CONTINUOUS PROCESS IMPROVEMENT IN SOFTWARE ORGANIZATIONS UTILIZING MATURITY MODELS

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ALGAN USKARCI

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Submitted by **ALGAN USKARCI** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Information Systems, Middle East Technical University** by,

Prof. Dr. Deniz Zeyrek Bozşahin
Director, **Graduate School of Informatics** _____

Prof. Dr. Yasemin Yardımcı Çetin
Head of Department, **Information Systems** _____

Prof. Dr. Onur Demirörs
Supervisor, **Information Systems, METU** _____

Examining Committee Members:

Prof. Dr. Semih Bilgen
Computer Engineering, Okan University _____

Prof. Dr. Onur Demirörs
Information Systems, METU _____

Assoc. Prof. Dr. Altan Koçyiğit
Information Systems, METU _____

Prof. Dr. Mehmet Halit S. Oğuztüzün
Computer Engineering, METU _____

Assist. Prof. Dr. Murat Yılmaz
Computer Engineering, Çankaya University _____

Date: 04 July 2017

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Name, Last name: Algan Uskarcı

Signature : _____

ABSTRACT

CONTINUOUS PROCESS IMPROVEMENT IN SOFTWARE ORGANIZATIONS UTILIZING MATURITY MODELS

Uskarcı, Algan

Ph.D., Department of Information Systems

Supervisor: Prof. Dr. Onur Demirörs

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During the last two decades, staged process maturity models have been successfully used by software organizations for process improvement. However, the subject of how effective these models are in terms of organization-wide continuous process improvement has not been extensively studied. This study aims to fill this gap by performing a multiple case study to answer questions such as "Are software process improvement activities continuous?", "Is there an organization wide commitment to process improvement activities?", "Do the process improvement activities cover all process areas of software development?", and "What is the relationship between the process improvement contribution and an employee's education, experience and role?". The applied case study methodology consists of three phases. First, the process improvement suggestions submitted by target organizations' employees are analyzed from three aspects, namely the submitter, timing, and content characteristics. In the second phase, the employees' perception regarding the organization-wide continuous process improvement activities are analyzed. The third phase validates the findings of previous two phases by the help of qualitative interviews performed with the organization members. The multiple case study shows that there are shortcomings with respect to organization-wide continuous process improvement. Based on these findings, improvement opportunities for staged models are discussed.

Keywords: Software Process Improvement, Staged Maturity Models, Employee Participation, Continuous Improvement

ÖZ

OLGUNLUK MODELİ KULLANAN YAZILIM KURULUŞLARINDA SÜREKLİ SÜREÇ İYİLEŞTİRME

Uskarcı, Algan

Doktora, Bilişim Sistemleri Bölümü

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Son yirmi yıldır seviyeli süreç olgunluk modelleri yazılım geliştirme alanında süreç iyileştirme için başarıyla kullanılmaktadır. Fakat bu modelleri kullanan kuruluşlarda yaygın ve sürekli süreç iyileştirme sağlanıp sağlanmadığı kapsamlı olarak araştırılmamıştır. Bu çalışma, "Süreç iyileştirme faaliyetleri sürekli oluyor mu?", "Kurum çapında katılım sağlanıyor mu?", "Tüm süreç alanlarında iyileştirme yapılıyor mu?", ve "Süreç iyileştirmeye katkı ile çalışanın eğitimi, tecrübesi ve görevi arasındaki ilişki nedir?" gibi soruları cevaplayan bir çoklu vaka çalışması ile bu eksikliği gidermeyi amaçlamaktadır. Çalışmada uygulanan yöntem üç aşamadan oluşmaktadır. İlk aşamada kurumdaki çalışanlar tarafından verilen süreç iyileştirme önerileri öneren kişi, öneri zamanlaması ve öneri içeriği açılarından analiz edilmiştir. İkinci aşamada çalışanların geniş katılımı ve sürekli süreç iyileştirmeye bakış açısı incelenmiştir. Üçüncü aşamada ise ilk iki aşamadaki bulgular kurumlardaki kişiler ile yapılan mülakatlar yardımıyla doğrulanmıştır. Çoklu vaka çalışması sonucunda seviyeli olgunluk modellerinin geniş katılımlı ve sürekli süreç iyileştirme açısından eksikleri tespit edilmiş ve bu tespitlere dayanarak çözüm önerileri değerlendirilmiştir.

Anahtar Kelimeler: Yazılım Süreç İyileştirme, Seviyeli Olgunluk Modelleri, Çalışan Katılımı, Sürekli İyileştirme

To My Parents

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LIST OF ABBREVIATIONS

CAQDAS	Computer Assisted Qualitative Data AnalysiS
CAR	Causal Analysis and Resolution
CM	Configuration Management
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
DAR	Decision Analysis and Resolution
DB	Database
DO	Document
EUROCAE	European Organization for Civil Aviation Equipment
IEC	International Electrotechnical Commission
IPM	Integrated Project Management
ISO	International Organization for Standardization
KMO	Kaiser–Meyer–Olkin
MA	Measurement and Analysis
MSAP	Multimission System Architecture Platform
N/A	Not Applicable
OID	Organizational Innovation and Deployment
OPD	Organizational Process Definition
OPF	Organizational Process Focus

OPP	Organizational Process Performance
OT	Organizational Training
PAT	Process Action Teams
PI	Product Integration
PMBOK	Project Management Body of Knowledge
PMC	Project Monitoring and Control
PP	Project Planning
PPQA	Process and Product Quality Assurance
PTI	Process and Technology Improvement
QPM	Quantitative Project Management
RD	Requirements Development
REQM	Requirements Management
RSKM	Risk Management
RTCA	Radio Technical Commission for Aeronautics
SAM	Supplier Agreement Management
SCAMPI	Standard CMMI Appraisal Method for Process Improvement
SP	Specific Practice
SPI	Software Process Improvement
SPICE	Software Process Improvement and Capability Determination
TS	Technical Solution
VAL	Validation

VER	Verification
VSE	Very Small Enterprise

CHAPTER 1

INTRODUCTION

1.1. Background

It has been 35 years since Crosby introduced the concept of staged maturity. Crosby's quality maturity management grid consists of 5 increasing stages or levels of maturity, where each stage defines different aspects of the state of the organization with decreasing quality costs (1979). His initial concepts were evolved over the years to more advanced frameworks such as CMMI-Capability Maturity Model Integration (CMMI Institute, 2010) that is developed based on the early works of Humphrey (Humphrey, 1989) and ISO-33000 family of standards (ISO, 2015) that have supplanted ISO-15504 (ISO, 2004). The application of these models for software process improvement (SPI) is called model-based improvement. These frameworks have been extensively used for the last two decades.

O'Regan states the following benefits of software process improvement (2010):

> *Software process improvement allows companies to mature their software engineering processes and to achieve their business goals more effectively. It helps software companies to deliver the agreed software on time and on budget, as well as improving the quality of the delivered software, reducing the cost of development, and improving customer satisfaction with the software. It has become an indispensable tool for software engineers and managers to achieve their goals and provides a return on investment to the organization.*

However, the very first reason of the creation of CMM (the predecessor of CMMI) back in 80's was to create a framework for U.S. Department of Defense to evaluate the bidders before awarding software contracts. Therefore, it is inherent in the soul of CMM that the main goal of using the model is to demonstrate that the organization possesses a certain maturity. Organizations frequently employ model-based process improvement initiatives not for the sake of improvement but for the fulfillment of a specific requirement for obtaining contracts from a specific customer. This customer

might be Department of Defense in the case of U.S. or the Undersecretariat for Defense Industries in the case of Turkey.

It is possible that the decision makers in the organizations employing process improvement activities base their decisions on the above mentioned external reasons instead of internal improvement goals. This external reason might become the only goal of improvement activities and the actual improvements (if any) are later used as post-action justifications mean.

In model-based improvement, the natural course of action for an organization is to first determine its current status (i.e. capability/maturity level) based on the model. After that, the organization performs a gap analysis in order to determine the deviation between the current capability level and the targeted capability level. (O'Regan, 2010) This procedure is called appraisal or assessment based on the model used. Once the deviation from the targeted level is determined, the quest for process improvement takes the form of tasks performed to fill the gap.

The commonly employed models usually come together with additional documents that present guidelines for performing the appraisal/assessment activities (Standard CMMI Appraisal Method for Process Improvement (SCAMPI) Version 1.3b: Method Definition Document for SCAMPI A,B, and C, 2014) (ISO/IEC 15504-2:2003, 2003). In order for the organizations to publish their established capability/maturity levels, the governing bodies for these models enforce a maximum interval between the appraisals/assessments. For example, for CMMI the validity duration of appraisal results are 3 years. Although it is possible to perform the appraisal/assessment activities with a higher frequency most organizations perform them at the latest possible time due to the overhead costs of these activities. This raises the question of "What happens in the organization between these appraisals/assessments from the process improvement viewpoint?"

Drucker has stated that in the post-capitalist society, organizations need to perform continuous improvement, exploit the organization's knowledge and innovate to be successful (1992). Argyris puts forward that in order to solve their problems the managers shall empower their employees and encourage them to take responsibility (1994). Furthermore, the employees must be internally committed instead of externally since externally committed individuals depend on their managers to have the incentive to work. Combining these two views, it can be stated that modern organizations need to continually improve themselves by committed members.

Although process improvement and staged maturity models have been extensively researched and discussed over the decades, these subjects have been more or less ignored. Although the models suggest in the contrary, as the nature of the models are discrete (in the form of capability/maturity levels that the organization strives to achieve and the appraisal/assessment periods) improvements can happen in discrete steps. We have frequently observed the discrete form of improvement cycles; myself

in my professional experience as a software engineer of more than 10 years and my supervisor Prof. Demirörs in his in his extensive academic experience in various aspects of software and process research (Aysolmaz & Demirörs, 2014) (Tarhan & Demirörs, 2006) (Ozcan-Top & Demirörs, 2013) (Coşkunçay & Demirörs, 2015).

A related topic that also needs to be shed light on is the contribution characteristics of the organization's members to process improvement activities while employing staged maturity models. Although the effects of improvement activities over a range of business metrics haven been previously analyzed, it is not clear who performs the improvement activities on which process areas. An analysis of the organization wide commitment from different groups may yield improvement opportunities for the models themselves. The variance of commitment with respect to role or experience within the organization might explain some of the shortcomings of staged-model based improvement.

Although the models are used for process improvement, the area where these processes are used is a human centric area. The software engineering practice is heavily dependent on the human beings who use the processes to create the software products. The effect of humans is so major that sometimes discussions arise whether software engineering is a form of art or whether the software engineering practice is a profession in the old school terms (Beadell, 2009).

There are studies that emphasize the importance of human factors in process improvement initiatives (Hall, Rainer, & Baddoo, 2002). However, the effects of process models on the practicing engineers have not been discussed in the literature in detail. (Beadell, 2009) Models define the processes software engineers use in their daily work lives and therefore have the largest impact on the engineers even more than the business metrics, maturity levels etc. The determination of the effects of the models might be helpful in improvement of the models in their forthcoming revisions. Furthermore, for organizations hearing the thoughts and voices of their practicing engineers might have a much higher benefit for their process improvement activities than quantitative data and numbers presented on a report.

1.2. Purpose and Impact of the Study

The purpose of this study is to provide an insight into the workings of model-based software process improvement activities and staged models. I try to answer the following questions for organizations that employ maturity model based process improvement initiatives:

- Are software process improvement activities continuous (i.e. uniform over time)?
- Is there an organization wide commitment to software process improvement activities?

- Do the process improvement activities cover all process areas of software development?
- What is the relationship between the software process improvement contribution and an employee's education, experience and role within the organization?
- Can we develop a systematic approach to identify the above relationships in multiple target organizations?

These questions also reflect general trends in process improvement. The following values put forward by SPI Manifesto (Pries-Heje & Johansen, 2010) are directly related to the questions above:

- Value A: SPI must involve people actively and affect their daily activities
  - Principle 2: Motivate all people involved
- Value C: SPI is inherently linked with change
  - Principle 9: Ensure all parties understand and agree on process

By discussing the answers to my questions, I present shortcomings in the software process improvement life of organizations. Furthermore, I present improvement suggestions for the process improvement activities themselves that target either the activities to be performed throughout the organizations or the staged maturity models.

The information gathered by the study may be used by decision makers and process improvement project managers for more effective and satisfying process improvement activities in their organizations. Any organization may employ the systematic approach presented here to that end and make a thorough analysis of the process improvement activities. The study will also be beneficial in the development of new models or the update of existing models.

Furthermore, I will let the voice of the software practitioners from the studied organizations be heard. These opinions might also be helpful in more effective implementation of process models since these engineers are the main recipients of the processes being improved.

1.3. Overview of the Study

In order to be able to understand the continuity of the model based process improvement as well as the contribution characteristics of the employees, I performed a multiple case study involving target organizations that employ maturity models.

It was difficult to find organizations that were willing to participate since organizations were not willing to let an outsider meddle in their process related activities. My study required access to organization’s archives and the participation of employees in a survey that was most probably answered during work hours. Another difficulty was finding organizations that employed staged maturity models for process improvement

activities. Fortunately, CMMI institute publishes appraisal results (Published CMMI® Appraisal Results) that helped me locate the handful of organizations that had a CMMI maturity level rating that are based in Ankara, Turkey. Four of these organizations responded positively to my request to include them in my study.

I studied the target organizations from multiple aspects. The extensive analysis reminds a holistic multiple case study design while evaluating the target organizations separately while it can also be named an embedded single case study design when the organizations are evaluated together (Yin, 2009). The case study methodology I applied is formed of three phases. First two phases constitute a quantitative analysis of both the actual commitment of the employees and their opinions on various aspects of the process improvement activities. The third phase consists of validation interviews of target organization members.

In the first phase, I focused on the relationship between staged models and continuous process improvement, organization-wide commitment and process-wide improvement by performing an archival data analysis. For this purpose, I analyzed the process improvement activities of the target companies by focusing on their process improvement databases. I evaluated all the process improvement suggestions in these databases in three dimensions; namely, the submitter characteristics (the experience and the role of the submitter in the organization), the timing characteristics (the date of the submission and its relevance to the organizational appraisals), and the content characteristics (the process area targeted by the improvement suggestion).

The second phase of the case study builds on the findings of the previous phase by quantitatively analyzing the opinions of the employees of the target companies in order to discover the relationship between software process improvement activities and employees' education, experience and role within the organization. For this task, I performed a questionnaire-based survey with the employees of the companies. I performed a statistical analysis on the survey findings in the form of a factor analysis and review the relationship of employee views with the employees' education, experience and role within the organization

In the third phase of the study I performed qualitative interviews by using the responsive interviewing model proposed by Rubin & Rubin (2011). I formulated a set of main questions regarding the findings from the previous two phases and tried to ask these questions to interviewees who are knowledgeable about the research problems, and asking additional questions stimulated by their answers.

This methodology was developed over time and the phases were added and updated during the course of this study. Initially the first two quantitative phases were developed and performed on two target organizations. Based on the experience from these two organizations the questionnaire was updated and tested in an open survey which targeted software practitioners without being bound by organization memberships. At this point the third phase was devised and added to the methodology

to qualitatively obtain an insight from the target organization members. This final version of the methodology with three phases was applied on two new target organizations.

1.4. Dissertation Summary

I choose to follow the reporting structure for case studies proposed by Runeson & Höst (2009) with minor modifications for the multiple case study. Therefore, in the second section of this dissertation I summarize the related work. In the third section, I offer an overview of the methodology that I have used together with the discussion of the validity. In the fourth section I present the separate case studies for each of the targets. Finally, I summarize the findings, conclusions and discussion in the last section together with plans for future work.

CHAPTER 2

LITERATURE REVIEW

Maturity models and process improvement are extensively studied by both academia and software organizations and a wide variety of the aspects of maturity models have been studied and published. These include subjects such as benefits, application problems, development of new models, customization of existing models, experience reports, organizational issues, and various extensive literature surveys.

There are many examples in the literature, which present positive contributions of staged models. The practitioners of staged models usually report these studies based on their actual experiences. These kinds of studies usually report overall improvements without discussing whether the improvements were the ones targeted at the first place.

A prime example of this kind of study is performed by Goldenson & Gibson and presented in the form of a technical report (2003). The study presents the benefits obtained by more than 10 global firms that applied CMMI-based process improvement. The benefits are grouped in five categories as cost, schedule, quality, customer satisfaction and return on investment. It is not surprising that the positive aspects of CMMI are documented in this report considering that the study is sponsored by the Software Engineering Institute which is the publisher of the CMMI model.

Another example of this type of a study is presented by Kandt (2009). The article presents the software development activities conducted in Multimission System Architecture Platform (MSAP) project at the Jet Propulsion Laboratory. Throughout this project the organization achieved CMMI level 3 and the author discusses the benefits of CMMI on the MSAP project. The author also presents quantitative results such as productivity and defect rates for documenting the benefits of CMMI compliant software development.

Tosun, Bener and Turhan (2009) conducted a study in Turkey that presents the results of a software quality improvement project based on CMMI for a small-sized Turkish software company. A detailed description of the steps taken during the improvement project is given and the experience gained by the project is shared in the form of best practices and things to avoid. A comparison of the performance of the company is also presented by comparing the metrics from a previous project and a newer project conducted after the process improvement activities.

Another approach in presenting the experiences is focusing on lessons learned and stating both the gains and the problems encountered. One such study by Wilkie,

McFall, & McCaffery (2005) describes the results of CMMI appraisal work with six small to medium sized companies. The article states the findings based on firm size and different process areas. This study is beneficial in identifying different trends with respect to CMMI in small to medium sized companies. A similar study is also conducted by Huang & Zhang (2010) for small and medium enterprises. The authors summarize a set of problems faced during process improvement activities in Chinese small and medium enterprises. These problems are the unsatisfactory implementation of CMMI with respect to business goals, conflicts with business operations, cost overruns, lack of specialized personnel, and finally poor implementation of CMMI by consultants. They present four key points in order to overcome these problems.

Another study sharing experiences with process improvement based on CMMI is introduced by the Maromba Project which is conducted in order to increase the maturity level of Eldorado Research Institute from CMMI level 3 to CMMI level 4. (Takara, Bettin, & Toledo, 2007) The article identifies problems and pitfalls for such an effort focusing on the metrics, measures and indicators mainly.

Not all studies in the literature aim at sharing experiences or stating gains. Some authors take an inquisitive approach and try to surface the shortcomings of staged models or propose improvement suggestions for the models. One such study by Beadell (2009) focuses on the human aspect of CMMI. The questions “How does the CMMI affect an engineer's job performance and job satisfaction?” and “What social or management theories are embedded in the CMMI and do they exploit or reinforce the negative effects of the organization vis-a-vis the worker?” are answered by the study in the form of an exploratory case study and ethnography and a resulting grounded theory is formed.

