PERFORMANCE AND COMPETENCE APPRAISAL IN PRODUCT DEVELOPMENT TEAMS

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ABSTRACT

Different diagnostic tools are used to evaluate the status and performance of organizations. Typical measurement approaches do not take organizational needs and individual differences into account sufficiently. Advanced measurement of performance is not very typical in product development. The purpose of this paper is to describe the use of two parallel measurement approaches - performance measurement and competence analysis. We describe how performance and competence can be measured in organizations, present results from an ongoing case study in a medium-sized Finnish electronics industry company, and present some implications of using performance and competence analysis in parallel.

INTRODUCTION

Through the intense international competition, demanding markets, and rapidly changing technologies, the interest in knowledge-related work, e.g. engineering and development has increased. For instance in product development, survival in the turbulent market calls for learning to act fast, responding to customer demand, and designing products with distinction and integrity [1]. The efforts to improve product development performance do not always produce expected benefits, however, and it is difficult to determine why. We presume that traditional performance measures should be complemented with softer issues such as measuring competence to produce expected benefits. Below we present our views towards performance measurement and competence appraisal in controlling product development performance and demonstrate how typical methodologies easily neglect actual needs within product development organizations.

Performance measurement in product development

Motives for performance measurement

Performance measures are tools used to follow-up the past performance in an organization or group, predict the level of future performance, and accomplish improvements in performance. Traditional performance measurement systems rely on financial accounting measures, e.g. revenue growth rate, return on investment, market share, and unit costs. Financial measures mainly report on what has happened in the past period without indicating how performance could be improved in the next. For performance improvement purposes, measures indicating learning, growth, performance seen by the customer, and organization’s internal issues should also be used. [2]

There are several motives for performance measurement. According to Oman and Pfleeger [3] the three major reasons are understanding, predicting, and controlling. A performance measurement program translates corporate goals and objectives into action. It makes progress towards goals visible, enabling clear communication, objective analysis, and fact-based decision making. Measurement information helps people achieve desired results continuously and identify opportunities for improving results. Measurement can also identify problems or show progress towards goals [4]. The starting point for measuring performance depends on the specific needs of the organization and, therefore, measurement items should vary across different organizations.

Typically, performance measures tend to reflect too much the organization chart and, as a result, isolate different functions instead of uniting them into business processes [5]. It is important to measure processes, not organizational functions. Process measures concentrate on the tasks and functions that produce an output [6]. If only organizational functions are measured, there is a danger of sub-optimization. For example, one might limit the measurement to the time used to design new products. Thus, the product testing time and the number of errors detected are neglected. In this case there is a possibility that new products are designed fast but the number of errors detected in the product testing phase, and the time needed to test the products may increase. Measuring the whole process, instead of only parts of it, would prevent this kind of sub-optimization from happening.

Content and methods of performance measurement

Our approach to performance measurement in product development is to design a balanced set of measures that are derived from the goals of the organization. According to Basili and associates [7], measurement, in order to be effective, must be focused on specific goals, applied to all life-cycle products, processes and resources, and interpreted based on the characteristics and understanding of the organizational context, environment and goals.

One framework for developing a balanced set of measures is the Balanced Scorecard approach developed by Kaplan and Norton [8]. In Balanced Scorecard, there are four perspectives from which to choose measures: financial, customer, internal-business-process, and learning and growth perspective. Each of these perspectives is linked to the strategic objectives and competitive demands in the company. Balanced Scorecard provides a balance between external and internal measures. The Scorecard functions as the cornerstone of the current and future success of an organization.

Basili's Goal Question Metric (GQM) is a systematic way of developing measures from goals [9]. The GQM method approach emphasizes that for an organization to measure in a purposeful way it must first specify the goals for itself and its projects, then it must trace those goals to the data that are intended to define those goals operationally, and then provide a framework for interpreting the data with respect to the stated goals. The GQM method ensures that the measures developed fit to the purposes, goals and needs of the organization and are relevant to serving the purpose of performance improvement.

