometric methods are used for evaluation some of the social factors. Existing researches focuses on measurement of time, cost, and quality [1], [3], [4], [5] and discusses social factor impact to the team performance [6], [7], [8].

The rest of the paper is structured as follows: Section 2 presents literature overview of the team performance and evaluation of the team performance.

Overview of the guideline is described in Section 3. Evaluation example of the team performance using the guideline is demonstrated in Section 4. Conclusion and future work is presented at the end of the paper.

II. LITERATURE OVERVIEW

In this section, we discuss the results of the literature review about the team performance and it influencing factors (Section II.A.), and evaluation of the team performance, its objectives and metrics (Section II.B) with a focus on the SD projects.

A. Team performance

For the team performance measurement uses objective and subjective measures [1]. Objective measures include team productivity (e.g. function points, time variance, cost variance, complexity metrics etc.) [1], [9]. Subjective measures of the team performance include a perceptual rating of the team performance by team members and stakeholders (e.g. team effectiveness, system viability, professional growth, user satisfaction, teamwork satisfaction, output quality etc.)[1], [9].

The team performance and its success are related to the project success. So, before analysing the team performance, we review the definition of the project success. The project success can be defined in different levels [10]:

- It delivers all or most of what it said it would, regardless of schedule or budget performance;
- It delivers what it said it would, on schedule and/or within the agreed budget;

- It delivers what it said it would, on schedule, within the agreed budget, and to the expected quality standards;
- It delivers on all agreed project objectives, be they scope, schedule, budget, quality or outcomes based;
- The product produced by the project creates significant net value for the organization after the project is completed.

The project success and the team performance can be reviewed from two perspectives: project management success (process view) and product success (product view) [11]. The process success evaluates time, cost, quality of technical specifications, stakeholder satisfaction, and development and quality management process [11]. The product success is evaluated based on lessons learned, used innovative technologies, achieved organizational objectives, possibilities to uses product in the future [11].

The team performance is part of the project performance and also noticeable impacts the project performance as the project team is the main implementer of project [2]. Two terms are used for description of project performance - effectiveness and efficiency [3]. Effectiveness refers to the extent to which customer requirements are being met, while efficiency is a measure of how economically a firm's resources are being used, providing a given level of customer satisfaction [3], [12]. Efficiency is easy to measure as it also focuses on time and costs [3]. There is a wide variety of researches related to the SD project performance, e.g., earned value method [2], performance evaluation practices used in SD projects [3], measures of the SD project performance [4] etc. The team performance also is defined as the degree to which team completes the project efficiently and effectively [6], [7].

So, the SD project team performance can be interpreted as a set of criteria that characterize results of activities performed by all project team members during an SD lifecycle. The team performance more focuses on the one project team (in a case of the multi-team project), its performance from project phase to phase and from one project to other.

During evaluation of the team performance, it is also important to analyze factors that may have an influence on the performance. These factors are technical and social (including psychological and organizational). Summary of influencing factors and related researches is given in Table I.

B. Evaluation of team performance

Measurement of the project team performance can be defined as the process of quantifying action, where measurement means the process of quantification and the performance of the operation is assumed to derive from the actions by its management and the project team interaction (adapted from the definition used in [3]). Main functions of the performance measurement

are alignment and prioritization, evaluation and incentives, operational control, and learning and improvement [3], [13]. And one of the main benefits of the performance measurement and evaluation is learning [14]. In its simplest terms, the performance evaluation is a process of assessing the results of the project team to determine how effective the operations are, and make changes to address performance gaps (adapted from the definition used in [4]). Evaluation of the team performance not radically different from other organizational measures systems, e.g. Plan-Do-Check-Act [15] etc.

Table I
Influencing factors

FACTORS	REF.
Technical factors	
Team size	[4], [16]
Requirement and it priority changes	[4]
Product size	[4], [16]
Specific of programming language	[4], [16]
Reuse of software artifacts	[4]
Development method	[16]
Social factors	
Communication and coordination processes in team	[1], [5], [6], [7], [8], [9]
Focus on goal	[6], [7], [8], [17]
Team cohesion, internal relationships, and team climate	[1], [5], [6], [7], [8], [9]
Organizational and mutual learning	[6], [7], [8], [17]
Management support	[7]
Rewards	[7]

Evaluation of the project team performance can be performed in three levels (based on principles defined in [17]):

- Level 1: Measurement and evaluation of specific numerical measure;
- Level 2: Measurement and evaluation process as defined algorithm that includes both numerical and qualitative measures;
- Level 3: Comprehensive strategic planning process of setting the appropriate team performance targets and evaluating their achievement in order to validate or revise the organization's/project goals.