Another approach for improving maturity models is to combine or compare them with other published models or best-practices. One such study (von Wangenheim, da Silva, Buglione, Scheidt, & Prikladnicki, 2010) proposes a unified set of best practices collected from the CMMI and Project Management Body of Knowledge (Project Management Institute, 1998). A very detailed best-practice table is presented focusing on the project management related process areas which are Project Planning (PP), Project Monitoring and Control (PMC), and Supplier Agreement Management (SAM). The prepared table is quite extensive and in fact useful as a summary of project management activities from both perspectives.

Another candidate for better implementation of process improvement activities is employing Six Sigma approach in order to help obtaining CMMI level 5. (Gonçalves, Bezerra, Belchior, Coelho, & Pires, 2008) The authors of this study present strategies for identifying, classifying and prioritizing improvement and innovation actions. Furthermore, an application example is presented by using the results for a medium-size organization named Atlantico.

While so much attention is given to CMMI the other most widely used process improvement model ISO/IEC 15504 shall be also be mentioned. A study by Ehsan, Perwaiz, Arif, Mirza, & Ishaque (2010) presents overviews of both CMMI and ISO/IEC 15504, also known as SPICE and a comparison of two models by using a table. Lastly a comparison from a practitioner's viewpoint is presented and the authors try to explain why CMMI is more widely adopted.

Another study also presents a comparison of three maturity models ISO 9001:2000, CMMI and ISO/IEC 15504-7. (Walker, 2008) The author summarizes shortcomings of these models by comparing them to DO-178B (RTCA/EUROCAE, 1992). The stated main problem is the mentioned models' lack of emphasis on the delivered information items' quality. This study is important by discussing the quality approach of DO-178B which is mainly used in safety-critical airborne systems.

A study by Yeşildoruk, Bozlu, & Demirörs (2009) puts forward that the widely used CMMI and ISO/IEC 15504 have shortcomings for application at small and medium enterprises, and gives a comparison of lesser-known models developed specifically for small and medium enterprises based on their employment of different process improvement tools such as reference model, modeling, assessment, improvement etc.

One problem with the CMMI is that it specifies what to implement but not how to do it. There is an example study (Huang & Han, 2006) which states that there is no official guideline for determining an improvement path for continuous representation of CMMI. A decision support model is presented in order to help managers determine the priority of process areas to be improved. The historical data in the International Software Benchmarking Standards Group Repository 7 was used to verify the proposed model.

The literature also contains studies that present different aspects of process improvement. It should be noted that depending solely on models and similar guidelines is not sufficient. One article (Mûller, Kraemmergaard, & Mathiassen, 2009) draws attention to the role of organizational culture in the success of software process improvement activities. The authors present a case study on SPI activities of two business units of a Danish high-technology company, Terma. An analysis of the organizational cultures in these two divisions is presented by using two different culture assessment methods; the competing values analysis and clinical inquiry analysis. The effect of the culture on the SPI success of the two units is discussed and guidance is supplied for managers in order to assess subculture and manage SPI activities accordingly.

Another study presents a 5-step approach for process optimization. (Chen, Zhou, & Luo, 2010) The steps are defined as VPML-based process modeling, automated process simulation, process evaluation, rule-based process optimization and identifying the priority for the optimized processes. The authors also present how the proposed method may be used to cover the 4 process areas of CMMI levels 4 and 5.

All the above-mentioned studies sampled from the literature focus on organizations already employing model-based software process improvement approach. However, the reasons why organizations adopt this approach are also of importance. In order to analyze and understand these reasons one must also ask the question "Why organizations do not adopt CMMI?". There is a study in the literature trying to answer this question. (Staples, et al., 2007) The authors use the sales figure and market research data from a CMMI consulting firm to answer the questions "Why do organizations decide not to adopt CMMI?", "How are these reasons related to the size of organizations?" and "How are these reasons related to organizational type?". The research obtained a variety of reasons and their relation to organization's size; however, a significant result was not obtained with respect to organizational type.

Staples and Niazi (2008) extended their study to a systematic review of organizational motivations for adopting CMM-based process improvement approaches by analyzing more than forty studies. They came to the conclusion that the main motivations are to improve the organization's product quality, project performance, and also process management capabilities. Satisfying customers was not a very common reason for adopting CMM-based approaches, and organizations rarely adopted CMM-based SPI in order to improve their employees' capability, motivation, or work environment.

The research activities specifically targeting the continuity and the extent of process improvement while employing maturity model based approaches are scarce. Wendler conducted an extensive survey of 237 maturity model related publications (2012). A wide range of research questions regarding different aspects of maturity model research such as the applied field or the publication forum are discussed by the study. One of the categorizations of the publications used by Wendler is based on the research content. However, the categorization does not include the continuity or the extent of process improvement as a separate category. Overall, the publications surveyed do not convey the research of the continuity or the extent of process improvement.

An exceptional study that mentions the continuous improvement in the context of CMM is performed by Seshagiri (1996). The author claims that process improvement shall be continuous irrespective of the current maturity level of the organizations. However, this study does not expose the relationship between continuous process improvement and staged maturity models. Instead it presents the process improvement experience of the organization that the author works for.

Although the continuity of model-based improvement has not been studied frequently, a range of research is focused on employee commitment for software process improvement activities. For example, Baddoo & Hall conducted a series of studies by using focus group discussions in 13 UK companies encompassing almost two hundred software practitioners. The first study discussed motivation theories and tried to identify what motivates developers, project managers and senior managers to be actively involved in SPI (Baddoo & Hall, 2002). The most important common motivators for all three practitioner groups are process ownership, evidence of the

success of SPI, and resources. In total, the study lists 32 different motivators that have varying importance for different practitioner groups.

The second study (Baddoo & Hall, 2003) employed identified de-motivating factors for software practitioners regarding software process improvement. Again, the results are presented based on the grouping of practitioners in three as developers, project managers and senior managers. It is concluded that common de-motivators for SPI activities are lack of resources, commercial pressures, the actual process constraints, implementation issues, and personnel factors.

A different approach to employee participation and commitment is presented by Türetken and Demirörs (2011) in the form of a methodology for business process modelling. Although this study is not directly related to process improvement but to business process modelling it is important in highlighting the importance of employee participation in process related activities.

Another study (Basri & O'Connor, 2010) presented findings obtained by a survey of Irish very small enterprise (VSE) employees. The questionnaires used include questions related to the involvement and the commitment of both the people and the managers in the SPI activities. The results indicate that VSE's commitment towards SPI is very high and positive. However, the analysis regarding the commitment is only a small part of the study and the main focus is on the overall SPI activities for VSEs. Unfortunately, these studies do not relate their findings with staged models but present them on a more generalized level for software process improvement.

Lastly, a study aiming on exploring and improving software process improvement models such as this one shall also include a background study on the creation of these models. A study regarding the creation of models is performed by von Wangenheim et al. (2010). The authors present some insight into the creation of software process capability/maturity models. They have conducted an extensive literature survey and sent questionnaires to the authors of 60 different models. They present their findings by comparison to a reference model they developed and they summarize the methodologies used for model creation. However, like the previous studies, the continuity or the extent of the models analyzed or the reference model developed is not discussed. There is also no mention of the actual commitment or participation to the models.

As detailed above different subjects have been thoroughly studied but the software industry and academia have not questioned the continuity and participation issues of process improvement with maturity models. Therefore, it has not been possible to synthesize the previous work into a sound body of knowledge that forms a direct background for our study. With this study, I contribute to the software process improvement literature by filling the gap regarding the continuity and participation issues.

CHAPTER 3

METHODOLOGY

3.1. Case Study

Yin defines case study as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident." (Yin, 2009, p. 18) and asks three questions in order to determine a research method from experiment, survey, archival analysis, history and case study as given in **Table 1**. According to these questions since the form of my research question is "how and why", there is no requirement for control of behavioral events and the focus is on contemporary events the chosen research method is case study.

Table 1. Relevant Situations for Different Research Methods

Method	*Form of Research Question*	*Requires Control of Behavioral Events?*	*Focuses on Contemporary Events?*
Experiment	How, Why	Yes	Yes
Survey	Who, What, Where, How Many, How Much	No	Yes
Archival Analysis	Who, What, Where, How Many, How Much	No	Yes/No
History	How, Why	No	No
Case Study	How, Why	No	Yes

Case studies can cover multiple cases and then draw a single set of cross-case conclusions (Yin, 2009). Yin suggests multiple-case designs over single case designs when the choice and the resources are available. Even a "two-case" case study increases the chances of doing a good case study.

3.2. Case Study Evidence

Yin identifies six sources of evidence as the most commonly used ones. These are documentation, archival records, interviews, direct observations, participant observation and physical artifacts. Not all of these sources will be employed throughout this research. The specific sources and their main usage are detailed below.

3.2.1. Documentation and Archival Records

Documentation and archival records within the target organizations will be analyzed in order to gather information on process improvement activity records. The process improvement activity records may take many forms from organization to organization. The most common type of record is a database holding the process improvement suggestions. These databases are normally accessible by all employees of an organization. Each employee may record his/her suggestions in the database and these suggestion entries are evaluated by process improvement group to decide the course of action for future improvement activities. These entries might be invaluable in evaluating the continuity and extent of process improvement activities. However, some organizations might not desire to share this information since it might be considered a "commercial secret". These problems might be overcome with commitment to confidentiality. (See Section 3.3)

3.2.2. Interviews

I employed the responsive interviewing model (Rubin & Rubin, 2011) for this study. This model revolves around three types of questions namely main questions, follow-up questions and probes. It is recommended that the main questions be prepared beforehand but the general flow of the interview be not rigid. The researcher (interviewer) and the conversational partner (interviewee) should engage in a free format conversation. The researcher should choose conversational partners who are knowledgeable on the research topics and who are willing to share their experiences and thoughts on that topic.

3.2.3. Surveys

Although Yin (2009) puts surveys on the same level as the case study as an alternative research method, I incorporated it as a data collection method in this study. Combining the case study method which is typically employed for qualitative research with surveys which is typically employed for quantitative research has its own advantages. Quantitative approach gives broad, generalizable findings which are rich in breadth while qualitative approach gives more focused findings from a much smaller sample set, that is rich in depth (Patton, 1990). For this study, I conducted a survey of the software practitioners who are members of the target organizations in order to shed light on their thoughts in more breadth while the interviews supplied the depth I required.

3.3. Ethics and Confidentiality

All the data collected through the means stated in the previous sections will be kept with strict confidentiality. The names of the participants or the companies comprising the case studies will not be made public in any phase or the finally presented dissertation based on this study.

I hope that this commitment to confidentiality has helped the participants to share their true thoughts regarding their work lives. Knowing that their identities will be kept secret, the participants were able to share their complaints and grievances regarding their organization together with their praises.

3.4. Research Design

I performed a case study in three phases. In the first phase of the case study, the answers of the following questions were explored for organizations that employ staged maturity models:

- Does the employment of staged models result in organization-wide commitment?
- Does the employment of staged models result in continuous process improvement?
- Does the employment of staged models result in improvement over the range of processes?

In the second phase of the study I explored the answer of the following questions:

- What are the prevailing opinions of members of the organizations that employ staged maturity models regarding the process improvement activities?
- How are these opinions related to the organization member's education, experience and role within the organization?

In the last phase of the study I tried to obtain in-depth understanding of the findings from the first two phases by the contribution of various conversational partners from the target organizations.

While searching for target organizations to perform this case study on, I contacted companies that perform process improvement activities by using staged maturity models. I specifically checked for organizations that have or recently had a CMMI rating since the information about these organizations are publicly available unless requested otherwise by the organization itself. I required a minimum maturity level of 3 so that the organization has an established process infrastructure that is open to improvement. Four organizations responded positively to my request and opened up their archival data and also gave me the opportunity to perform a survey among their employees.

First target company, which will be referred by using the pseudonym AvioTech from here on, is a CMMI level-3 software and electronics company operating in the defense industry sector. The total number of employees of AvioTech is near to 300 with the software group comprising of about 100 employees. The main areas of interest for the software group are avionics software and command & control software. Our previous research regarding AvioTech is given in (Uskarcı & Demirörs, 2011) and (Uskarcı & Demirörs, 2012).

The second company operates in the telecommunication, security and defense sectors with more than 1000 employees. The pseudonym TeleSoft will be used for this company in this study. Although TeleSoft had a CMMI level-3 rating in the past, they have chosen not to renew their appraisal in 2011 due to managerial reasons. However, they were still following the established process infrastructure and organizational processes as required by CMMI level-3 at the time of this study. Despite choosing not to renew their appraisal, the company has a strong process improvement initiative and they continue various process improvement activities. The research & development department of the company, comprising of more than 100 employees is the main target of this study.

The third target is DefSys operates primarily in the defense sector by developing and producing weapons and command & control systems. The company had 850 employees with 569 of them being engineers at the time of the study. The target group within the company is the software department that employs 88 engineers. The company uses CMMI Maturity Model and has a level-3 rating since 2012 with an aim of attaining maturity level 5 in the near future.

The last target organization which is to be named CommCorp specializes in the telecommunication and information technologies. The company mainly serves in the defense sector with main products in both software and hardware where serial production is adopted. The company had 2468 employees at the time of the study. Among these employees 509 of them were engineers and they constituted the target group of this study. The company employs CMMI Maturity Model and has a level-3 rating since 2013.

In the first phase, I analyzed the process asset libraries of the target companies. All companies have been maintaining internal Process and Technology Improvement (PTI) suggestion databases, AvioTech since December 2006, TeleSoft since January 2007, DefSys since January 2015 and CommCorp since January 2012. The PTI DBs are important in the sense that it is the major tool that can be used by employees for contributing to the software process improvement activities. All employees have the right to record any suggestion regarding the process assets of the organization in the database. The entries are evaluated by the responsible parties of the target companies and the suggestions which are deemed beneficial are integrated into the process assets of the companies. The total number of entries in the databases at the time of the study was 845 for AvioTech as of February 2011, 307 for TeleSoft as of August 2012, 117

for CommCorp as of March 2017, and 120 for DefSys as of May 2017. The submission characteristics of the improvement database were analyzed with respect to the roles of submitters and their experience level. Furthermore, the time-based variation of the submission counts was taken into account. Finally, the contents of the submissions were analyzed by using a range of categorizations.

For the second phase of this study, I prepared an online questionnaire and announced it by internal e-mails to the related employee groups of each target organization. The questionnaire consists of two parts. The first part consists of questions with 5-level Likert scale (Likert, 1932) answers which are coded as 1 for "Strongly Disagree" to 5 for "Strongly Agree". These questions aim to document the opinion of the employees regarding the process improvement activities and the improvement database used within the organization.

After the analyses were performed for AvioTech and TeleSoft (Uskarcı & Demirörs, 2017) the questionnaire was updated based on the experience obtained from those two organizations. New questions were added and the wording was updated to better capture the underlying opinions of organization members. Furthermore, the questions were tagged either as "Personal" or "Organizational" where the personal questions are related to the personal opinion of the participant regarding how things should be and the organizational questions are related to how things are in the target organization. The number of questions was increased from 15 to 22 by this update. The new version of the questionnaire was tested in an open survey that was announced online to international software practitioners.

The questions of the first part of the questionnaire are given in **Table 2** together with the associated codes, which will be used for the rest of this study. The second version of the questionnaire is presented in **Table 4**. The second part of the questionnaire consists of 8 questions, which obtain personal information about the employee as presented in **Table 3**. However, the second part was also updated after AvioTech and TeleSoft to include questions about the participants' organization so that the survey may be performed without being limited to a known organization. The updated version is presented in **Table 5**. The unit of measurement for the three questions regarding experience duration is months. The role and organization's work area variables are measured in the nominal scale.

Table 2. Questionnaire Part I – version 1

Code	Question
SPIRequired	Process improvement activities are required and important for the success of organizations.
SPIContinous	Process improvement activities shall be performed continuously independent of maturity level assessments.
ProcessesMature	Processes of my organization do not need to be improved.
AllParticipate	All members of the organization shall participate in process improvement activities.
SmallTeam	A small dedicated team shall perform process improvement activities while minimally disturbing the rest of the organization.
RoleBased	Participation ratio in process improvement activities shall be based on the employee's role.
SeniorityBased	Participation ratio in process improvement activities shall be based on the employee's seniority and experience.
HeavyWorkload	I cannot spare time for process improvement activities because of my heavy workload.
NotJustified	The gains obtained from process improvement activities is not high enough to justify the effort dedicated to them.
SPIKnowledge	I have adequate knowledge about what I can do for the improvement of my organization's processes.
PTIKnowledge	I have adequate knowledge about the Process and Technology Improvement Database (PTI DB).
PTIBeneficial	PTIDB is beneficial in continuous process improvement activities.
PTISufficient	PTIDB is sufficient in continuous process improvement activities.
PTIContent	I know the possible content of suggestions that I can submit to PTIDB.
PTIEvaluation	I think that the suggestions I have submitted/plan to submit to the PTIDB are evaluated in an adequate way.