When implementing performance measures several practical issues should be taken into consideration. For example, there is the issue of data collection. If the data collection takes too much effort compared to the benefits of the measurement information, it may not worth the effort to implement that particular measure. Secondly, decisions need to be made on who collects the data and how often. Thirdly, design of the performance measurement model should occur in co-operation with all involved. Fourthly, data visualization is one important factor of measurement system implementation, too. With good and simple visualization the measures will be more understandable, and trends are easily detected. Finally, updating of the metrics should be easy, and reporting frequency should also be considered.

Competence assessment in product development

A number of studies have aimed to identify factors driving superior product development performance, largely from new product development viewpoint but also at product development program and firm level. These factors deal with the strategic intent of the company, product development process, market environment, and organizational issues [10]. The organizational issues section is often largely neglected by designers and engineers. It contains not only the organizational structure and resources but also organizational and team climate and culture, interdepartmental collaboration, job design, employee competencies, leadership, designers' work motivation, etc. [11].

One starting point for this paper is the assumption that the so called organizational issues are paramount to succeeding in product development and achieving the necessary balance between innovation and creativity, and direction and control [12]. By the side of performance measurement, we particularly focus on job competence and skills that are needed and used in product development work. Competence or skills analysis is often mixed with the term performance appraisal, but it refers rather to a long-term accumulation of knowledge than short term outcomes. Competence management can be considered one part of performance management.

The concept of competence

In our view, a job competence is an underlying characteristic of an individual that is causally related to criterion-referenced effective and/or superior performance in a job or a situation. [13]. What is relevant here is that competence is **context-specific**, it is evaluated through some **performance criteria**, and it is something that the **individual is or possesses**. Competence is more than skills or knowledge: it includes the person's motives (or value judgements), traits, and self-concept (within a social network) [14]. Competence is "the potential to succeed in a situation" including judgements about the context, goals, sufficiency of skills and knowledge, and expected performance. Competence, therefore, is in tight relationship with performance: it is needed to accomplish superior performance repeatedly in a particular context or situation. Competence can be approached at individual, group and organizational level. We view competence at the group level, and would additionally like to make a distinction with core competence which refers to an organizational strategic choice of competitive product and process traits [15].

There are different competence models listing what is relevant to superior performance. For instance Spencer and Spencer [16] have constructed a general competence model consisting of Achievement and action, Helping and human service, Impact and influence, Managerial competencies, Cognitive competencies, and Personal Effectiveness. In each job, most if not all of these competencies are needed, but to varying extents. Some talk about general competencies (shared by all) and specific or individual core competencies (distinguishing between threshold and superior performance in a particular job). What becomes especially important in designing competence studies is the particular job in question, and the organizational strategy and goal-setting of the group under study. Designing competence studies consists of defining performance effectiveness criteria, then identifying the criterion sample (superior and average performers), collecting data, identifying job tasks and competence requirements, validating the model, and determining applications of the model [17].

Assessment of competence

As competence is relevant only in context and if matched with performance criteria, the level of competence can be evaluated. We talk of assessing or appraising when referring to evaluating the level or "goodness" of competence. Analysis of competencies can be used e.g. in identifying existing personnel capabilities and gaps between required and existing competencies, estimating the total human capital in an organization, and in determining training needs [18]. It can also be used to identify potential problems in job design and to improve performance. Different mechanisms of assessing competence are presented in Figure 1.

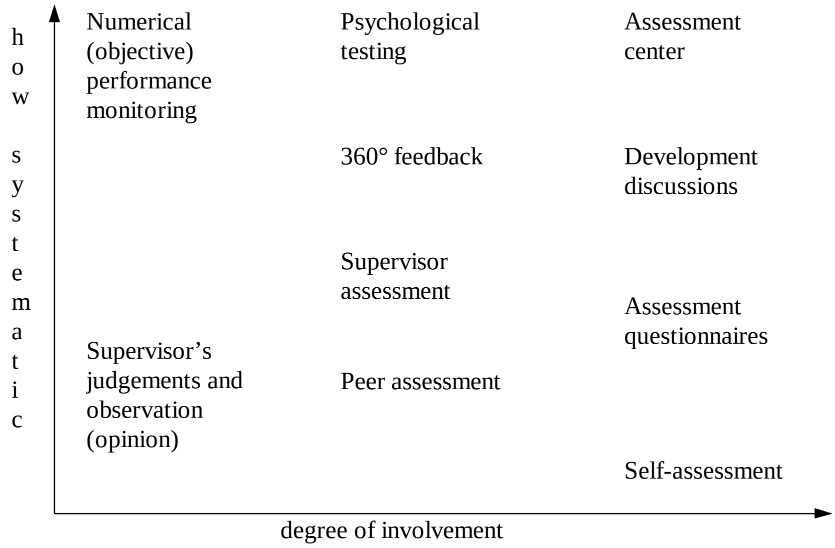

Figure 1. Different means to assess competencies.