Organizations can perform the evaluation of the project team performance with different purposes. Some examples:

- Increase productivity [17];
- Evaluation of organizational capability to archive defined business or project goals [3], [4];
- Benchmarking [3], [4];
- Increase motivation and client satisfaction [3], [17]
- Identify resource underload/overload [3], [9];
- Evaluate performance of individual team member [9];
- Performance prediction [4];

Different measures that can be used for evaluation of the team performance and other factors in the SD projects are summarized in Table II.

Table II
Measures

MEASURE	DESCRIPTION
Qualitative performance measures [4]	
Project effort	Total project team time ($Team\_Member\_Hours_i$) that is spent on project-related activities during the life cycle of the project $$= \sum_{i=1}^{n} Team\_Member\_Hours_i$$
Productivity	Expressed as size per hours. Project size defined in logical lines of code, function points, story points etc. $$= \frac{Size}{ProjectEffort}$$
Project duration	Measure of the length of a project in work days (num_days), excluding times when the project is not active due to work stoppage ($stoppage\_days$) $$= num\_days - stoppage\_days$$
Schedule predictability	Measure of how much the original project duration estimate ($EstimProjDuration$) differs from the actual project duration ($ProjDuration$) that was achieved $$= \frac{ProjDuration - EstProjDuration}{EstProjDuration} * 100$$
Requirements completion ratio	Measures the extent to which planned functional requirements ($PlannedReqs$) were satisfied ($SatisfiedReqs$) in the final product implementation $$= \frac{SatisfiedReqs}{PlannedReqs} * 100\%$$
Post-release defect density	Number of unique defects per unit size discovered during the first six months after initial deployment of the software $$= \frac{Defects}{Size}$$
Team velocity [18]	How many story points team have done during an iteration. Used in Agile SD projects.
Social indexes [19], [20]	
Sociometric status of team member	Calculated depending on the number of positive choices (B⁺), negative choices (B⁻) and count of respondents (N). $$= \frac{B^+}{N-1} - \frac{B^-}{N-1}$$
Team mutual relation index	Calculated depending on the number of mutually positive choices (R) and count of respondents (N). $$= \frac{R}{N-1}$$
Team cohesion degree	Calculated in accordance with the number of mutual positive choice pairs (P) and count of respondents (N). $$= \frac{P}{((N-1)/2)}$$
Team integration index	Calculated in accordance with the number of respondents who do not receive any choice (S). $$= \frac{1}{S}$$
Subjective measures	
Client, team member and teamwork satisfaction	Different surveys. E.g. team motivation based on based on a Maslow hierarchy of needs [21], customer satisfaction surveys, retrospectives [18] etc.

Qualitative performance measures evaluate results of activities performed by all project team members. Social measures help to understand social factors in the project team that is expressed as different social indexes [19], [20]. Social measures are measured with surveys that fix employees given advantages to one of the other team member in given situations (formal and/or informal) [22]. The social indexes are used together with sociomatrices and sociograms [20]. The client, team member, and teamwork satisfaction is analyzed with different surveys.

For team performance prediction, Stochastic Automation Network model has been used as modeling method for evaluation of different scenarios [23].

III. GUIDELINE FOR EVALUATION OF TEAM PERFORMANCE

The guideline for evaluation of the team performance has been designed based on the best practices identified during literature review. The guideline needs to include following requirements:

R1. Evaluation needs to be done in the comprehensive strategic planning level (Level 3.). In accordance with the best practices from the enterprise-wide formal performance measurement systems, evaluation of the team performance need to take following steps (adapted from an idea used in [4]):

1. Set clear and achievable evaluation objective of the team performance;
2. Define measures and measurement indicators to characterize performance relative to the objectives;
3. Establish measurement targets that reflect the desired condition or expectation for each performance measure;
4. Collect the measurement data;
5. Evaluate data and use results to adjust team related processes that will improve the probability of reaching the targets.