Table 3. Questionnaire Part II – version 1

Code	Question
Gender	Gender
University	University
Department	Department
TargetExp	Employment duration in target company
MaturityExp	Employment duration in an organization with a maturity level certificate (CMMI, ISO 15504 etc.) other than the target company
NonMaturityExp	Employment duration in an organization without a maturity level certificate (CMMI, ISO 15504 etc.) other than the target company
Role	Role
PTISubmission	PTIDB Submission Count

Table 4. Questionnaire Part I – version 2

Code	Question	Type
SPIRequired	Process improvement activities are required and important for the success of organizations.	Personal
SPIContinuous	Process improvement activities shall be performed continuously within the organization independently of process maturity assessments.	Personal
ProcessMature	Processes of my organization do not need to be improved.	Organizational
AllParticipate	All members of the organization shall participate in process improvement activities.	Personal
SmallTeam	A small dedicated team shall perform process improvement activities while minimally involving the rest of the organization.	Personal
RoleBased	Participation ratio in process improvement activities shall be based on the employee's role (software development, quality, configuration management etc.).	Personal

Code	Question	Type
SeniorityBased	Participation ratio in process improvement activities shall be based on the employee's seniority and experience.	Personal
ParticipateSpareTime	Employees shall participate to process improvement activities in their spare time.	Personal
NotJustified	The gains obtained from process improvement activities is not high enough to justify the effort dedicated to them.	Personal
TrainingEffect	Internal/external training on process improvement has a positive effect on the participation ratio of employees in the process improvement activities.	Personal
PerformedContinuously	Process improvement activities are performed continuously and independent of process maturity assessments in the organization that I work for.	Organizational
ModelHinderance	Using a process maturity model has a negative effect on providing continuous process improvement activities in the organization that I work for.	Organizational
SameLevel	Process improvement is carried out at the same level in all possible areas in the organization that I work for.	Organizational
HeavyWorkload	I cannot spare time for process improvement activities because of my heavy workload.	Personal
IndependentProfile	Employees participate in the process improvement activities independent of their profiles (experience, education, role etc.) in the organization that I work for.	Organizational
EducationalEffect	Educational background (the graduated school / department) of the employees affect their participation ratio in the process improvement activities in the organization that I work for.	Organizational

Code	Question	Type
RolesEffect	Roles (software development, quality, configuration management, etc.) of the employees affect their participation ratio in the process improvement activities in the organization that I work for.	Organizational
SeniorityEffect	Seniority and experience level of the employees affect their participation ratio in the process improvement activities in the organization that I work for.	Organizational
MaturityEffect	The employment of a maturity model in the organization that I work for affect the participation ratio of employees in the process improvement activities	Organizational
SPIKnowledge	I have adequate knowledge about what I can do for the improvement of my organization's processes.	Personal
EmployeeSatisfaction	The employment of a maturity model in the organization that I work for has a positive effect on employee satisfaction.	Organizational
OrganizationInnovation	The employment of a maturity model in the organization that I work for has a positive effect on organizational innovation.	Organizational

Table 5. Questionnaire Part II – version 2

Code	Question
Gender	Gender
UnderGraduate	Name of the University / Department (Undergraduate)
Graduate	Name of the University / Department (Graduate)
TargetExp	Employment duration in target company
MaturityExp	Employment duration in an organization with a maturity level certificate (CMMI, ISO 15504 etc.) other than the target company
NonMaturityExp	Employment duration in an organization without a maturity level certificate (CMMI, ISO 15504 etc.) other than the target company
MaturityName	Maturity model name and level
CurrentRole	Role
WeeklyHoursSPI	Weekly hours that employee spend on his/her SPI activities
PTISubmission	PTIDB Submission Count
OrganizationSize	Organization size
DeparmentSize	Number of employee who work in the same department with participant
WorkArea	Organization work area

A factor analysis (Field, 2009) in the form of a principal component analysis was performed on the questionnaire results to identify the underlying approaches of the practitioners from each target organization.

The factors for each target organization is determined separately based on the questions that contribute to that factor. The factor naming is chosen from the following list that match with the themes explored in this study:

- Knowledge: Denotes the participant's knowledge level regarding process improvement
- Support: Denotes the participant's support of process improvement
- Tool: Denotes the participant's satisfaction regarding tools used for process improvement

- Participation: Denotes the participant's support of wide scale participation to process improvement
- Profile: Denotes the participant's view of the effect of the profile (role, experience etc.) on process improvement

For the last phase, interviews were conducted on stakeholders with various characteristics such as role, experience or education regarding their thoughts and opinions about staged models.

I tried to select a sample group from the organization employees to conduct the interviews as much as possible. I use pseudonyms for all participants to ensure confidentiality.

The responsive interviewing model (Rubin & Rubin, 2011) that I employed suggests preparing the main questions beforehand at least in broad form. Therefore, I prepared the main question list given in **Table 6**. Not all main questions were asked in all interviews and I tried to use the list a general guideline instead of a must-follow-checklist. The model suggests not preparing the follow-up questions in detail and asking them whenever necessary by following the flow of the interview. However, I prepared broad follow-up headings for some of the main questions. These follow-up questions are given in bullets in **Table 6**.

Table 6. Interview Main Questions

No	Question
1.	What is your educational background? • Undergraduate • Graduate
2.	What is your role/responsibility in the organization? • How long have you been performing that role? • What was your previous role/responsibility?
3.	How long have you been working in software development? • In this organization? • In other organizations that employ maturity models? • In other organizations that do not employ maturity models?
4.	Do you have any responsibilities regarding process management or improvement in addition to your defined role?
5.	What is your experience regarding maturity models?

No	Question
6.	Are the process improvement activities continuous in your organization? • Are the improvement suggestions given frequently? • What is the effect of the employment of a maturity model?
7.	What is the relationship of the maturity models and the process areas of the organization? • Are all process areas improved or some are prioritized?
8.	Do all organization members participate in process improvement or some are more prominent?
9.	What is the relationship between the members' education background and their participation in process improvement?
10.	What is the relationship between the members' role in the organization and their participation in process improvement?
11.	What is the relationship between the members' experience level and their participation in process improvement?
12.	What is the relationship between the maturity model and the participation of members in process improvement?
13.	What is the effect of maturity models on the organizational process improvement? • What is the difference between organizations that employ maturity models and the ones that do not.
14.	What do you suggest to increase the continuity of process improvement activities?
15.	What do you suggest to increase participation of organization members to process improvement activities?
16.	What are the most critical factors for success of process improvement activities? • Appraiser/Assessor • Training • External consultancy • Experience
17.	Are the effects of process improvement on cost, productivity, time and quality measured?
18.	Does the employment of maturity models increase organization members' satisfaction? • Your personal satisfaction?
19.	What is the effect of maturity models on organizational innovation?

In order to analyze the data obtained from the interviews I used the 7 steps suggested in the model (Rubin & Rubin, 2011).

1. *Transcribe and summarize each interview.*

2. *Define, find, and mark in the text (that is, code) excerpts that have relevant concepts, themes, events, examples, names, places, or dates.*

3. *From across your interviews, find the excerpts marked with the same code, and sort them into a single data file; then summarize the contents of each file.*

4. *Sort and resort the material within each file, comparing the excerpts between different subgroups, and then summarize the results of each sorting.*

5. *After weighing different versions, integrate the descriptions from different interviewees to create a complete picture.*

6. *Combine concepts and themes to generate your own theory to explain the descriptions you have presented. While doing so, constantly test your ideas by examining them in light of the interviews.*

7. *See how far your results generalize beyond the individuals and cases studied.*

I employed a Computer Assisted Qualitative Data Analysis (CAQDAS) tool for the analysis of the interviews.

The final methodology for the case studies is summarized in **Fig. 1**.

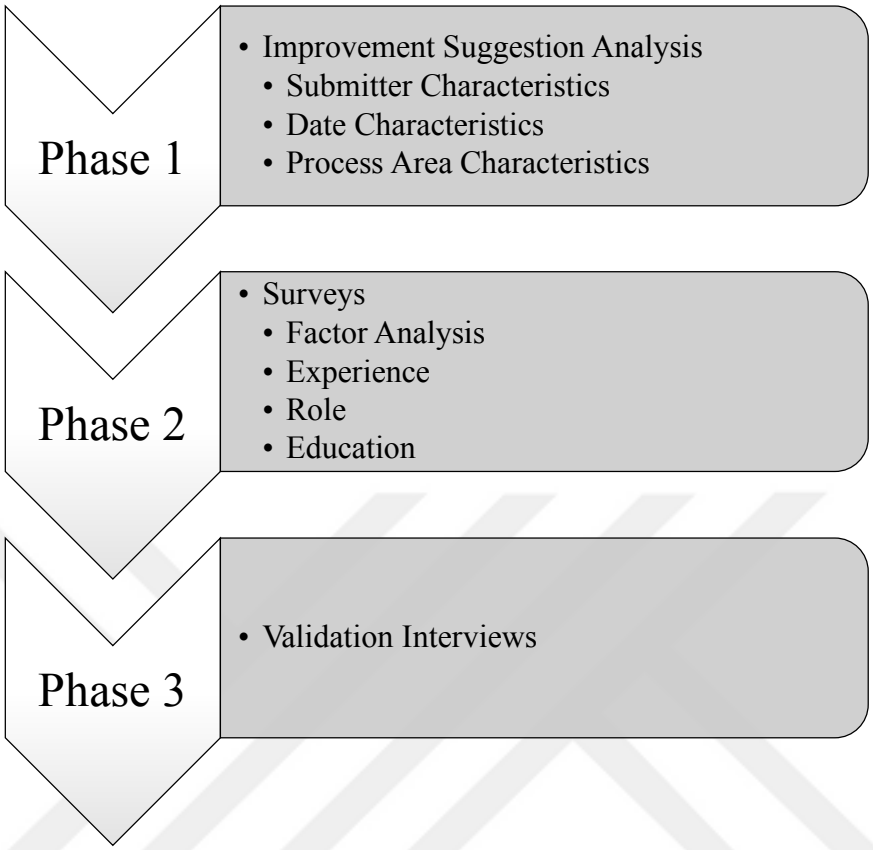

Fig. 1. Summary of Methodology

3.5. Validity

For the evaluation of the validity of our study, I use the approach suggested by Yin (2009) and analyze the validity threats in four categories as follows.

3.5.1. Construct Validity

I have performed the first phase of this study in order to answer our research questions regarding the continuity, participation and extend of process improvement activities. Naturally, different metrics might have been used to analyze the process improvement activities of the target organizations. One such metric is the actual effort put into the process improvement activities by the employees. This metric is available from the weekly timesheets of the employees and might give some insight into the answers of our research questions. However, these data mainly reflect the effort of the people actually responsible for process improvement activities and fail in supplying the contribution characteristics of the general populace required by this study. On the other hand, the suggestion databases are accessible and used by all the employees voluntarily. The characteristics of the improvement suggestions reflect both the continuity, participation and extend of process improvement in the target organization. Therefore, after deliberation I chose improvement suggestion databases as the main source used for the first phase of this study.

For the second phase, I chose the survey questions to reflect different aspects of our research question. I made a preliminary test of the questionnaire by asking two different employees of AvioTech to evaluate the questions and provide their feedback. My aim was to make sure that the questions were understood as I have intended. The questions were updated based on the feedback from the initial test and distributed to the other employees of the target organization after that. The update of the questionnaire based on the insight obtained from the first two organizations also improved the construct validity. During the surveys, I also made clear to all the participants of the questionnaire that I was available for any clarification as required by the participants.

I have performed the study in three phases to be able to use multiple sources of evidence. For the first phase, our source of evidence was the archival records of both target organizations while for the second phase it was the surveys we performed in the form of questionnaires. Finally, for the third phase I employed qualitative interviewing methods. Furthermore, I have established a clear chain of evidence by presenting all the steps of my analysis in detail. The results of all phases of our case study were used in deriving the conclusions as presented below.

Finally, the validation of the findings was realized by presenting the results to the key personnel of the target organizations. Their comments were also taken into account while preparing the conclusion and discussion to refine the results.

3.5.2. Internal Validity

Being an exploratory case study, the internal validity of this work is not specifically threatened. Nevertheless, for the statistical findings I performed a range of validity and reliability tests such as Kaiser–Meyer–Olkin measure, Bartlett's test of sphericity, and Cronbach's Alpha where applicable. The detailed results of these tests and measures are presented together with the overall analysis of the results.

3.5.3. External Validity

I employed a literal replication design for target organizations for this multiple case study. I performed all the steps of the analysis for the first two phases of this study for all of the target organizations. The findings of all these replicated designs were more or less inline and helped me in drawing the conclusions.

However, as the results of case studies are difficult to generalize (Wohlin, Höst, & Henningsson, 2003); I need further studies in more organizations. The target organizations that have participated in this study are all maturity level 3 organizations, using the same model (CMMI) and based in Ankara, Turkey. Extending the study to other organizations specifically with higher levels of maturity, using other models such as ISO/IEC 15504, or from different countries will better generalize the results. It is not possible to eliminate the effects of the specific model used, the actual maturity level, or the organizational and national culture from the findings thus hindering the generalization of the results.

3.5.4. Reliability

The protocol of this case study is given in detail throughout this document. The Research Design section explains the research questions, the selection of target organizations, and the data collection methods. Following sections present the detailed steps of the analyses with the purpose of making possible of the repetition of this study. I maintain the data collected for all phases of this study from all target organizations in the form of spreadsheets and from the interviews in the form of audio files, notes and transcripts. However, this data is considered confidential by these target organizations and conversational partners and have been shared with me for the sole purpose of this study. Therefore, it is not possible for me to publish the raw data without the explicit consent of the target organizations and conversational partners. Nevertheless, it should be noted that all target organizations employ database management tools for maintaining their improvement suggestions databases and it is very convenient to re-obtain the raw data by the automated reporting capabilities of these tools if consent is given by the target organizations.

CHAPTER 4

CASE STUDY FINDINGS

4.1. AvioTech Case Study

4.1.1. Analysis of Process Improvement Suggestions

The analyses of the improvement suggestion databases of target organizations were conducted to extract information about three characteristics namely submitter, timing and content as presented in the following sub-sections.

4.1.1.1. Submitter Characteristics

The submitters are analyzed according to their roles within the target organization and their experience. Although there are more than 30 role types in target companies, the roles were grouped separately for each target based on the internal organization. The role groups for AvioTech is presented in **Table 7**.

Table 7. Role Groups for AvioTech

Code	Roles
CM	Software Configuration Managers
QA	Quality Assurance Engineers
SU	Contract, documentation, process and project management specialists
SW	Software developers, software engineers, and software test engineers

The second categorization I use is the overall work experience or seniority of organization members measured in years. Due to the difference in the organizational structure of targets similar but separate categories were employed with the categorization for AvioTech given in **Table 8**.

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Table 8. Seniority Categorization for AvioTech

S1	S2	S3
0 - 5	5 - 10	10 +

Two different characteristics for each target company are presented as average submission count per employee and the ratio of employees with at least one submission. The number of employees for each role group-seniority combination is given together with the number of database entries submitted by that combination. The average entry per employee is given in the second column for each combination. For example, it can be seen that there are 3 employees in S1 group in AvioTech who work as software configuration managers. This group has submitted a total of 47 entries in the improvement database. So, the average entry per CM employee in S1 group is 15.67.

Table 9. Submission Count per Employee – AvioTech

	S1		S2		S3		Total	
CM	47	**15.67**	60	**60**			107	**26.75**
	3		1				4	
QA	223	**14.87**			24	**24**	247	**15.44**
	15				1		16	
SU	77	**11**					77	**11**
	7						7	
SW	19	**0.37**	100	**4.55**	292	**22.46**	411	**4.78**
	51		22		13		86	
Total	366	**4.82**	160	**6.96**	316	**22.57**	842	**7.45**
	76		23		14		113	

Number of database entries
Number of employees
No employee
Suggestion number per employee

The analysis of the submitted entries for AvioTech reveals that the number of submissions per employee is highest in the configuration management group. The average submission number is more than three times the company average. The next active group is the quality assurance engineers whose submission ratio is more than twice the company average. The support group follows with a more than average ratio. The greatest group in the company which is the software engineers and developers has the lowest improvement suggestion ratio.

Table 10. Employee Participation – AvioTech

	S1		S2		S3		Total	
CM	3	**100%**	1	**100%**			4	**100%**
	3		1				4	
QA	14	**93.3%**			1	**100%**	15	**93.8%**
	15				1		16	
SU	6	**85.7%**					6	**85.7%**
	7						7	
SW	10	**19.6%**	15	**68.2%**	9	**69.2%**	34	**39.5%**
	51		22		13		86	
Total	33	**43.4%**	16	**69.6%**	10	**71.4%**	59	**52.2%**
	76		23		14		113	

Number of employees who have entries
Total number of employees
No employee
Employee participation ratio

The analysis of the participation ratios yields similar results to the submission counts for AvioTech. All members of the configuration management group have at least one entry in the database. The quality assurance and support groups have a near complete participation in the process improvement activities as well. However, the software group has a much lower participation ratio when compared to other groups. Especially among the junior members of the software group only one out of five employees has an entry in the database.

4.1.1.2. Timing Characteristics

The improvement database of AvioTech went online in December 2006. 845 improvement suggestions had been submitted as of February 2011. The number of submissions per month is presented at **Fig. 2**.

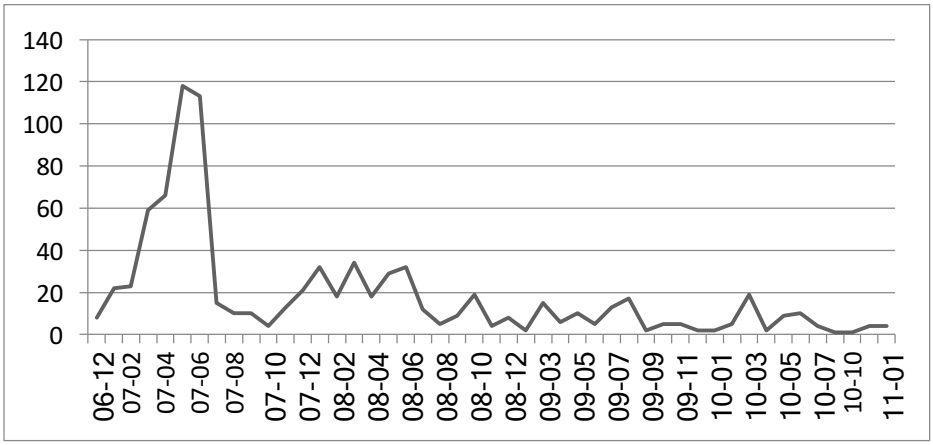

Fig. 2. Number of improvement suggestion submissions per month – AvioTech

The analysis of the submission dates of the entries in the process improvement database of AvioTech reveals that a significant portion of entries is submitted in the first 7 months of the database. The submission rates for AvioTech reach peak values of more than one hundred entries per month in May and June, 2007. This situation results from the fact that the company underwent their first SCAMPI (CMMI Institute, 2014) Class A appraisal for CMMI in June 2007. The submission rates decrease rapidly after the assessment is completed successfully. After a few months' time of relaxation, the rates increase albeit to a level much lower than the appraisal times. Despite this slight increase, the overall trend is in the direction of a constant decrease. A small increase is also observed in March 2010, when the company underwent SCAMPI Class B appraisal in preparation of the next formal CMMI assessment in June 2010. Eventually, the monthly submission rates fall down to just a few entries per month by the end of 2009. A small increase is observed in March 2010, when the company underwent SCAMPI Class B appraisal in preparation of the next formal CMMI assessment in June 2010. A minor increase is also observed for that month when SCAMPI Class A appraisal is conducted.

4.1.1.3. Content Characteristics

The improvement database contains a large variety of data fields for each entry. The foremost field related to the content of the suggestion is the body of the suggestion; however, it is not possible to analyze the exact contents of this field for all of the entries of all target companies in the scope of this study. Therefore, other data fields which contain categorical information for the entries are analyzed.