Generally it is thought that knowledge work cannot be evaluated or measured and that engineers and designers are hesitant to competence-based measurement. Today, since the objectives of product development work have become higher (develop faster, more economically, and better), there is an increasing need to somehow control the intangible assets, such as the competence of employees. Competence analysis can be considered more positive if used for developmental rather than administrative (e.g. as a basis of pay) purposes. Also, it is participatory methods of competence assessment that can be used as means to encourage improvement of competence and performance in the long term. According to Kowtha [19], controlling work through mere output is possible only where performance ambiguity is low. In product development, performance ambiguity is high as well as is task uncertainty, and professional ("clan culture") and behavior (rules and procedures) control is needed. This can be achieved through long periods of socialization, developing firm-specific skills, and keeping turnover rates low.

Summary and research task

Product development is a typical expert task in which both short-term performance and long-term competence accumulation count. Therefore, we need to develop control systems which take both of them into account. Performance measures easily neglect the needs of the organization in question, the actual process, and organizational issues. Competence studies on their side are too often used for administrative rather than developmental purposes, ignore the firm-specific needs and contexts, and are kept separate from performance improvement. Below, we present a case study where processes, project management, and existing and required competencies are studied in product development groups and used as a basis for performance measurement and improvement.

RESEARCH MATERIAL AND METHODS

The case company and product development groups

The study was carried out in a Finnish metal industry organization of about 400 people. We will call the organization *Tech* for confidentiality reasons. The products of Tech are fairly small, pretty far standardized and modular, and manufactured through very automated systems. The product range is wide, and divided into two primary product lines. The company strategy is to have a coherent range of products and appropriate control electronics for end-product manufacturers. The conventional product market is pretty much stabilized and large ("a cash cow"), whereas the electronic product market is expanding and demanding cheaper products. In general, the company is doing well thanks to its conventional product line, but a lot of resources and money is required for the development work in the second product line.

The organization has five product development groups, consisting of altogether 39 full-time employees at the time of the project. Five of these are the team leaders, and the rest are technicians, engineers, designers, and other specialists (the term designer will be used of all of them). Additionally there is the product development manager and some shared resources who are excluded from this examination as they represent each of the teams equally. The teams included in this study, their sizes and the number of respondents in each group are presented in Table 1. The groups serve the two different product lines and production units. There is a prospective, emerging, third product type currently under research within electronics new product development. The role of new product development is moderate compared to the role of product improvements. Mechanical and machine design serves both conventional and electronic product development.

Table 1. The five product development teams included in this study.

Acronym	*Team task*	*Size*	*No. of interviewees*	*No. of questionnaire respondents*
A	Electronics NPD	7	5	7
B	Electronics Product Maintenance	10	9	9
C	Electronics Product Testing	7	6	5
D	Conventional NPD and Product Maintenance	7	7	6
E	Mechanical and machine design	8	8	6
	total	*39*	*35*	*33*

The company aims to redefine its product development processes, implement them, and use new measures to improve the efficiency of the process.

Methods

Performance measurement and competence analysis methods are used to analyze current state, and to set objectives for performance improvement. For process, performance, and competence analysis purposes, interviews were made in company management (n=4), with each product development team member individually (n=35 + 2 from shared resources) and with other interest groups (n=7).

Analysis of processes and performance

The performance measure design was started with qualitative interviews of the product development personnel. The purpose of the interviews was to clarify the current state of the product development processes, and to model them. Additionally, the aim was to identify existing performance measures and utilize them as a basis for developing new measures, if possible. The structured interviews dealt with the organization of product development, interfaces to other departments, productivity, and responsibilities. Additionally, existing documentation was studied, and discussions were held amongst the product development teams and other relevant interest groups.