R2. The guideline needs to promote learning activities as it is one of the main benefits of the performance evaluation process.

R3. The qualitative performance measures of team activity results need to be measured.

R4. The subjective performance measures of the team can be collected if needed based on the evaluation objectives.

R5. The technical and social factors need to be measured and evaluated together with the qualitative/subjective performance measures.

The proposed guideline process for evaluation of the team performance is given in Figure 1. The proposed guideline focuses on the overall evaluation process, data collection, and its evaluation but doesn't propose how to use results for the team problems solving or performance improvement because data interpretation based on the context situation of team,

project and organization, and evaluation objectives. All metrics/factors can be evaluated in different combinations.
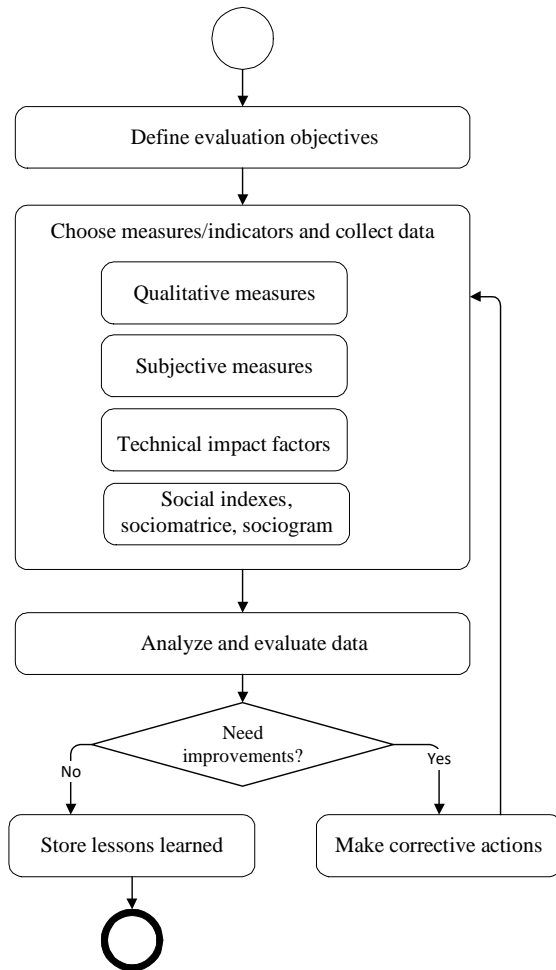

Fig.1. Process for evaluation of team performance

Some very general examples of the evaluation results analyze and usage:

- Social environment in the project and individual productivity/post-release defect density/team velocity – communication processes and atmosphere, and individual integrity can impact individual/team performance.
- Team size and communication network in the team – if the team is large then possible exists subgroups in the team that can be identified by analyzing sociogram.
- Product size and schedule predictability can be analyzed together as is possible correlations.
- Defect density, programming language, and individual productivity can be analyzed together as is possible programming language specifics.
- The schedule predictability can be impacted by estimated and actual reuse of artifact.

Additional aspects of the evaluation process:

- Not all qualitative metrics can be collected at any time, e.g., the schedule predictability and the requirements completion ratio are available at the end of project or project phase and the post-release defect density is available after the release of the SD product. Social indexes are easy to measure and evaluate during the project. So, based on the evaluation objectives possible different metric collection frequency.
- Between metric collection or evaluation iterations (e.g. after corrective actions) possible that team members or project/SD product have been changed. So basically, need carefully evaluate possibilities to compare results between iterations.

IV. EXAMPLE OF PERFORMANCE EVALUATION

For demonstration purposes of the proposed guideline private IT company team has been chosen and already finished team project has been used for qualitative measurement and technical factor analysis.

The objectives and expected results of evaluation of the team performance:

- Understand team technical performance in the previous project. Also, two measurement target has been defined: 1) the schedule predictability is less than 10%; 2) the post-release defect density is less than 20 defects per 100 LLOC;
- Identify less integrated team member and possible reasons as this team continue work on other projects.