The database of AvioTech contains a *Process Area* field which defines the related CMMI process area based on CMMI version 1.2. This field is filled up by the submitter

and is not mandatory. 69 entries in the database did not have this information. The distribution of the 776 entries to the process areas is presented in **Fig. 3**.

It was observed that 21 out of the 22 process areas of CMMI are covered by the entries in the database of AvioTech. This situation is evidence that the improvements are spread over the *spectrum* of process areas. It is also interesting that even the process areas which are not formally required of a level-3 organization (Causal Analysis and Resolution (CAR), Organizational Innovation and Deployment (OID), and Organizational Process Performance (OPP)) are covered.

However, it is evident that the distribution of suggestions to these process areas is not balanced. The ratio of the highest submission count process area (CM: Configuration Management) to lowest (OPP: Organizational Process Performance) is nearly 43 disregarding the single process area that has no entries for namely Quantitative Project Management (QPM).

The process definitions and assets of the AvioTech are also categorized in a scheme independent of the CMMI process areas. The improvement suggestion database has an additional field for defining the related process according to the company classification named *Process*. Similar to the *Process Area* this field is not mandatory. Therefore, 794 entries in the database have this data available as presented in **Fig. 4**.

The distribution of suggestions in this aspect is more balanced than the CMMI process areas with the exception of the Supplier Agreement Management process. This result shows that the process improvement suggestions of AvioTech are more evenly distributed to the process assets who manage the daily operation of the target company. It is observed that an internally defined classification schema is more balanced than the externally defined CMMI process area distribution.

Fig. 3. Number of improvement suggestion submissions per CMMI Process Area – AvioTech

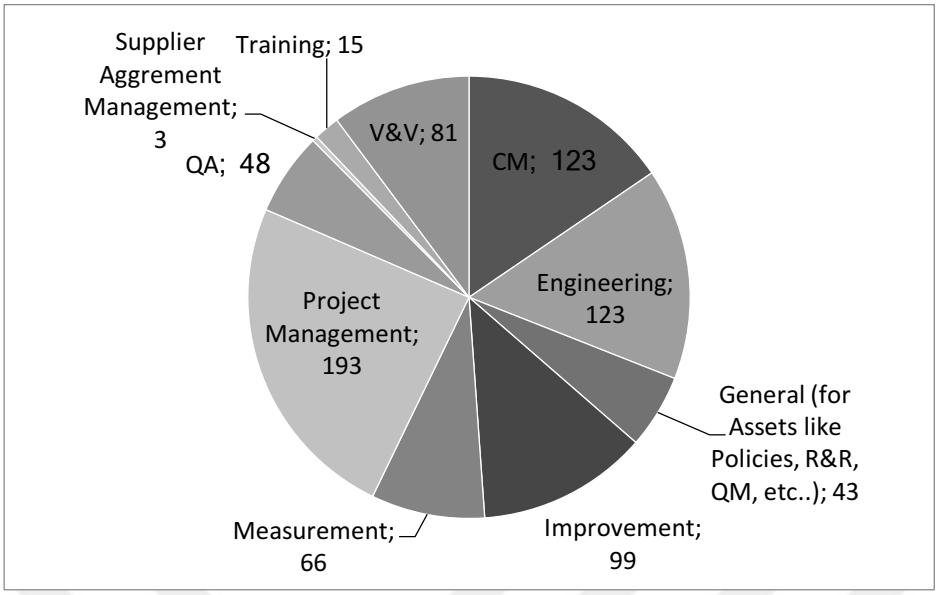

Fig. 4. Number of improvement suggestion submissions per company process category – AvioTech

4.1.2. Analysis of the Survey

As the second phase of this case study I performed the analysis of the questionnaire answers, in order to understand the perception of process improvement among employees and to explore the quality of the employees who participate in process improvement work. A total of 42 people submitted answers for the questionnaire from AvioTech. Among these answers 35 were complete.

A factor analysis (Field, 2009) in the form of a principal component analysis is performed on the questionnaire results to identify the underlying approaches of the target company employees. As a first step the variables of the first part of the questionnaire were subjected to a factor analysis. However, the results did not converge to logically coherent factors. As an improvement, the PTISubmission variable from the second part of the questionnaire was added to the analysis. The improvement submission count is a strong indicator of an employee's commitment to the process improvement activities. Therefore, its inclusion in the variable list has improved the underlying logic of the factors.

The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis, KMO = .523 and Bartlett's test of sphericity χ^2 (120) = 172.378, p = .001, indicated that the correlations between items were sufficiently large. Finally, it was decided that

three components explaining 48.38% of the variance might yield a meaningful grouping based on the analysis of the Scree plot. The analysis with three components is presented in **Table 11**. It should be noted that orthogonal rotation has been applied to the results and weights less than 0.4 are not shown.

The first component is deemed to indicate the *knowledge* dimension. Employees with this attitude feel that they have adequate information about Software Process Improvement and the suggestion database used; they appreciate the benefits of the database, they think that current processes are not mature, and they have high PTI submission counts.

The second component indicates an attitude opposing continuous process improvement activities. This attitude includes the thought that the processes are already mature and the currently used suggestion database is sufficient for process improvement. Furthermore, SPI activities need not be continuous and should be performed based on the roles or the workload of the employees. Therefore, this attitude covers the *support* of continuous process improvement.

The third component is the view regarding the suggestion *tool* used. This attitude is based on the thought that the improvement database is beneficial and effectively used. Any extra effort for SPI is not justified according to this view.

Table 11. Components Obtained by the Factor Analysis - AvioTech

	Components		
	Knowledge	**Support**	**Tool**
PTIContent	.824		
PTIKnowledge	.821		
SPIKnowledge	.763		
PTISubmission	.643		
SeniorityBased	.447		
PTISufficient		.716	
SPIContinous		-.709	
SPIRequired		-.708	
RoleBased		.662	
ProcessesMature	-.404	.557	
HeavyWorkload		.490	
PTIEvaluation			.726
NotJustified			.638
PTIBeneficial	.487		.504
SmallTeam			-.460

4.1.2.1. Reliability Analysis

A reliability analysis is performed by calculating Cronbach's Alpha for each factor (Field, 2009). The questions with negative weight are reversed for the purpose of the reliability analysis. I used a lower threshold of 0.6 considering the low number of items. The components with higher number of items may be evaluated against a threshold of 0.7 which is a more commonly used threshold for reliability (Peterson, 1994). The findings of the analysis are presented at **Table 12**.

Table 12. Reliability Analysis Results - AvioTech

Components	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
Knowledge	.264	.778	7
Support	.684	.725	6
Tool	.400	.472	4

Knowledge. Although Cronbach's α is low, the value based on standardized items is satisfactorily high. This is due to the inclusion of PTISubmission, which has a different scale than the other variables in the factor analysis. Cronbach's α is increased if PTISubmission is deleted, which suggests that the inclusion of PTISubmission decreases reliability despite increasing the logical foundation of the factors determined.

Support. Cronbach's α is satisfactorily high for this factor, and the deletion of none of the items increases Cronbach's α significantly. Therefore, this factor is deemed to be reliable.

Tool. Cronbach's α is not high for this factor. The deletion of SmallTeam increases the reliability, albeit by a small amount (Cronbach's α after deletion is 0.539).

4.1.2.2. Multiple Regression Analysis

The next step I performed is the determination of the relationship between the factors and the experience of the employees obtained in three categories represented by the TargetExp, MaturityExp and NonMaturityExp variables by performing multiple regression analysis (Field, 2009).

Knowledge. The results obtained through backward elimination method shows that the experience in the target company (sig. = .000) and any other company with a maturity level certification (sig. = .008) significantly affects the knowledge attitude in employees. The experience in any other type of company is not significant (sig. = .394) and therefore was dropped from the model. The experience in the target company is more effective than the experience in other certified organizations (standardized coefficients 0.560 to 0.356). The model consisting of the experience levels explains nearly 50% of the variance in the knowledge attitude.

Support. The support of an employee to process improvement is not related to his/her experience. The regression model eliminated all the experience types without reaching a significant model during the analysis.

Tool. The view of the employee regarding the suggestion database is not related to his/her experience. The regression model eliminated all the experience types without reaching a significant model.

4.1.2.3. Comparison of Means

Our research question also asks about the relationship of software process improvement contribution and the role and the education of the employee. Unfortunately, the survey data collected was uneven with respect to these variables. For example, there was only 1 employee with CM role while there were 30 employees with SW role (See **Table 13**). Therefore, a statistical study more advanced than comparing the means could not be accomplished. It should also be noted that the weights of the variables for Support factor are multiplied by -1 since the variables originally denote a negative view of Support. With the help of this minor modification a higher average denotes higher support value in the following figures.

Table 13. Count of Employees in Role groups - AvioTech

Abbreviation	No. of Employees
SW	30
QA	3
CM	1
SU	2
Blank	6

Role. The mean values for the factors based on the employee roles are presented in **Fig. 5**. The members of the quality and configuration management believe that they are knowledgeable about the process improvement activities and tools, while software

engineers and support personnel believe that they are not knowledgeable. The quality assurance and configuration management staff is also the proponents of process improvement activities within the organization. All groups except the software engineers are satisfied with the currently used improvement suggestion database.

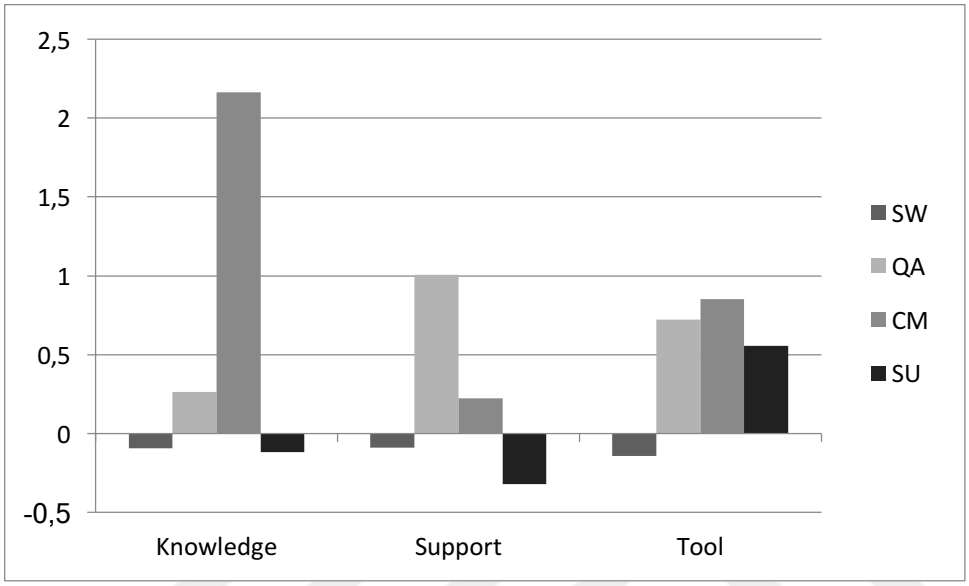

Fig. 5. Factor Mean Values Based on Role – AvioTech

Education. Although the target company specializes in software, employees come from a variety of educational backgrounds. The undergraduate specializations of the employees who have participated in the survey are summarized in **Table 14** and the mean values for the factors based on the employee education are presented in **Fig. 6**. An interesting finding is that computer engineering and electronics engineering graduates, which are the largest groups, have opposite approaches for all three factors. However, I do not have adequate data to further elaborate on this finding and therefore assume that this might be studied in a future work.

Table 14. Educational Background of Employees - AvioTech

Undergraduate Degree	Abbreviation	No. of Employees
Computer Engineering	CENG	22
Electrical-Electronics Engineering	EEE	9
Statistics	STAT	3
Others (Chemical Engineering, Mechanical Engineering)	Other	2
Blank	N/A	6

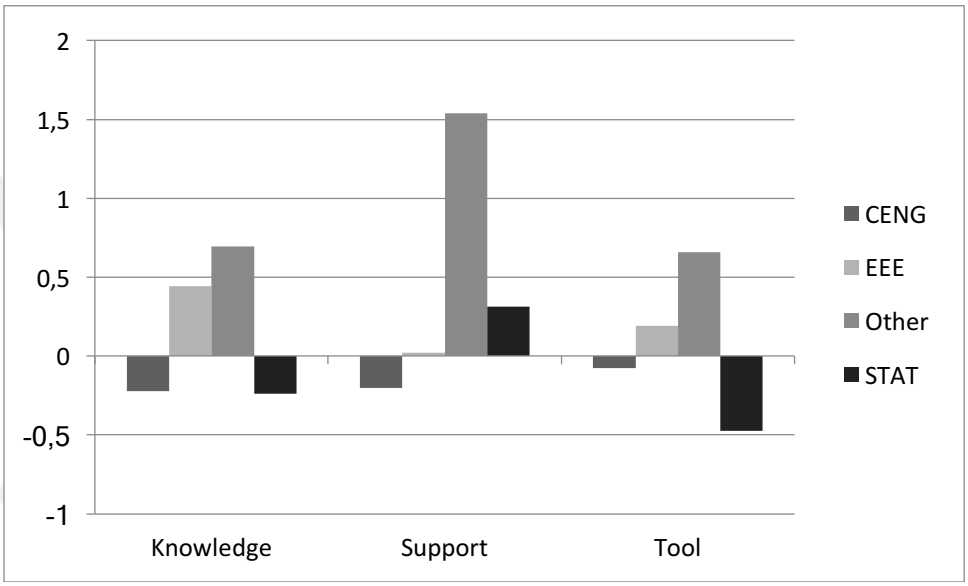

Fig. 6. Factor Mean Values Based on Education – AvioTech

4.1.3. Summary of the Findings

Analysis of given tables reveals that participation of employees in using the suggestion DBs is more or less directly proportional to their experience levels. Furthermore, it is seen that employees' participation in process improvement is related to their role in the organizations. The discrepancies between the ratios of different groups may be explained by the fact that the quality engineers are usually employed at maturity level assessment activities and audits within the companies thus gaining a higher level of understating of the processes within the companies. Furthermore, their duties usually include ensuring that the activities within the company are performed in accordance

with the defined processes. These two factors might form the basis for their high level of contribution to process improvement activities.

The software developers and engineers, which form the majority, have a much lower contribution to process improvement, although the processes are enforced in the first place to mold the way that they produce their software products. Therefore, it is observed that the staged model based initiative has not been successful in enabling organization-wide process improvement commitment. The current situation is a *process-wise oligarchy* where a minority manages the processes for a majority who use them. It might not be the goal of the company to establish a *process-wise democracy* where every employee has equal commitment and voice in the process improvement; however, it was concluded that the organization-wide process improvement commitment is not enabled for both of the organizations by using staged models.

It was observed that process improvement suggestions are concentrated before the maturity level assessment periods. This results in approximately half of the database entries being submitted in only 5 months for over 5 years. Therefore, it is not possible to state that the staged model based approach results in continuous process improvement for the organization. The process improvement suggestions are submitted continuously, but the rate is not steady with huge differences as observed in AvioTech.

The content-wise analysis reveals that the staged maturity models have failed to result in a balanced distribution of process improvement activities over the range of process categorizations. Although the staged maturity models do not set a goal for a balanced distribution, the very high difference across different categorizations shows that improvement across the range of processes cannot be obtained.

By performing a factor analysis, three factors are identified among AvioTech employees. These factors are the employee's knowledge regarding SPI (*Knowledge* factor), his/her support level to SPI (*Support* factor), and the satisfaction in the improvement database the target company uses (*Tool* factor).

In the first phase, I had observed that the submission counts of the employees and therefore their commitment to process improvement increases with the experience of the employee. For AvioTech, it is determined that the experience of an employee in maturity level certified organizations significantly affects his/her self-image regarding knowledge level. However, this experience does not make him/her a proponent of SPI activities or alter his/her thoughts on the effectiveness of the improvement database used.

Therefore, it can be concluded that with increasing experience employees feel that they gain adequate information about software process improvement, and they appreciate the need for improving the current processes within the organizations. Naturally, the

experience in the target organization raises the awareness of the employee regarding the tools and methods used in the organization for process improvement. However, it is seen that experience explains only half of the variance regarding knowledge. Therefore, there is room for improving the perceived knowledge of employees with varying experiences. This improvement might even be incorporated into the models used for process improvement by AvioTech.

The relationships regarding the employee's role and education could not be analyzed exhaustively due to the uneven distribution of answers from the conducted survey. The first phase of our study has shown that configuration managers, quality assurance engineers, and – to a lesser extent – support personnel have much higher contribution to process improvement suggestions than software engineers. The second phase has verified these results by showing that the mentioned role groups see themselves more knowledgeable than the software engineers. They are also proponents and believers of software process improvement activities within the organization. Therefore, the claim of the existence of a *process-wise oligarchy* within AvioTech still holds. It should also be noted that nearly for all the factors the quality assurance engineers have opposite attitudes to the software engineers.

The analysis regarding educational background faced challenges since the most significant outcomes belonged to groups with small number graduates. Nevertheless, it is interesting that computer engineering and electrical-electronics engineering graduates, which are the largest groups, usually have opposite approaches to the determined factors for both organizations.

4.2. TeleSoft Case Study

4.2.1. Analysis of Process Improvement Suggestions

The analysis of the improvement suggestion database of TeleSoft conducted to extract information about three characteristics namely submitter, timing and content is presented in the following sub-sections.

4.2.1.1. Submitter Characteristics

The submitters are analyzed according to their roles and experience. The role groups and experience categories used for TeleSoft are given in the following tables.

Table 15. Role Groups for TeleSoft

Code	Roles
CM	Software Configuration Managers
QA	Quality Assurance Engineers
SU	Contract, documentation, process and project management specialists
SW	Software developers, software engineers, and software test engineers
HW	Hardware, electronics or mechanical designers, technicians

Table 16. Seniority Categorization for TeleSoft

S1	S2	S3	S4	S5
0 - 5	5 - 10	10 - 15	15 - 20	20 +

Table 17. Submission Count per Employee – TeleSoft

	S1		S2		S3		S4		S5		Total	
CM	0	**0**	1	**0.33**			1	**1**			2	**0.4**
	1		3				1				5	
QA	4	**4**	55	**7.86**	13	**3.25**	22	**3.67**	6	**3**	100	**5**
	1		7		4		6		2		20	
SU	0	**0**	8	**4**	13	**6.5**	35	**11.67**	32	**4**	88	**5.5**
	1		2		2		3		8		16	
SW	1	**0.06**	10	**0.43**	21	**2.63**	74	**4.63**	6	**0.86**	112	**1.58**
	17		23		8		16		7		71	
HW	0	**0**	5	**0.63**	0	**0**	0	**0**	0	**0**	5	**0.16**
	4		8		5		11		4		32	
Total	5	**0.21**	79	**1.84**	47	**2.47**	132	**3.57**	44	**2.10**	307	**2.13**
	24		43		19		37		21		144	

Number of database entries
Number of employees
No employee
Suggestion number per employee

A trend similar to AvioTech is also observed for TeleSoft with one major difference. The configuration managers have much lower submission figures compared to the configuration managers of AvioTech. It shall also be noted that they even have much lower submission figures than the company average of TeleSoft. Quality assurance and support groups within TeleSoft have much higher submission ratios than software developers just like AvioTech. However, the additional group defined for TeleSoft, namely hardware specialists has much lower submission ratios although there are specific processes defined for hardware development activities within TeleSoft. This finding may be explained by the fact that the most of defined processes are related to software development and hardware specialists do not mingle with the software processes. I will not go into much detail about the hardware specialist since the focus of this study is software process improvement.