Design of competence scales, and competence assessment

The competence analysis methodology was tailored for the case company based on the interviews mentioned above, feedback sessions, and group work of the team leaders. From competence viewpoint, the interviews dealt with such topics as superior performance, skills needed at work, and competence development. The analysis method was designed to measure competencies relevant for successful performance in the product development tasks of each group. The method was a questionnaire-based self-assessment of current and required job competence. A Likert-type scale of 1 (I have very little of this skill/My work requires very little of this skill) through 5 (I have very much of this skill/My work requires very much of this skill) was used. Altogether 38 items were used, including for example basic skills in electrical engineering, component knowledge, problem-solving skills, creativity, flexibility and adaptability, communication skills, product knowledge, and computer skills, to name a few.

Six aggregate variables were created from the 38 competence items for both the required and existing competencies: Goal orientation (9 items), Technical competence (10 items), Task Control (11 items), Customer orientation (both internal and external, 7 items), Process competence (9 items), and Documentation and use of tools (7 items). The variables are non-exclusive, i.e. some items are included in two of the variables. The reliability of each competence scale was calculated as Cronbach's Alphas which ranged from .72 through .92. When comparing to the "technical and professional" grouping presented e.g. by Spencer and Spencer [20], these aggregate variables do find a match in other studies.

For each respondent, aggregate variable data was calculated as an average of items relevant to the variable. Furthermore, descriptive statistics were calculated for groups. Differences in group means both for items and aggregate variables were tested by Kruskal-Wallis H. Only two aggregate variables had significant differences between groups (Technical competence and Documentation and use of tools), and we have to take the results as suggestive where comparisons are made.

RESULTS

Current state of process and project management

Based on the analysis of interview data, there are two rather different approaches to managing product development processes and performance in Tech: the controlled and the uncontrolled way.

In the Electronics groups, i.e. NPD, Product Maintenance and Product Testing, the processes are managed in a structured way. In the Electronics NPD, some process guidelines are defined for the projects, and the process models are modified depending on the project at hand. There are efforts made to improve the processes. The Electronics Product Maintenance process is strictly managed. Every product maintenance task in the process belongs to a certain class depending on its status. The Electronics Product Testing team functions very much in isolation from the other teams. The testing process is highly structured and carried out, followed up, and documented accordingly. It additionally does research type of work which is not in close relation to the daily development tasks.

The Electronics NPD, Product Maintenance and Product Testing groups use various measures to assess their performance. The process models include milestones and reviews which help to evaluate the projects, and fairly conventional and simple measures are being used such as project status and timeliness. The Electronics Product Maintenance group additionally measures the number of implemented product changes by change type such as the number of product changes initiated by cost reduction needs. The Electronics groups do not use measures related to project costs or product development quality. Some performance measures are linked to the organization's reward system.

The Conventional NPD and Product Maintenance, and Mechanical and Machine Design groups have quite a different approach than the one in the other three groups. One could call it uncontrolled, or emergent. There are no formal processes and process follow-up in the groups but, rather, strictly limited job roles and responsibilities for each designer, developed over the years through experience. The Conventional NPD and Product Maintenance group does not have regular meetings, and no memos are written on its operation. Mechanical and Machine Design has regular meetings, but rather in an informal manner to solve project-related problems than to control the process. These groups seem to give great value to the designers' professional experience, and rely highly on their knowledge about customers, products and competitors. Problems may arise when key designers for some reason leave the organization, their personal experience is lost, and competence is not accumulated through organizational learning.

In the Conventional NPD group, there are new product development projects approximately once a decade, so projects are very rare. An NPD project was launched last fall and it will be ending in the end of this year. The project has a separate project organization, project reviews and strict follow-up in terms of timeliness, and product and project costs. The ongoing project is one of the biggest the organization Tech has launched recently.

The summary of product development teams' strengths and weaknesses from the viewpoint of project and process management are presented in Table 2.

Table 2. The strengths and weaknesses in the product development teams' operation.