Values of measures and indicators have been summarized in Table III. This example doesn't include subjective measures of the team performance.
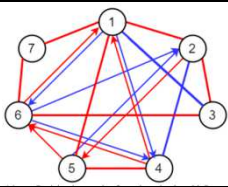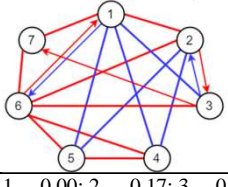
Evaluation summary about example team:

- The team technical performance is positive – project duration and effort is close to estimated, all requirements are completed, values of productivity and defect density are satisfactory.
- Programming language impact to individual productivity / defect density has been seen in the results. Ruby is more productive language that shows also results with better productivity for Team member 3 and less defect after the release (after 2 months).
- Team cohesion degree is below 0.5 both formal and informal relation that means communication environment is not healthy.
- The best sociometric status is for Team member 6 (performs project manage role) but the worst for Team member 2 (programmer).
- By analyzing sociogram of formal relations can be concluded that Team members 1, 2, 3, 6 and 7 are good relation, no relation between

3 and 4 and mutually negative relations between 1 and 3, and 2 and 4.

- A little different situation is in informal relations. There are two subgroups – 4, 5, 6 and 1, 2, 6, 7 that have been connected through Team member 6. Team member 1 is mutually negative relations with 3, 4, 5 that means no common interest.

The main recommendation for this team is to try to increase the team cohesion and more integrate Team member 2. Possible corrective actions – team buildings, pair programming, and knowledge share events.

Table III
Results of evalution of Example team performance

MEASURES/FACTORS	VALUE
Technical factors	
Team size	7
Requirement and it priority changes	15% of total project effort estimation
Product size	DB – 796 LLOC; Oracle Forms – 1511 LLOC; Ruby – 1125 LLOC
Programming language	Oracle Forms, PL/SQL, Ruby
Reuse of software artifacts	6.1 %
Development method	More waterfall
Social factors	
Formal relation sociogram	
Formal sociometrical status of team member	1. – 0.67; 2. – -0.17; 3. – 0.33; 4. - -0.33; 5. – 0.5; 6. – 0.5; 7. – 0.33;
Formal team cohesion degree	0.33
Formal team integration index	0
Informal relation sociogram	
Informal sociometrical status of team member	1. – 0.00; 2. - -0.17; 3. – 0.17; 4. – 0.00; 5. – 0.00; 6. – 0.67; 7. – 0.50;
Informal team cohesion degree	0.38
Informal team integration index	0
Qualitative performance measures	
Project effort	718h (Estimated 700h)
Productivity	4.78 Separate productivity is evaluated for programmers: 1.(PL/SQL) – 6.03; 2 (Forms). – 8.48; 3 (Ruby) – 10.41
Project duration	32 days (Estimated 30 days)
Schedule predictability	6.67
Requirements completion ratio	100%
Post-release defect density	After two months: PL/SQL – 0.04; Forms – 0.01; Ruby - 0

V. CONCLUSIONS

Evaluation of the team performance needs to be systematic and comprehensive strategic planned similar as suggesting the best practices from the enterprise-wide formal performance measurement systems. Evaluation of the team performance includes measuring of subjective and objective measures. Objectives measures are easy to evaluated as it is related to time, cost and quality and has been widely evaluated during existing researches about the performance evaluation of team and project. Subjective measures are no so easy to evaluate and the most used approaches are surveys or interviews.

For correct analyze and evaluation of the collected performance metric also context situation or the performance influencing factors are important for understanding of the team success criteria and compare with other teams. These factors can be divided in technical and social. The impact of social factors has been widely discussed in different existing researches.

The proposed guideline for evaluation of the SD project team performance includes the collection of measures (qualitative and subjective) and influencing factors (technical and some of social). The sociometric method has been proposed for social factors evaluation that can help to understand communication and coordination processes in the team, the team cohesion, internal relationships and the team climate.

Demonstration example of the guideline has been given in the paper with a target to show how to use the guideline. But as previous already has been mentioned, data collection and analyze depends on context situation of team, project and organization, and evaluation objectives.

Possible directions of the future research on this topic are the analysis of including more subjective measures (currently qualitative measures are evaluated); the analysis of other social factors (currently only the sociometric method is used); and the guideline evaluation with other industry case studies.

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