Table 18. Employee Participation – TeleSoft

	S1		S2		S3		S4		S5		Total	
CM	0 1	**0%**	1 3	**33.3%**			0 1	**0%**			1 5	**20%**
QA	1 1	**100%**	6 7	**85.7%**	3 4	**75%**	5 6	**83.3%**	2 2	**100%**	17 20	**85%**
SU	0 1	**0%**	1 2	**50%**	2 2	**100%**	3 3	**100%**	6 8	**75%**	12 16	**75%**
SW	2 17	**11.8%**	8 23	**34.8%**	4 8	**50%**	11 16	**68.8%**	5 7	**71.4%**	30 71	**42.3%**
HW	0 4	**0%**	4 8	**50%**	0 5	**0%**	3 11	**27.3%**	2 4	**50%**	9 32	**28.1%**
Total	3 24	**12.5%**	20 43	**46.5%**	9 19	**47.4%**	22 37	**59.5%**	15 21	**71.4%**	69 144	**47.9%**

Number of employees who have entries
Total number of employees
No employee
Employee participation ratio

It was observed that the findings for TeleSoft align with the previous findings. Quality assurance and support personnel have high participation ratios while the software developers have less-than-average participation in process improvement activities. However, it should be noted that the discrepancies observed between **Table 17** and **Table 18** are due to the fact the two different snapshots with different dimensions were supplied by TeleSoft while performing this study.

4.2.1.2. Timing Characteristics

The summary of improvement database entries of TeleSoft, which contains 307 entries submitted over a time span from January 2007 to August 2012, is given in **Fig. 7**.

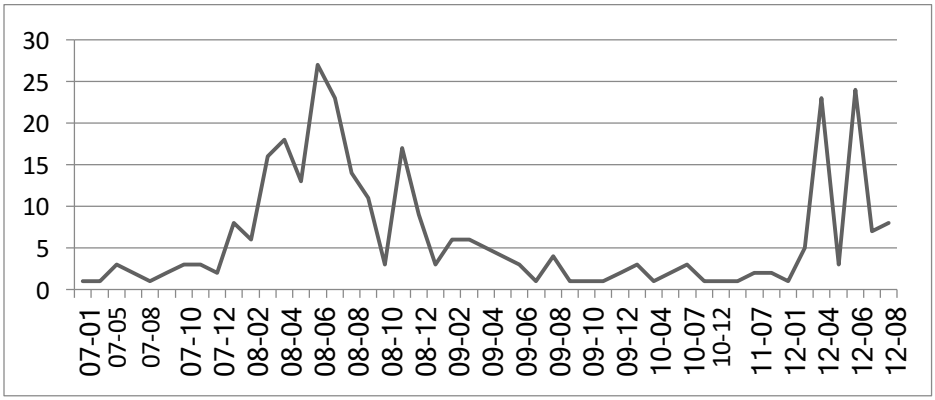

Fig. 7. Number of improvement suggestion submissions per month – TeleSoft

The analysis of the improvement submission dates of TeleSoft revealed results similar to AvioTech findings. It is seen that the majority of all submissions are concentrated in the year 2008. The organization underwent their first CMMI appraisal during this period. After this period, the submission rates significantly drop for nearly 4 years. It should be noted that the organization decided not to renew their CMMI appraisal after the mandatory 3-year period. A period of significant increase in submission rates is observed in 2012. During this period, organizational changes in TeleSoft resulted in the quality assurance group taking the responsibility of process management and extensive audits and assessment performed by them on the organization's process library. This activity may be considered to be similar to a CMMI appraisal and therefore the increase in suggestions aligns with our previous findings for AvioTech.

4.2.1.3. Content Characteristics

The improvement suggestion database of TeleSoft contains only one mandatory field named *Process* for categorizing entries. No categorization data based on CMMI process areas is available for the suggestions. The distribution of all entries to the matching 21 *Processes* for TeleSoft is given in **Fig. 8**.

The distribution of suggestions to processes is not balanced even for the internally defined classification schema for TeleSoft. The highest number of suggestions is related to Change Management Process with 98 entries, while there are three processes with only one entry.

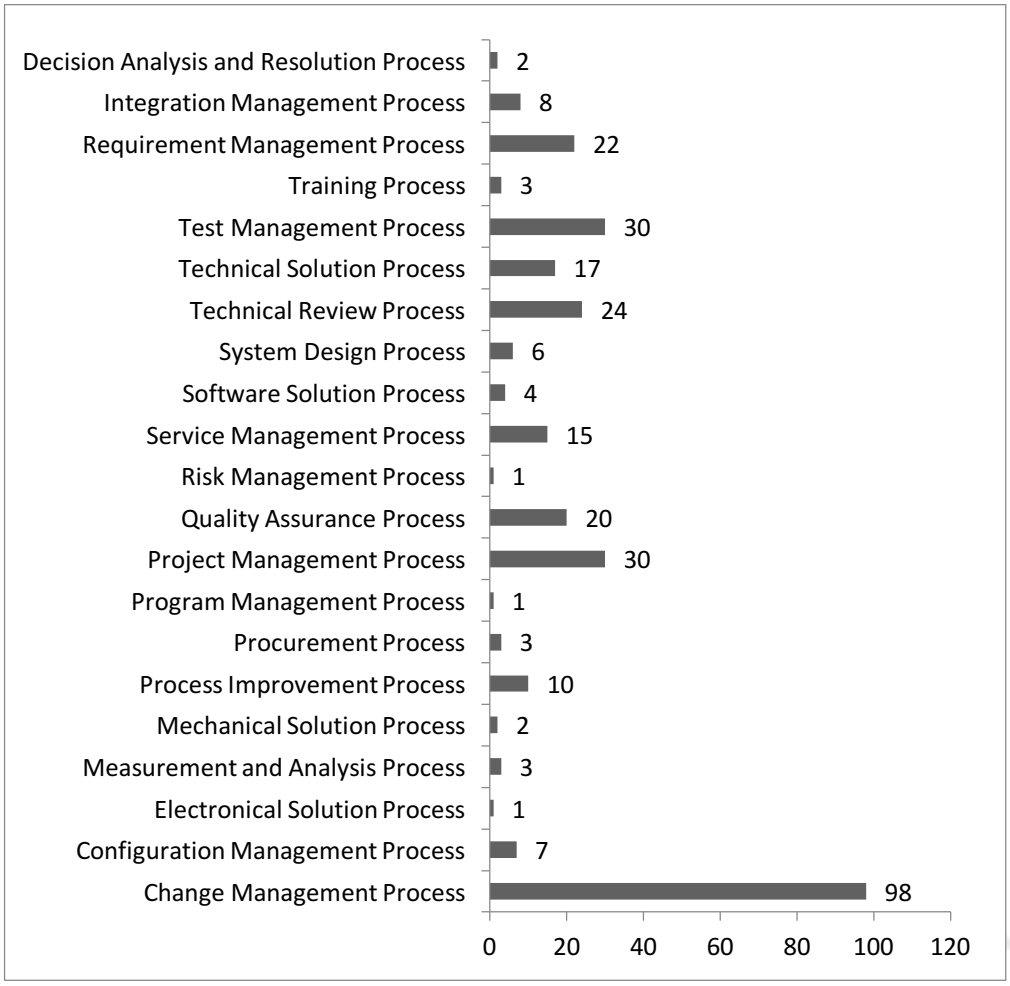

Fig. 8. Number of improvement suggestion submissions per company process category – TeleSoft

4.2.2. Analysis of the Survey

Participants from TeleSoft submitted 45 complete forms during the survey. The factor analysis yielded logically coherent factors without the need for the inclusion of PTISubmission variable from the second part of the questionnaire. The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis, KMO = .596 and Bartlett's test of sphericity χ^2 (105) = 270.984, $p < .001$, indicated that correlations between items were sufficiently large. Finally, it was decided that three components explaining 53.72% of the variance might yield a meaningful grouping based on the analysis of the results by choosing different component numbers. The analysis with three components is presented in **Table 19**. It should be noted that oblique rotation has been applied to the results and weights less than 0.3 are not shown.

The first component is deemed to indicate the s*upport* attitude. Employees with this attitude believe that the effort put into SPI is justified, organization's processes are not mature, SPI is required and all should participate irrespective of their workloads, SPI should be continuous and the improvement database used is beneficial. They also believe that they have adequate knowledge about SPI.

The second component indicates an attitude for keeping participation in SPI activities at minimum. Therefore, this attitude is named *participation* and the employees with this attitude believe that the processes of the organization are already mature and a small team formed according to roles and seniority of employees must be responsible for SPI activities. This attitude also includes the view that the process improvement suggestion database is sufficient for SPI activities.

The third component is deemed to indicate the *knowledge* level of both SPI and the tool used in the company. Employees with this attitude do not feel that they have adequate information about SPI or improvement database used. They are not sure about what to suggest for improvement and they do not believe that their suggestions are handled adequately. Therefore, the improvement database is not beneficial or sufficient according to this view. As it is seen employees with this attitude seem to have problems with the improvement database used. They also think that SPI does not need to be continuous.

Table 19. Components Obtained by the Factor Analysis - TeleSoft

	Components		
	Support	**Participation**	**Knowledge**
NotJustified	-.905		
SPIRequired	.859		
AllParticipate	.585		
SPIContinous	.523		-.360
PTIBeneficial	.495		-.424
HeavyWorkload	-.354		
RoleBased		.769	
SmallTeam		.759	
SeniorityBased		.671	
ProcessesMature	-.384	.408	
PTIKnowledge			-.854
PTIEvaluation			-.715
PTIContent			-.708
SPIKnowledge	.304		-.662
PTISufficient		.335	-.369

4.2.2.1. Reliability Analysis

The findings of the reliability analysis performed by calculating Cronbach's Alpha for each factor are presented at **Table 20**. The questions with negative weight are reversed for the purpose of the reliability analysis.

Table 20. Reliability Analysis Results - TeleSoft

Components	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
Support	.778	.786	8
Participation	.640	.632	5
Knowledge	.777	.776	7

It is seen that Cronbach's α is satisfactorily high for all factors, and the deletion of none of the items increases Cronbach's α significantly. Therefore, all factors are deemed to be reliable.

4.2.2.2. Multiple Regression Analysis

The findings of the multiple regression analysis performed in order to determine the relationship between the factors and the experience of the employees obtained in three categories represented by the TargetExp, MaturityExp and NonMaturityExp variables is presented below.

Support. The results obtained through backward elimination method shows that the experience in other companies with or without a maturity level certification significantly (sig. = .010 for MaturityExp and sig. = .025 for NonMaturityExp) affects the support attitude in employees. The experience in the target company is not significant (sig. = .758) and therefore was dropped from the model. However, the model consisting of the experience levels explain only 23% of the variance in the support attitude. An interesting finding is that the experience in a maturity level certified organization negatively affects the support attitude while experience in a not certified organization has a positive effect.

Participation. The employee's view on the formation of teams responsible for process improvement is not related to his/her experience. The regression model eliminated all the experience types without reaching a significant model during the analysis.

Knowledge. The analysis resulted in both the TargetExp and NonMaturityExp being eliminated due to insignificance. Only the experience in a maturity level certified organization significantly (sig. = .019) affects the knowledge attitude. However, only 12% of the variance is explained by the model consisting of MaturityExp. Interestingly, – similar to Support attitude – previous experience in a maturity level certified organization decreases employees' self-image regarding knowledge related to SPI. This may be due to heavy influence of the questions regarding the improvement database in the knowledge factor. Employees who have used different tools for the same purpose in the past might have difficulty in adapting to the tool of their new company.

4.2.2.3. Comparison of Means

Similar to AvioTech, the survey data collected for TeleSoft was uneven with respect to the role and education variables. For example, there was only 1 employee with CM role while there were 30 employees with SW role. Therefore, I only performed a comparison of means again. It should also be noted that the weights of the variables for Participation and Knowledge factors are multiplied by -1 since the variables originally denote negative views. With the help of this minor modification a higher average denotes higher Participation and Knowledge values in the following figures.

Table 21. Count of Employees in Role groups - TeleSoft

Abbreviation	No. of Employees
SW	30
QA	2
CM	1
SU	12

Role. Count of employees in each role group is given in **Table 21** and the mean values for the factors based on the employee roles are presented in **Fig. 9**. The members of the quality assurance and configuration management groups are strong proponents of SPI activities, while software engineers slightly oppose SPI. Quality assurance group is a strong proponent of participation. For the knowledge attitude, it is seen that the variance with respect to role groups is not high except the single employee in the configuration management group who believe that he/she is knowledgeable regarding SPI and the tools used in the company.

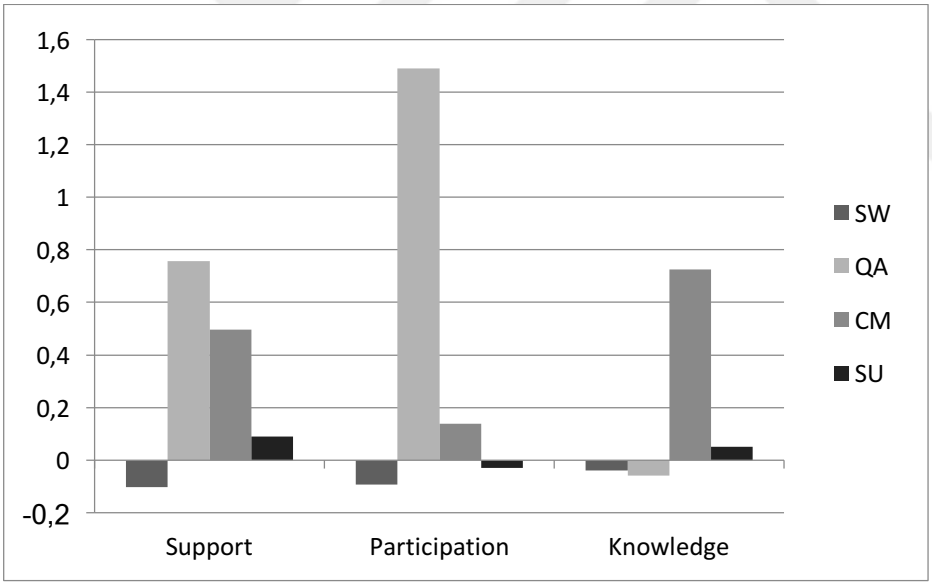

Fig. 9. Factor Mean Values Based on Role – TeleSoft

Education. The undergraduate specializations of the employees who have participated in the survey are summarized in **Table 22** and the mean values for the factors based on the employee education are presented in **Fig. 10**. A higher ratio of employees in TeleSoft have a degree in electrical and electronics engineering since the company is active in electronics development and manufacturing. Similar to the results for AvioTech, the two largest groups – computer engineers and electronics engineers – have opposite attitudes regarding participation and knowledge factors. However, for TeleSoft the computer engineers seem to have more desirable views regarding SPI. Another interesting finding is that neither the computer nor electronics engineers are proponents of SPI.

Table 22. Educational Background of Employees - TeleSoft

Undergraduate Degree	Abbreviation	No. of Employees
Computer Engineering, Software Engineering, Computer Technology & Information Systems	CENG	9
Electrical-Electronics Engineering	EEE	32
N/A – High School Graduate	HS	2
Others	Other	2

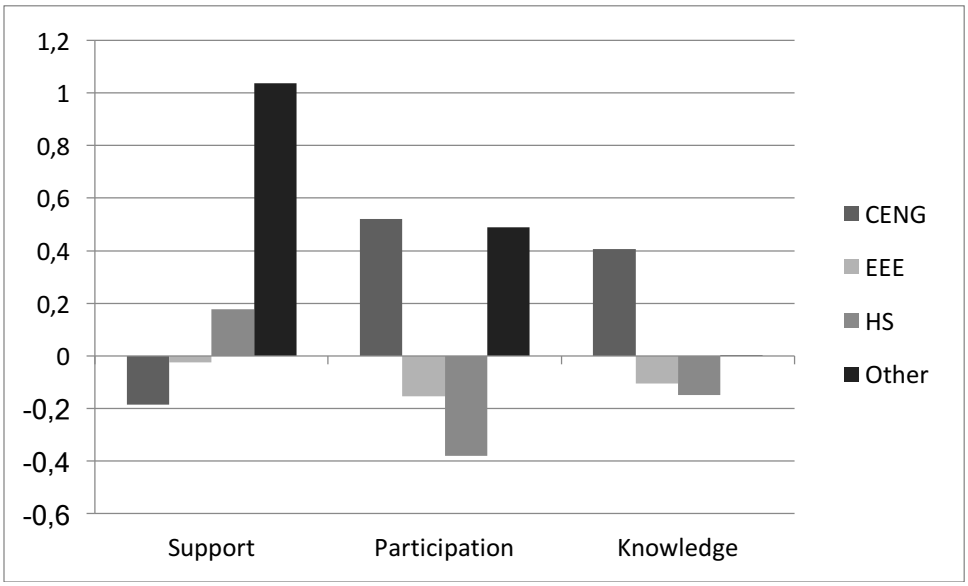

Fig. 10. Factor Mean Values Based on Education – TeleSoft

4.2.3. Summary of the Findings

Analysis of improvement suggestion characteristics reveals that participation of employees in using the suggestion DBs varies based on their roles. Similar to AvioTech, the discrepancies between the ratios of different groups may be explained by the fact that the quality engineers are usually employed at maturity level assessment activities within the companies thus gaining a higher level of understating of the processes within the companies. Furthermore, their duties usually include ensuring that the activities within the company are performed in accordance with the defined processes. These two factors might form the basis for their high level of contribution to process improvement activities.

The software developers and engineers again have a much lower contribution to process improvement, although the processes are enforced in the first place to mold the way that they produce their software products. Therefore, the finding of a *process-wise oligarchy* rather than a *process-wise democracy* holds true for TeleSoft and organization-wide process improvement commitment is not enabled by using staged models.