Team	*Strengths*	*Weaknesses, problems*
Electronics NPD	processes are documented, reviews are in use, changes in requirements are controlled	communication problems with production, lack of resources
Electronics Product Maintenance	every change request is closely detected before taken into the process, process is very strictly managed	sometimes the team has to give its own resources to NPD
Electronics Product Testing	strictly managed process, a new, competitive test laboratory	functional and not always so challenging jobs
Conventional NPD and Product Maintenance	close co-operation with production, fluent communication within group	operations are chaotic and non-repeatable, no process follow-ups
Mechanical and Machine Design	good knowledge on both products and production	some very experienced designers are retiring in the near future

Existing and required competencies

Based on the self-assessment of competence by designers, there is a gap between existing competence and that required in work. The assessments of existing and required competence are not particularly high: the averages of aggregate variables range from just below three to four (on a scale of 1 through 5). Individual responses do, though, range the full scale in different items. The competencies related to Goal orientation, Documentation and use of tools, and Task control are considered the highest at the moment, and also they are required at work the most (Table 3, column "Mean"). The lowest are Process competence and Technical competence, Customer orientation being in the middle.

Table 3. Competence scores for the five product development teams.

Existing competencies	*Mean*	*s.d.*	*A*	*B*	*C*	*D*	*E*	*Chi-Square p*
Goal orientation	3.78	0.57	3.86	3.68	4.16	3.91	3.39	5.41
Technical competence	2.97	0.76	3.26	2.66	3.68	3.18	2.32	12.49 **
Task Control	3.50	0.52	3.44	3.52	3.53	3.71	3.29	1.51
Customer orientation	3.24	0.75	3.20	3.30	3.69	3.21	2.83	4.82
Process competence	2.91	0.59	2.94	2.77	3.29	3.11	2.56	4.20
Documentation and use of tools	3.52	0.57	3.63	3.48	4.06	3.67	2.88	12.84 **

Required competencies	*Mean*	*s.d.*	*A*	*B*	*C*	*D*	*E*	*Chi-Square p*
Goal orientation	4.00	0.59	3.97	3.78	3.98	4.35	4.02	3.33
Technical competence	3.40	0.78	3.69	3.15	3.60	3.58	3.03	3.74
Task Control	3.74	0.64	3.73	3.50	3.53	4.14	3.85	3.49
Customer orientation	3.45	0.77	3.41	3.18	3.66	3.89	3.33	2.99
Process competence	3.37	0.77	3.46	3.22	3.29	3.63	3.28	0.95
Documentation and use of tools	3.90	0.55	3.96	3.62	4.14	4.24	3.69	6.22

The groups' competence profiles look somewhat different even though there are not many statistically significant differences. Electronics Product Testing has the highest scores in most of the existing competencies, and the average gap between existing and required competence is small or even negative. Conventional NPD and Product Maintenance has the highest score in Task control when compared to the other groups, and the gaps of required and existing competence are quite big. Electronics NPD has moderate scores in existing competencies, higher than other requirements in Technical competence, and generally a rather big competence gap. Electronics Product Maintenance has moderate to fairly low scores in existing skills, rather low required skills, and a fairly small competence gap. The scores for existing competence are the lowest in Mechanical and Machine Design, and the gaps to required competencies are quite big. The low competence gap of Electronics Product Maintenance and Product Testing indicates that there are limits to learning or lack of clear goal setting in current jobs. The high competence gap for Electronics NPD, Conventional NPD and Product Maintenance, and Mechanical and Machine Design refers to challenging tasks and goals, a high desire to learn, perhaps a limited number of training opportunities, or especially in Mechanical and Machine Design a critical attitude towards own competence.

Ideas for further action

The above results indicate that in less controlled product development processes the experienced competence gap is high. Achieving or keeping up superior performance would require an ability to react to and even anticipate changes in the business environment, and learn and fulfill the competence gap. If process is controlled through competence tied to certain responsibilities and persons, performance may deteriorate if needs change or key persons leave, and requirements may become too high to be experienced positively. On its side, if process is managed through strict performance measures, designers may become frustrated and hesitant to adopting the measures. In order to improve performance continuously, the experienced competence gap should be challenging but not too high, and it should be in line with the competencies required to meet with actual performance objectives.