Another somewhat expected finding is that the more experienced employees contribute and participate more in software process improvement activities. However, there is a minor exception with the S5 group in TeleSoft. Although, the trend of increasing SPI commitment with increasing experience is clearly seen from rest of the groups, this exception of S5 group has not been analyzed thoroughly within the scope of this study.

It was observed that process improvement suggestions are concentrated before the maturity level assessment periods and other planned process improvement initiatives. This results in approximately half of the database entries being submitted in only 7 months over 5 years. Therefore, it is not possible to state that the staged model based approach results in continuous process improvement for TeleSoft. The process improvement suggestions are submitted continuously, but the rate is not steady with huge differences as observed.

Similar to AvioTech, the content-wise analysis findings reveal that the staged maturity models have failed to result in a balanced distribution of process improvement activities over the range of process categorizations. The very high difference across different categorizations shows that improvement across the range of processes cannot be obtained.

The factor analysis outcomes are the support of an employee for SPI activities (*Support* factor), the reluctance of an employee to participate in SPI teams (*participation* factor),

and the perceived lack of knowledge of the employee regarding both SPI and the process improvement tools used within the company (*knowledge* factor).

In the first phase, I had observed that the submission counts of the employees and therefore their commitment to process improvement increases with the experience of the employee. The analysis of the determined factors produced interesting findings since the support of an employee for SPI was found to be related to his/her previous experience but not the time spent working for the target organization. It may be concluded that people who have experienced the inner workings of different companies have a tendency for supporting process improvement.

It was also seen that the view of an employee regarding to whom the responsibility of process improvement falls is not affected by experience. It was also concluded that the experience in other organizations increases the perceived lack of knowledge regarding SPI and the tools used such as the improvement suggestion database. Employees who have used different tools for the same purpose in the past might have difficulty in adapting to the tool of their new company.

Like AvioTech, the relationships regarding the employee's role and education could not be analyzed exhaustively due to the uneven distribution of answers from the conducted survey. The first phase of this study has shown that quality assurance engineers have much higher contribution to process improvement suggestions than software engineers. The second has verified these results by showing that the quality assurance engineers are proponents of software process improvement activities within the organization. It should also be noted that nearly for all the factors the quality assurance engineers have opposite attitudes to the software engineers.

The analysis regarding educational background faced challenges since the most significant outcomes belonged to groups with small number graduates. Nevertheless, it is interesting that computer engineering and electrical-electronics engineering graduates, which are the largest groups, usually have opposite approaches to the determined factors like AvioTech.

4.3. Analysis of the Open Survey

After the methodology was updated the questionnaire phase was tested in an open survey where any software practitioner was able to participate through the internet.

4.3.1. Analysis of the Survey

There was a total of 58 participants to the survey. The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis, KMO = .526 and Bartlett's test of sphericity χ^2 (231) = 448.109, $p < .001$, indicated that correlations between items were sufficiently large. Finally, it was decided that four components explaining 49.19% of the variance might yield a meaningful grouping based on the analysis of the results by choosing different component numbers. The analysis with four components is presented in **Table 23**. It should be noted that oblique rotation has been applied to the results and weights less than 0.4 are not shown.

The first component is deemed to indicate the *support* attitude. Employees with this attitude believe that the maturity models increase both employee satisfaction and organizational innovation and all should participate in process improvement activities. In addition, they think that the process improvement activities are balanced over the range of process areas in their organization. They mainly support the model based process improvement.

The second component indicates an attitude for participating in SPI activities based on the role and seniority. Therefore, this attitude is named *participation*.

The third view is based on the idea that process improvement activities are not affected by the education, role or experience of the organization members. The participation is independent of theses personal characteristics and therefore this component is named *Profile*.

The last component is not as logically coherent as the previous three. It is not named since it was also found to not to be reliable as presented below.

Table 23. Components Obtained by the Factor Analysis – Open Survey

	Components			
	Support	**Participation**	**Profile**	**N/A**
EmployeeSatisfaction	.801			
OrganizationInnovation	.778			
AllParticipate	.594			
SameLevel	.428			
RoleBased		.788		
SeniorityBased		.781		
EducationalEffect			-.843	
RolesEffect			-.744	
SeniorityEffect			-.720	
ParticipateSpareTime				-.733
ProcessMature				-.640
MaturityEffect				.532

4.3.1.1. Reliability Analysis

The findings of the reliability analysis performed by calculating Cronbach's Alpha for each factor are presented at **Table 20**. The questions with negative weight are reversed for the purpose of the reliability analysis.

Table 24. Reliability Analysis Results – Open Survey

Components	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
Support	.657	.653	4
Participation	.694	.701	2
Profile	.788	.787	3
N/A	.389	.384	3

It is seen that Cronbach's α is satisfactorily high for the first three factors. Only significant increase in case of deletion of a variable is observed for the support factor. The deletion of SameLevel increases Cronbach's α to .729 for support factor. However, since the value is already high the variables are used as is. For the last factor, Cronbach's α is not high and the deletion of none of the variables increases it to

satisfactory levels. I have already noted that coherence of this factor was not high and the reliability analysis supports that view. Therefore, this factor will not be used for the rest of this analysis.

4.3.1.2. Multiple Regression Analysis

As the target of the open survey is not a single organization the regression analysis was performed by using only two variables; the total experience of the participant in organizations having and not having maturity level certification. The first variable was named TotalMaturityExp and was calculated by the addition of TargetExp and MaturityExp.

Support. The results obtained through backward elimination method shows that the both types of experience significantly (sig. = .045 for NonMaturityExp and sig. = .007 for TotalMaturityExp) affects the support attitude in participants. However, the model consisting of the experience levels explain only 14% of the variance in the support attitude. An interesting finding is that the experience in a maturity level certified organization negatively affects the support attitude while experience in a not certified organization has a positive effect.

Participation. The participant's view on the formation of teams responsible for process improvement is not related to his/her experience. The regression model eliminated all the experience types without reaching a significant model during the analysis.

Profile. Similar to the participation factor the regression model eliminated all the experience types without reaching a significant model during the analysis.

4.3.1.3. Comparison of Means

The survey data collected was again uneven with respect to the role and education variables. For example, there was only 1 employee with OP role while there were 33 employees with SW role. Therefore, I only performed a comparison of means again. It should also be noted that the weights of the variables for Participation and Profile factors are multiplied by -1 since the variables originally denote negative views. With the help of this minor modification a higher average denotes higher Participation and Profile values in the following figures.

Table 25. Count of Employees in Role groups - Open Survey

Role	Abbreviation	No. of Employees
Operations	OP	1
Project Management	PM	8
Quality Assurance	QA	5
Systems Engineering	SE	3
Software Engineering	SW	33
Systems/ Software Test	TE	8

Role. Count of employees in each role group is given in **Table 25** and the mean values for the factors based on the employee roles are presented in **Fig. 11**. There is no evident pattern with respect to goals like the patterns observed for previous target organizations. This is not surprising considering that the role definitions change greatly from organization to organization and characteristics of people with a certain role also change. An observation that aligns with other target organizations is the overall support of quality assurance practitioners regarding process improvement and participation issues.

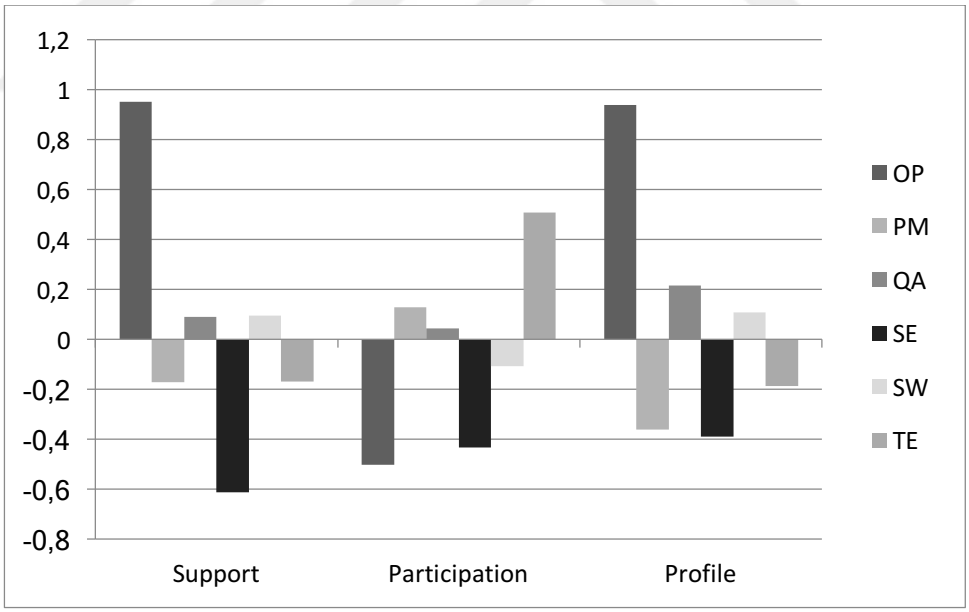

Fig. 11. Factor Mean Values Based on Role – Open Survey

Education. The undergraduate specializations of the employees who have participated in the survey are summarized in **Table 26** and the mean values for the factors based on the employee education are presented in **Fig. 12**. Unfortunately, the number participants who have given the undergraduate degree information is not high and nearly all of them are computer engineers. It should also be noted that the mean values for computer engineers are very close to 0 for all factors. Therefore, it is not possible to reliably analyze that data.

Table 26. Educational Background of Employees – Open Survey

Undergraduate Degree	Abbreviation	No. of Employees
Business Administration	BA	1
Computer Engineering, Software Engineering, Computer Technology & Information Systems	CENG	33
Electrical-Electronics Engineering	EE	3
Industrial Engineering	IE	1
International Relations	IR	1
Statistics	STAT	1

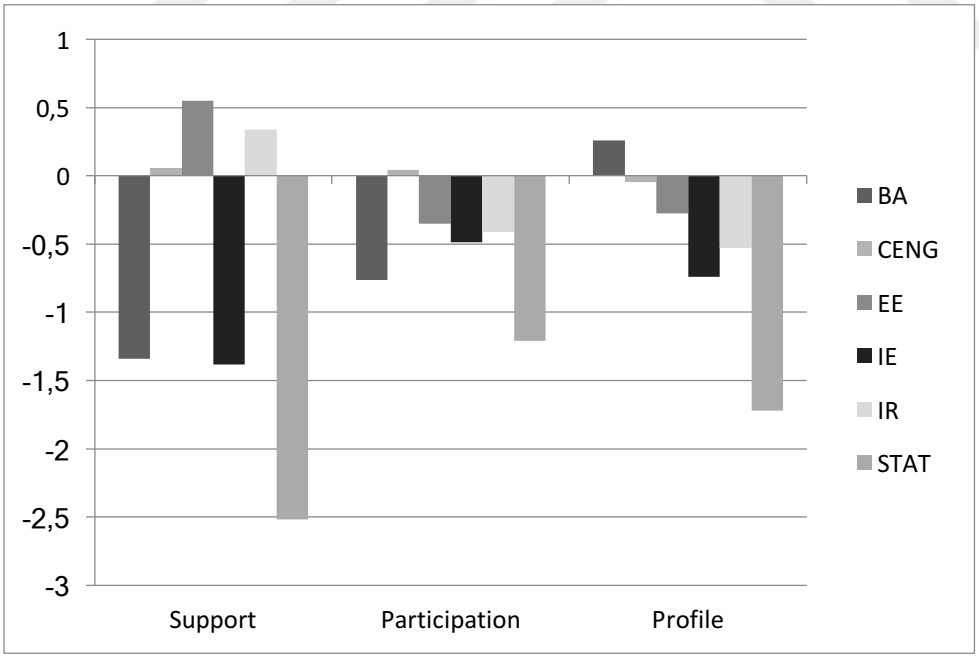

Fig. 12. Factor Mean Values Based on Education – Open Survey

4.3.2. Summary of the Findings

The factor analysis for the open survey resulted in three reliable factors; maturity models are beneficial and all should participate (*Support* factor), participation based on only on role and seniority (*Participation* factor) and the independence of participation ratios to the education, role or experience (*Profile* factor).

In the first phase, I had observed that the submission counts of the employees and therefore their commitment to process improvement increases with the experience of the employee. The analysis of the determined factors produced interesting findings since the support of an employee for SPI was found to be related to his/her previous experience but not the time spent working for the target organization. It may be concluded that people who have experienced the inner workings of different companies have a tendency for supporting process improvement.

The supporting view of an employee regarding process improvement is directly affected by his or her experience according to my analysis. However, an interesting finding is that the experience in a maturity level certified organization negatively affects the support attitude while experience in a not certified organization has a positive effect. This might be due to the employee experiencing the negative aspects of a non-certified organization and a desire to correct or improve them.

Like other organizations, the relationships regarding the employee's role and education could not be analyzed exhaustively due to the uneven distribution of answers from the open survey. An observation that aligns with other target organizations is the overall support of quality assurance engineers regarding process improvement and participation issues.

Unfortunately, the number participants who have given the undergraduate degree information is not high and nearly all of them are computer engineers. It should also be noted that the mean values for computer engineers are very close to 0 for all factors. Therefore, it is not possible to reliably analyze that data.

4.4. DefSys Case Study

4.4.1. Analysis of Process Improvement Suggestions

The analysis of the improvement suggestion database of DefSys was conducted in the same manner with the previous target organizations.

4.4.1.1. Submitter Characteristics

The submitters are analyzed according to their roles and experience. The role groups and experience categories used for DefSys are given in the following tables. It should be noted that 3 entries in the database have erroneous submitter information and therefore omitted from submitter related tables.

Table 27. Role Groups for DefSys

Code	Roles
SW	Software Engineers
QA	Quality Assurance Engineers
TE	Software Test Engineers

Table 28. Seniority Categorization for DefSys

S1	S2	S3	S4	S5
0 - 5	5 - 8	8 - 12	12 - 15	15 +

Table 29. Submission Count per Employee – DefSys

	S1		S2		S3		S4		S5		Total	
SW	1 14	**0.07**	6 11	**0.55**	0 22	**0**	47 12	**3.92**	28 6	**4.66**	82 65	**1.26**
QA					7 2	**3.5**	0 2	**0**	22 2	**11**	29 6	**4.83**
TE	0 17	**0**	0 23	**0**	0 8	**0**	6 16	**0.38**			6 64	**0.09**
Total	1 31	**0.03**	6 34	**0.18**	7 32	**0.22**	53 30	**1.77**	50 8	**6.25**	117 135	**0.87**

Number of database entries
Number of employees
No employee
Suggestion number per employee

Similar to other target organizations the increase in submission counts with increasing seniority level is evident for DefSys. 88% of all submission come from S4 and S5 groups. A look at the roles reveals that quality assurance group is leading the process improvement submissions. An interesting finding is the low amount of submissions coming from the test group. Their average submission rate is nearly one tenth of the company average and about 53 times lower than the quality assurance group. It can be said that the test engineers group do not participate in process improvement activities at all.

Table 30. Employee Participation – DefSys

	S1		S2		S3		S4		S5		Total	
SW	1	**7%**	0	**0%**	2	**9%**	8	**67%**	3	**50%**	14	**22%**
	14		11		22		12		6		65	
QA					2	**100%**	2	**100%**	2	**100%**	6	**100%**
					2		2		2		6	
TE	0	**0%**	0	**0%**	0	**0%**	3	**16%**			3	**5%**
	17		23		8		16				64	
Total	1	**3%**	0	**0%**	4	**13%**	13	**43%**	5	**63%**	23	**17%**
	31		34		32		30		8		135	

Number of employees who have entries
Total number of employees
No employee
Employee participation ratio

Although there are irregularities it is seen that participation is increased with increased experience. From the role viewpoint, the dominance of quality assurance group is evident with 100% participation level. The test group lags behind the other two groups like the submission ratios. The software engineers group has a higher-than-company average due to the test groups effect on the average. Still the participation ratio of software engineers is only 22%. It should be noted that the discrepancies observed between **Table 29** and **Table 30** are due to the processed data being supplied by DefSys while performing this study and it has not been possible to pinpoint the reason of these discrepancies and correct them since raw data was not supplied.

4.4.1.2. Timing Characteristics

The distribution of suggestions from DefSys over time is given in **Fig. 13**. The 120 suggestions span a time from January 2015 to May 2017.

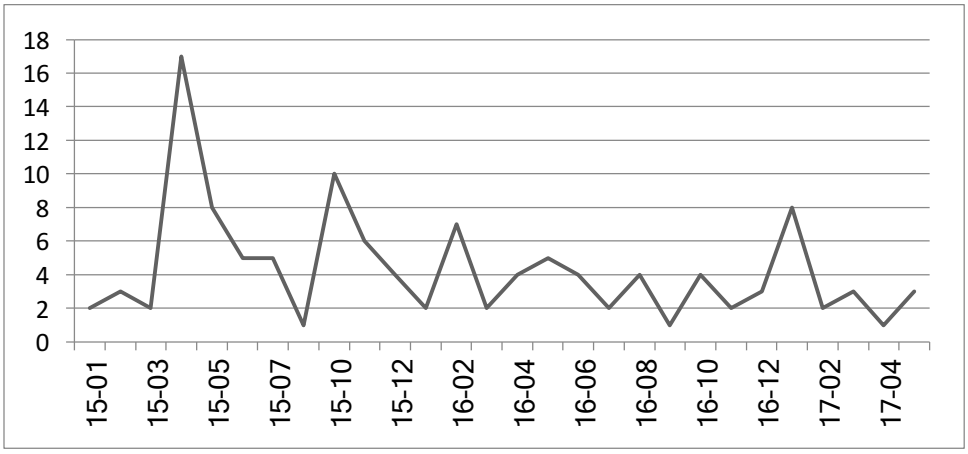

Fig. 13. Number of improvement suggestion submissions per month – DefSys

The jagged character of submission dates figure is also observed for DefSys like the previous examples. Peak values are observed in 2015 when the company underwent CMMI appraisals. Unfortunately, the data supplied for this research does not cover the previous appraisal period in 2012 so we cannot see whether this behavior is recurring at each appraisal. Nevertheless, it is observed that the process improvement suggestions are not submitted in a continuous manner with some months even having no suggestions at all.

4.4.1.3. Content Characteristics

The improvement suggestion database of DefSys contains only one mandatory field named *Process Area* for categorizing entries. However, there is no direct relation of that field with the CMMI process areas. The distribution of all entries to the internal *Process Areas* for DefSys is given in **Fig. 14**.

The distribution of suggestions to categories is not balanced even for the internally defined classification schema for DefSys. The highest number of suggestions is related to Process Improvement – General. Considering that this value is used as an all-encompassing option, I compared the next highest one namely Process Improvement – Test to lowest one which is Process Improvement – Documentation and the difference is more than fivefold.

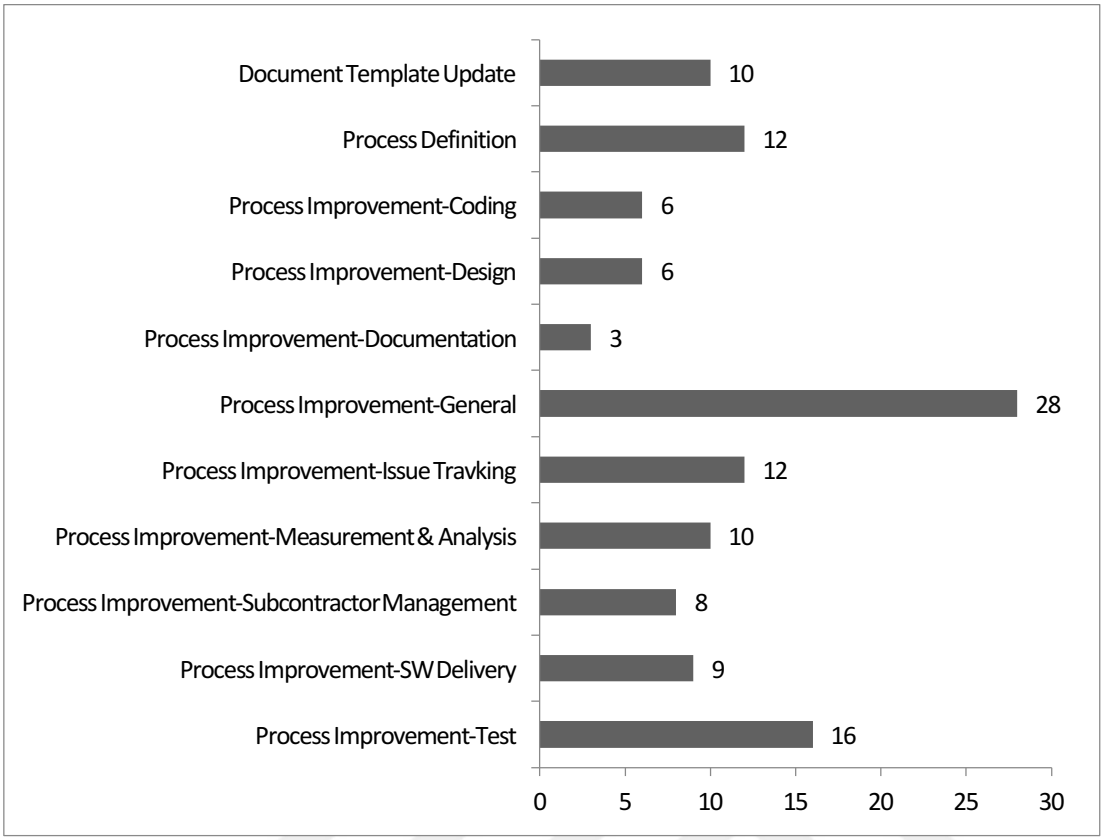

Fig. 14. Number of improvement suggestion submissions per company process category – DefSys

4.4.2. Analysis of the Survey

Participants from DefSys submitted 39 complete forms during the survey. Unfortunately, the number of participants was too low compared to our total number of questions and the Kaiser–Meyer–Olkin measure failed to verify the sampling adequacy for the analysis, KMO = .372. Since it was not possible to increase the number of participants the number of questions (i.e. variables) subject to factor analysis had to be reduced. Therefore, only the personal type questions which are similar to the question set from the early version of the questionnaire were employed.

The factor analysis of the personal questions for DefSys yielded 3 logically coherent factors. The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis, KMO = .693 and Bartlett's test of sphericity χ^2 (55) = 183.803, $p < .001$, indicated that correlations between items were sufficiently large. It was decided that three components explaining 64.72% of the variance might yield a meaningful grouping based on the analysis of the results by choosing different component numbers. The analysis with three components is presented in **Table 31**. It should be noted that oblique rotation has been applied to the results and weights less than 0.4 are not shown.

The first component is deemed to indicate the *support* attitude. Employees with this attitude believe that the effort put into SPI is justified, SPI is required and should be continuous. They also believe people should not limit process improvement activities to their spare time and training has a positive effect on process improvement.

The second component indicates an attitude for keeping participation in SPI activities at minimum. Therefore, this attitude is named *participation* and the employees with this attitude believe that a small team formed according to the seniority of employees should be responsible for SPI activities and everybody should not participate.

The third component is not named since it is found not to be reliable as presented below.

Table 31. Components Obtained by the Factor Analysis - DefSys

	Components		
	Support	**Participation**	**N/A**
SPIRequired	.904		
SPIContinuous	.785		
AllParticipate		-.874	
SmallTeam		.878	
SeniorityBased		.623	
ParticipateSpareTime	-.856		
NotJustified	-.897		
TrainingEffect	.711		
HeavyWorkload			.688
SPIKnowledge			.705

4.4.2.1. Reliability Analysis

The findings of the reliability analysis performed by calculating Cronbach's Alpha for each factor are presented at **Table 32**. The questions with negative weight are reversed for the purpose of the reliability analysis.

Table 32. Reliability Analysis Results - DefSys

Components	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
Support	.876	.878	5
Participation	.764	.764	3
N/A	.175	.175	2

It is seen that Cronbach’s α is satisfactorily high for support and participation factors, and the deletion of none of the items increases Cronbach’s α. Therefore, these factors are deemed to be reliable.

However, Cronbach’s α is very low for the last factor. Variables cannot be deleted since there are only two of them. This factor will not be employed for the rest of the analysis for DefSys due to the low reliability.

4.4.2.2. Multiple Regression Analysis

The findings of the multiple regression analysis performed in order to determine the relationship between the factors and the experience of the employees obtained in three categories represented by the TargetExp, MaturityExp and NonMaturityExp variables is presented below.

Support. The results obtained through backward elimination method shows that the experience in other DefSys and previous experience in a non-maturity certified organization does not have a significant effect (sig. = .756 for TargetExp and sig. = .767 for NonMaturityExp) on the support factor. Only the experience in a maturity certified organization has a significant (sig. = .001) effect. This experience explains 49% of the variance in the support attitude. An interesting finding is that the experience in a maturity level certified organization negatively affects the support attitude.

Participation. The employee's view on the formation of teams responsible for process improvement is not related to his/her experience. The regression model eliminated all the experience types without reaching a significant model during the analysis.

4.4.2.3. Comparison of Means

Similar to previous target organizations, the survey data collected for DefSys was uneven with respect to the role and education variables. For example, there were only 2 employees with PM role while there were 27 employees with SW role. Therefore, I only performed a comparison of means again. It should also be noted that the weights of the variables for Participation factor are multiplied by -1 since the variables originally denote a negative view of Participation. With the help of this minor modification a higher average denotes higher participation value in the following figures.

Table 33. Count of Employees in Role groups - DefSys

Role	Abbreviation	No. of Employees
Software Engineers	SW	27
Quality Assurance	QA	4
Systems Engineers	SE	3
Software/System Test Engineers	TE	3
Project Managers	PM	2

Role. Count of employees in each role group is given in **Table 33** and the mean values for the factors based on the employee roles are presented in **Fig. 15**. The members of the quality assurance and project management groups are strong proponents of SPI activities, while software engineers slightly oppose SPI. Again, quality assurance and project management groups strongly believe in the participation. It is interesting that the quality assurance and project management groups have always have the same view and that view opposite to those of software engineers'.

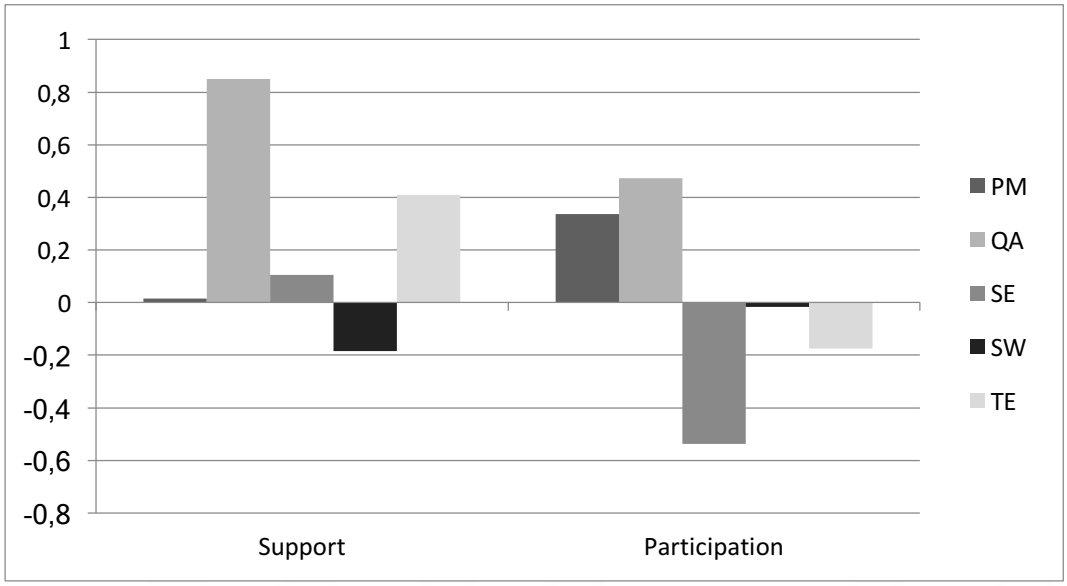

Fig. 15. Factor Mean Values Based on Role – DefSys

Education. The undergraduate specializations of the employees who have participated in the survey are summarized in **Table 34** and the mean values for the factors based on the employee education are presented in **Fig. 16**. Similar to the previous results, the two largest groups – computer engineers and electronics engineers – have opposite attitudes regarding. It is also interesting that computer engineers are not proponents of SPI activities.

Table 34. Educational Background of Employees - DefSys

Undergraduate Degree	Abbreviation	No. of Employees
Computer Engineering	CENG	19
Electrical-Electronics Engineering	EEE	12
Mechanical Engineering	ME	3
Others	Other	5

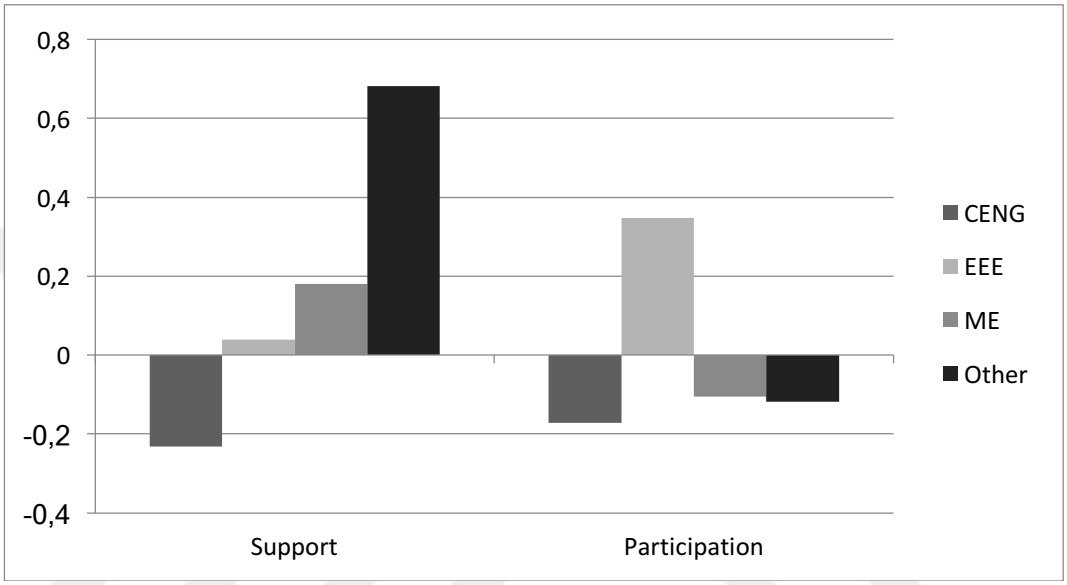

Fig. 16. Factor Mean Values Based on Education – DefSys

4.4.3. Analysis of the Interviews

There were 9 conversational partners from DefSys that participated in this study. Each interview took about half an hour and the main questions given in **Table 6** were used. The list of participants and brief introductions about them are given in **Table 35**.

Table 35. Conversational Partners from DefSys

Pseudonym	Description
Henry	A mechanical engineer with more than 30 years' experience. Mainly worked in quality assurance during his career and is the head of DefSys quality assurance at the moment.
Anthony	An electronics engineer by education but has been working as a software developer since his graduation in 2005.
Carol	A junior software engineer of nearly two years' experience. Graduated from computer engineering.
Earl	A computer engineer who has been working as a software team leader at DefSys for the past 2 years. He has a work experience of more than 10 years before that.
Sydney	Another software team leader who has been working at DefSys for more than 10 years. He is an electronics engineer by education.
Eric	A computer engineer of nearly 20 years' experience. He is working as a manager in software department of DefSys.
Nelly	An electronics engineer by education but has been working at DefSys first as a software engineer then as a software test engineer.
Steven	A senior software engineer of more than 10 years' experience who is currently leading software process improvement activities at DefSys.
Elizabeth	An experienced industrial engineer who has been working as a quality assurance engineer at DefSys.

The majority of the interviewees think that the process improvement activities are performed continuously at DefSys. Only Henry thinks that there is some variation with respect to continuity. This is an interesting finding since it contradicts with the findings from the analysis of improvement suggestions. Although there is a consensus on the continuity among employees, everybody is not sure about the effect of the maturity model used (CMMI) on the continuity. Nearly half of the interviewees believe that CMMI does not affect continuity at all with the other half believing that it has a positive effect.

Regarding participation, all of the interviewees have realized that the participation ratio of employees is low with the exception of quality assurance engineers. Henry, Anthony, Steven and Elizabeth all mention that the high participation of quality assurance engineers is natural due to their audit duties within the company. They have also observed that participation increases with the experience of the employee. For example, Carol says;

> *Usually the same people participate [in process improvement activities], Experienced people, senior [engineers], team leaders, managers always participate and give more suggestions.*

These views align with the previous findings. However, an interesting point that I have not foreseen is that most of the interviewees add a new dimension to the employee profile; personality. The personality traits affecting participation range from "loving this job [of process improvement]" to "people who want to change the system" according to the interviewees.

Interestingly, three interviewees mention software engineers together with quality assurance engineers when talking about highly participating groups. This totally contradicts the findings from the first phase. Furthermore, Henry told "I expect test engineers to participate more than the other but I did not observe the actual situation" which is of note considering that the test engineers are least participating group according to phase one findings.

A recurring thought among interviewees regarding participation is the workload from projects limiting the participation. Sydney says;

> *Because of heavy workload, improving processes is a luxury.*

Elizabeth has observed that;

> *The employees perceive [process improvement] as an extra duty.*

Another dimension of the improvement suggestions that is in focus of this study is the distribution of suggestions over the different processes. The interviewees put forward two views regarding that subject. Half of them believe that all processes are improved equally, while the other thinks that software related processes lead the improvement efforts. The first view again contradicts with the findings from phase one but it is not possible to compare the second view with the previous findings since the process categorization supplied by DefSys does not have a clear distinction between "software processes" and other processes. At this point it should be reminded that most of the suggestions were categorized as "Process Improvement - General" and the breakdown of these suggestions is not available.

Regarding education, most of the interviewees correctly identified the contribution of computer engineers when compared to electrical and electronics engineers. Although being an electronics engineer himself, Sydney told that

> *Newly graduated electrical and electronics engineer do not submit suggestions but computer engineers do with their vision.*

While Steven approached the subject from a different perspective and said

> *Undergraduate department is not important. The ones who have taken elective courses on software engineering contribute more.*

The interviews have differing views for increasing the process improvement continuity and participation. A point mentioned by half of the interviewees is the importance of process improvement related training. Henry suggests increasing frequency of CMMI appraisals to every year instead of every three years. Anthony, Earl, Eric, and Elizabeth all think that the employees should see the actual benefits of process improvement activities. Earl says;

> *The employees should see that their [process improvement] suggestions are put to use.*

Combining these views, the thought may be summarized as that the improvement suggestions should be put to use and the actual beneficial results of this use should be visible all employees.

Another prevalent suggestion is to establish extrinsic motivation factors such as rewards for participation to process improvement. Eric and Steven build on the reward idea and suggest using gamification based approaches such as a ranking system.

Some other suggestions put forward by interviewees are the usage of [process management] tools by Henry and Eric and the rotation of process related posts among employees to increase awareness by Elizabeth.

The summary of views of all conversational partners is presented in **Table 36**. Key views are listed together with whether each interviewee agrees with that view.

Table 36. Summary of Views from DefSys

Views	**Henry**	**Anthony**	**Carol**	**Earl**	**Sydney**	**Eric**	**Nelly**	**Steven**	**Elizabeth**
Process improvement is continuous.	D	N/A	A	N/A	A	A	A	N	A
All process areas are covered uniformly.	A	N/A	A	A	D	N/A	A	D	D
Participation is affected by role.	A	N/A	A	A	A	D	D	A	A
Participation is affected by education.	N/A	N/A	A	D	A	A	D	N	D
Participation is affected by experience.	N	A	A	A	A	A	A	A	A
Continuity is affected by the employment of a maturity model.	A	N	A	D	A	N/A	N/A	A	A
Participation is affected by the employment of a maturity model.	A	A	N/A	N/A	N/A	A	A	D	A
Employment of a maturity model has a positive effect on employee satisfaction.	N/A	N	A	N	D	N	A	N/A	A
Employment of a maturity model has a positive effect on innovation.	A	N	A	D	A	A	A	A	N/A

*A: Agree, D: Disagree, N: Neutral, N/A: No information given

4.4.4. Summary of the Findings

Similar to other target organizations the participation ratio of different role groups to process improvement is quite different. Again, the discrepancies between the ratios of different groups may be explained by the fact that the quality engineers are usually employed at maturity level assessment activities within the companies thus gaining a higher level of understating of the processes within the companies. Furthermore, their duties usually include ensuring that the activities within the company are performed in accordance with the defined processes. These two factors might form the basis for their high level of contribution to process improvement activities. This possible explanation also came up in validation interviews thus strengthening its validity.

The lowest contributing group in DefSys are the test engineers. Their participation is way lower than other groups. The software developers and engineers again have a higher contribution to process improvement, although not being close to that of quality assurance engineers'. Therefore, the finding of a *process-wise oligarchy* rather than a *process-wise democracy* also holds true for DefSys and organization-wide process improvement commitment is not enabled by using maturity models.