Next steps in performance measurement

In the aim for performance improvement, each group seems to have different needs. In the case company, the next steps of development include process redesign, selection of relevant performance measures, implementation of new performance measures, and continuous monitoring. The idea is to make the development work in a participative manner so that not only management but also designers and team leaders commit to the new measures and ways of working.

First, the product development process in the Electronics NPD will be improved. The written process model will be evaluated and redesigned if inconsistent with reality and good practice. The Conventional NPD process will not be made explicit because the team is not willing and motivated to make changes in their operation. Rather, new performance measures will be selected and implemented to fit the current process. For the three other groups, process redesign will be left for a later point.

Second, performance measures will be selected for one team at a time because implementing a metrics program over time holds less risk than a “big bang” approach [21]. The measure development will be started from senior management, i.e. strategic goals for the company. Management goals will provide a link to the corporate strategy and a framework for the measures. The team members will be involved in the idea generation phase of metrics development, and also in a measure selection phase. When involving designers in the metrics planning, the metrics development process is fairly slow but the benefits, such as increased commitment, are highly desirable. The goals of the designers will be generated by using different group work methods, depending on the situation in the group. Performance measures will be derived from the goals of the groups so that the measures will direct the operations towards the goals.

Third, the measures will be implemented in the five product development groups, and their usefulness will be evaluated. The measures will be continuously improved: if some measures appear to be unnecessary or too complicated in terms of data collection, understanding, and visualization, they will be deleted or replaced with an improved measure.

Ideas for competence management

The competence analysis revealed three important questions: are the designers’ perceptions of required competence in line with strategic requirements, is the degree of existing competence sufficient in the groups, and does the pace of learning enable achievement of future performance objectives. In order to make use of existing competence and encourage learning in the right direction, the groups and individuals need to be aware of critical performance and competence development objectives. When strategic performance goals have been clarified at group level, it would be useful to discuss them, their relevance, and the gap between current competence and actual performance goals at individual level with each designer in a personal competence review. This would help in identifying core areas of competence development in team and individual level, and could be used as a basis of detailed development and training plans.

In literature, product development work is generally described as innovative, creative and challenging, but the competence results indicate that job design can affect if it is experienced that way, and the resulting product development performance. Therefore, deficiencies in job design such as too high or negative competence gaps should be taken into account when improving product development processes and performance in the case company. For instance, improving the performance of Electronics Product Testing group could be enabled through expanded job scope or increased goals. For Conventional NPD and Product Maintenance, and Mechanical and Machine Design, performance improvement could mean clearer, shared objectives and process steps, i.e. sub-goals that would decrease the gap between requirements and existing competence. For Electronics Product Maintenance, more active training and development efforts and improved performance feedback could be the key to performance improvement. In Electronics NPD, training seems to be needed as well as more long-term orientation, and perhaps yet clearer process management.

CONCLUSIONS

We have above presented results of a qualitative exploration of processes and project management, and a self-assessment study of existing and required competencies in five product development groups. The study has now progressed to metrics development and competence development planning, and actual performance measurement results will be reported in later contexts. The study has demonstrated that, in product development, technical measures indeed need to be balanced with human issues. Taking individuals and groups, their needs, and the company context into account are especially important. Tailoring the methodology of measurement both for performance and competence appraisal are essential for ensuring commitment, and designers' interest towards the topic. Measures should be selected to fit the needs of each group and support the goals of the organization.

However, the use of performance measurement and competence appraisal in parallel contains a number of concerns. The numerical evaluation of competence is difficult, and the measured levels of competence cannot easily be explained through evident reasons. The estimate of competence is easily subjective even if done by a supervisor or peer, and the result is influenced by individuals' interpretation of relevance of each competence. Therefore, competence assessment should be viewed as a developmental and idea-generating rather than a monitoring tool, whereas performance measurement clearly focuses on diagnosing and fact-based management. The relation of competence, performance, and process or project management is not easy to interpret: the coexistence of strategic, process, organizational, and external issues is what in the end determines performance. Furthermore, both the performance and competence measures may need redesign due to changes in business environment and organizational goals.

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