Another somewhat expected finding is that the more experienced employees contribute and participate more in software process improvement activities. Although having some minor variations, this finding is in line with both the previous targets and the views of interviewees.

It was observed that process improvement suggestions are concentrated before the maturity level assessment period. This results in approximately half of the database entries being submitted in only 6 months over 2.5 years. Therefore, it is not possible to state that the staged model based approach results in continuous process improvement for DefSys. However, all of the interviewees think the opposite. It is interesting that a wide range of company employees fail to grasp the real characteristics of the organizational process improvement activities. It can be said that there is an *illusion of continuity* among the DefSys employees.

Similar to previous targets, the content-wise analysis findings reveal that the staged maturity models have failed to result in a balanced distribution of process improvement activities over the range of process categorizations. The very high difference across different categorizations shows that improvement across the range of processes cannot be obtained.

For DefSys the factor analysis produced two factors. The factor analysis outcomes are the support of an employee for SPI activities (*Support* factor), and the reluctance of an employee to participate in SPI teams (*Participation* factor).

In the first phase, I had observed that the submission counts of the employees and seen that their commitment to process improvement increases with the experience of the

employee. The analysis of the proponent factor revealed that employee's experience in a maturity certified previous organizations negatively affects the support of SPI. This contradicts our previous findings for other target organizations and the view of the interviewees. It was also seen that the view of an employee regarding to whom the responsibility of process improvement falls is not affected by experience at all.

Again, the relationships regarding the employee's role and education could not be analyzed exhaustively due to the uneven distribution of answers from the conducted survey. The first phase of this study has shown that quality assurance engineers have much higher contribution to process improvement suggestions than other groups. The second has verified these results by showing that the quality assurance engineers are proponents of software process improvement activities within the organization. It should also be noted that nearly for all the factors the quality assurance engineers have opposite attitudes to the software engineers but same attitudes with project managers. It is interesting that the test engineers are proponents but they have the lowest contribution. One interviewee even mentioned the test engineers as a possible strong contributor. The reason behind their low contribution might be the subject of a future study since it contradicts other findings.

Similar to previous targets, it was observed that computer engineering and electrical-electronics engineering graduates, which are the largest groups, have opposite approaches to the determined factors which is a finding supported by the interviewees.

The interviewees mentioned the idea that personality traits are important in understating the participation variations. A future work may focus on that idea and try to elaborate on that.

4.5. CommCorp Case Study

4.5.1. Analysis of Process Improvement Suggestions

The analysis of the improvement suggestion database of CommCorp was conducted in the same manner with the previous target organizations.

4.5.1.1. Submitter Characteristics

The submitters are analyzed according to their roles and experience. The role groups and experience categories used for CommCorp are given in the following tables.

Table 37. Role Groups for CommCorp

Code	Roles
QA	Quality Assurance and Configuration Engineers, Process Specialists
SE	Systems Engineers
PM	Project Management Engineers and Specialists, Contract and Documentation Specialists
DE	Design Engineers, Test and Integration Engineers, Software Developers, Production Engineers

Table 38. Seniority Categorization for CommCorp

S1	S2	S3	S4
0 - 5	5 - 10	10 - 15	15 +

Table 39. Submission Count per Employee – CommCorp

	S1		S2		S3		S4		Total	
QA	2	**0.5**	1	**0.3**	17	**2.8**	12	**3**	32	**1.8**
	4		3		6		4		17	
SE	0	**0**	3	**0.02**	8	**0.7**	8	**0.12**	19	**0.09**
	16		111		11		64		202	
PM	0	**0**	2	**0.15**	14	**0.48**	9	**1.8**	25	**0.3**
	26		13		29		5		73	
DE	2	**0.05**	4	**0.18**	13	**0.3**	22	**0.18**	41	**0.18**
	36		22		40		119		217	
Total	4	**0.04**	10	**0.06**	52	**0.6**	51	**0.26**	117	**0.22**
	82		149		86		192		509	

Number of database entries
Number of employees
Suggestion number per employee

Similar to other targets the quality assurance group leads the process improvement suggestion numbers. Their contribution is more than eight times the company average. The only other group which has a higher-than-average is the project managers. The systems and design engineers have the lowest average contribution to the suggestion database although having the highest number of members.

Table 40. Employee Participation – CommCorp

	S1		S2		S3		S4		Total	
QA	1	**25%**	1	**33%**	6	**100%**	4	**100%**	12	**70%**
	4		3		6		4		17	
SE	0	**0%**	1	**1%**	5	**45%**	4	**6%**	10	**0.5%**
	16		111		11		64		202	
PM	0	**0%**	2	**15%**	6	**20%**	5	**100%**	13	**18%**
	26		13		29		5		73	
DE	2	**0.5%**	2	**0.9%**	5	**12%**	10	**0.8%**	19	**0.9%**
	36		22		40		119		217	
Total	3	**0.3%**	6	**0.4%**	22	**25%**	23	**12%**	54	**10%**
	82		149		86		192		509	

Number of employees who have entries
Total number of employees
Employee participation ratio

It was observed that the participation ratios for CommCorp align with the submission count findings. Quality assurance and project management personnel have high participation ratios while the engineers have less-than-average participation in process improvement activities. In fact, the discrepancy for CommCorp is much higher than AvioTech and TeleSoft with the quality assurance group's participation ratio being 140 times the participation of systems engineers.

4.5.1.2. Timing Characteristics

The representation for the improvement database of CommCorp, which contains 117 entries submitted over a time span from January 2012 to March 2017, is given in **Fig. 17**.

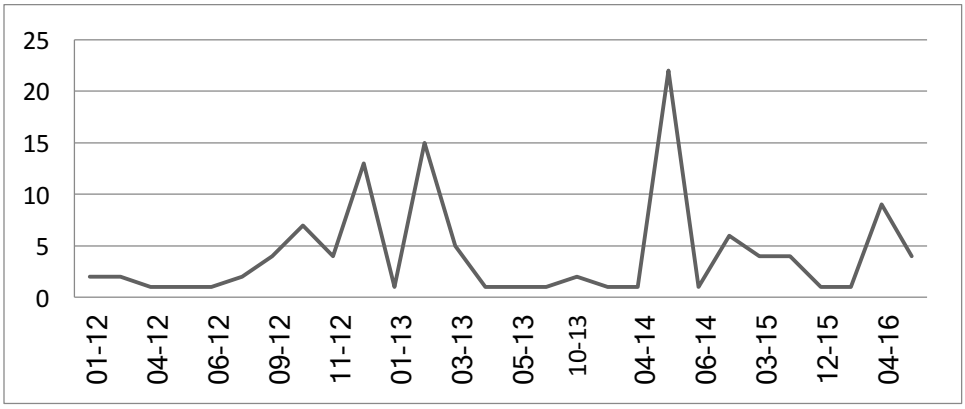

Fig. 17. Number of improvement suggestion submissions per month – CommCorp

The analysis of submission dates of the entries in the process improvement database of CommCorp clearly shows irregularities like previous targets. The first peak value is observed on December 2012, as a result of CMMI appraisal preparations that were conducted with internal gap analyses and audits. The second peak value reached on February 2013 results from the fact that SCAMPI Class B appraisal which is conducted for preparation for SCAMPI Class A appraisal in June 2013. The submission rates decrease significantly after the appraisal is completed successfully. A highest monthly submission rate is observed in May 2014, when yearly internal audits were conducted within the company. In year 2015, internal audits were skipped activities were performed to fulfill the gaps detected in the 2014. Another peak is observed in April 2016 when the company underwent SCAMPI Class B appraisal in preparation of the next formal CMMI appraisal in June 2016.

4.5.1.3. Content Characteristics

The improvement suggestion database of CommCorp includes a mandatory *Process* field that can have values which are directly mapped to CMMI v1.2 process areas. The distribution of all entries to the mapped CMMI process areas is given in **Fig. 18**.

Among the 22 process areas for CMMI, 7 of them have no entry including process areas which are mandatory for a level 3 company. The highest number of suggestions is for the Technical Solution (TS) process area with 34 entries while the lowest is for the Organizational Innovation and Deployment (OID) with only a single entry.

A point of note regarding the high number of entries for the TS process area is the fact that the processes related with technical solution (design and development) before the organization aspired to obtain a CMMI appraisal. Therefore, these process definitions were created from scratch for the sake of CMMI appraisals.

Combining the content-wise analysis findings from all target organizations reveals that the staged maturity models have failed to result in a balanced distribution of process improvement activities over the range of process categorizations. Although the staged maturity models do not set a goal for a balanced distribution, the very high difference across different categorizations shows that improvement across the range of processes cannot be obtained.

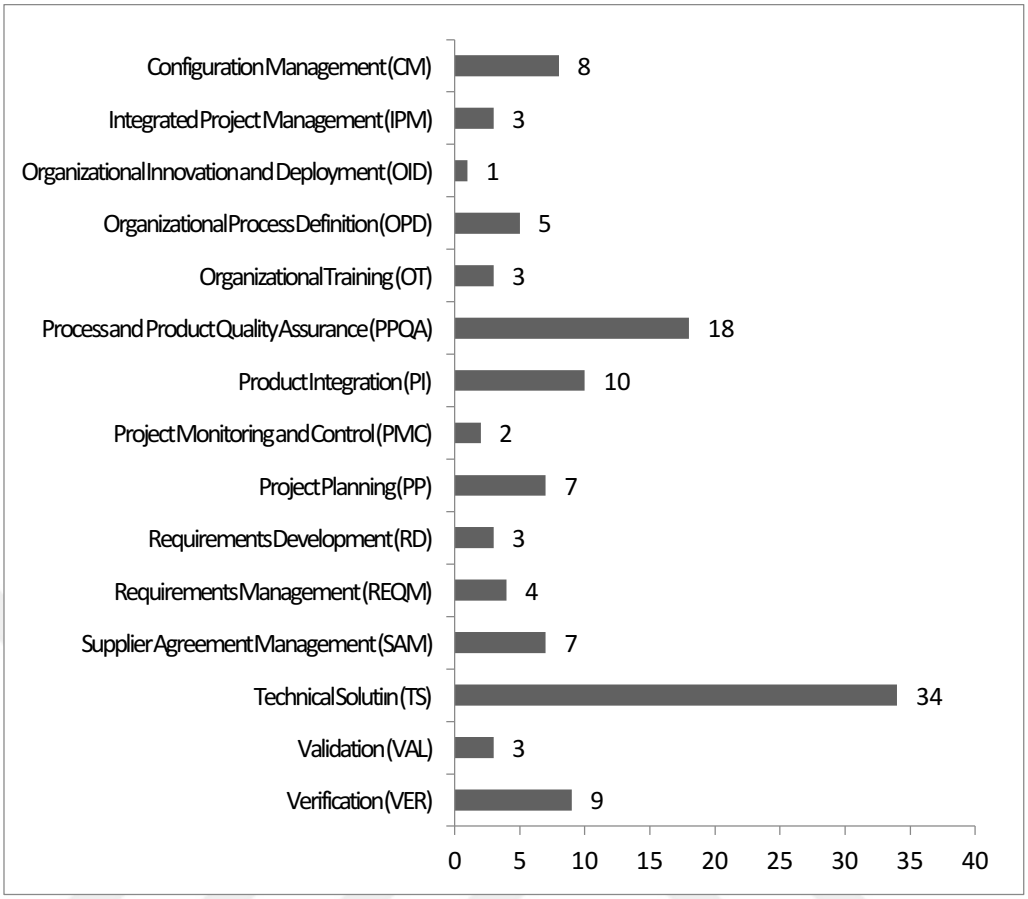

Fig. 18. Number of improvement suggestion submissions per company process category – CommCorp

4.5.2. Analysis of the Survey

Participants from CommCorp submitted 27 complete forms during the survey. Similar to DefSys, the number of participants was too low and the Kaiser–Meyer–Olkin measure failed to verify the sampling adequacy for the analysis, KMO = .356. Therefore, only the personal type questions were employed again.

The factor analysis of the personal questions for CommCorp yielded 3 logically coherent factors. The Kaiser–Meyer–Olkin measure verified the sampling adequacy for the analysis, KMO = .589 and Bartlett's test of sphericity χ^2 (55) = 136.542, $p < .001$, indicated that correlations between items were sufficiently large. It was decided that three components explaining 68.92% of the variance might yield a meaningful grouping based on the analysis of the results by choosing different component numbers. The analysis with three components is presented in **Table 41**. It should be noted that oblique rotation has been applied to the results and weights less than 0.4 are not shown.

The first component is deemed to indicate the *knowledge* attitude. Employees with this attitude believe that they don't have adequate knowledge about SPI and training has a positive effect on process improvement. They also believe that the effort put into SPI is justified, SPI is required and all should participate irrespective of their workloads.

The second component indicates an attitude for keeping participation in SPI activities at minimum. Therefore, this attitude is named *participation* and the employees with this attitude believe that a small team formed according to roles of employees should be responsible for SPI activities. They believe that the people should only work towards process improvement if they have spare time from other activities and they have no time for process improvement due their heavy workload. The interesting thing is that they also believe that SPI should be continuous. The view may be summarized as process improvement shall be performed continuously but by other people not themselves.

The third component is deemed to indicate the *support* to process improvement. Employees with this attitude do not believe in the need to improve the processes continuously and they think that the effort put into that activity is not justified. Therefore, employees should only participate if they have spare time and based on their seniority in the organization.

Table 41. Components Obtained by the Factor Analysis - CommCorp

	Components		
	Knowledge	**Participation**	**Support**
AllParticipate	.904		
TrainingEffect	.839		
SPIKnowledge	-.720		
RoleBased		.803	
SmallTeam		.637	
HeavyWorkload		.549	
SeniorityBased			.923
SPIContinuous		.514	-.703
ParticipateSpareTime		.439	.600
NotJustified	-.539		.570
SPIRequired	.517		-.541

4.5.2.1. Reliability Analysis

The findings of the reliability analysis performed by calculating Cronbach's Alpha for each factor are presented at **Table 42**. The questions with negative weight are reversed for the purpose of the reliability analysis.

Table 42. Reliability Analysis Results - CommCorp

Components	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
Knowledge	.844	.858	5
Participation	.556	.533	5
Support	.808	.817	5

It is seen that Cronbach's α is satisfactorily high for knowledge and support factors, and the deletion of none of the items increases Cronbach's α. Therefore, these factors are deemed to be reliable.

Unfortunately, Cronbach's α is not high for participation factor. The deletion of ParticipateSpareTime increases the reliability, albeit by a small amount (Cronbach's α after deletion is 0.597).

4.5.2.2. Multiple Regression Analysis

The findings of the multiple regression analysis performed in order to determine the relationship between the factors and the experience of the employees obtained in three categories represented by the TargetExp, MaturityExp and NonMaturityExp variables is presented below.

Knowledge. The employee's view regarding knowledge is not related to his/her experience. The regression model eliminated all the experience types without reaching a significant model during the analysis.

Participation. The analysis resulted in both the MaturityExp and NonMaturityExp being eliminated due to insignificance. Only the experience in target organization significantly (sig. = .005) affects the participation attitude, explaining 52% of the variance. However, it is interesting that with increasing experience in CommCorp the participation attitude decreases.

Support. Similar to knowledge factor the employee's view regarding the support of process improvement is not related to his/her experience. The regression model eliminated all the experience types without reaching a significant model during the analysis.

4.5.2.3. Comparison of Means

Similar to all target organizations, the survey data collected for CommCorp was uneven with respect to the role and education variables. For example, there were only 3 employees with QA role while there were 11 employees with PM role. Therefore, I only performed a comparison of means again. It should also be noted that the weights of the variables for all factors are multiplied by -1 since the variables originally denote negative views. With the help of this minor modification a higher average denotes higher factor value in the following figures.

Table 43. Count of Employees in Role groups - CommCorp

Abbreviation	No. of Employees
PM	11
SE	9
DE	4
QA	3

Role. Count of employees in each role group is given in **Table 43** and the mean values for the factors based on the employee roles are presented in **Fig. 19**. It is observed that design engineers and systems engineers form a group having the same attitude for all three factors. Similarly, quality assurance engineers and project managers form another group with the same attitudes. Like the previous target organizations these two groups have opposing views. However, the interesting point is that design engineers and systems engineers have positive attitudes and quality assurance engineers and project managers have negative attitudes for all three factors. This finding is the opposite of all other target organizations.

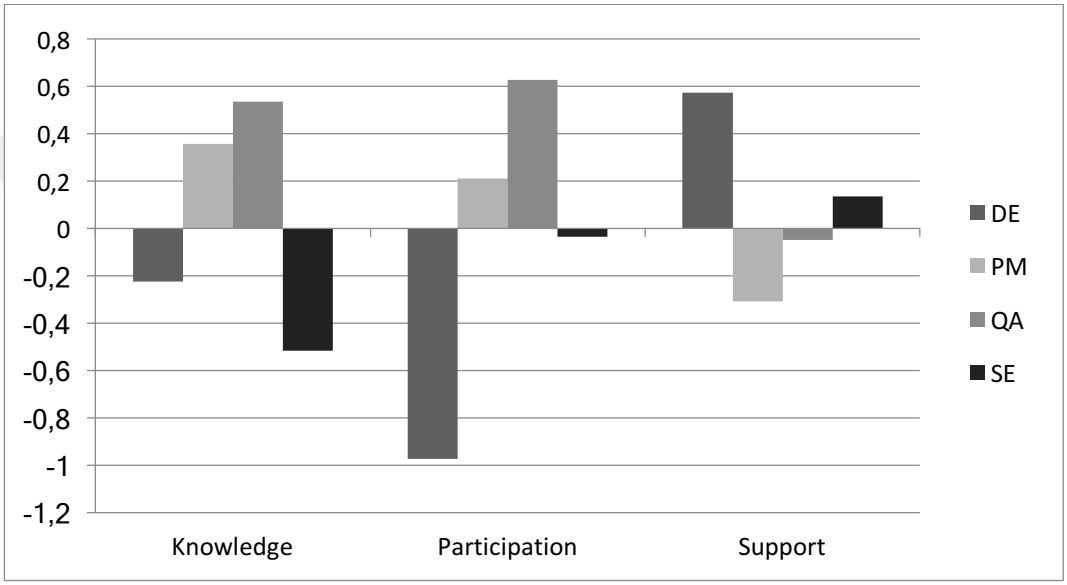

Fig. 19. Factor Mean Values Based on Role – CommCorp

Education. The undergraduate specializations of the employees who have participated in the survey are summarized in **Table 44** and the mean values for the factors based on the employee education are presented in **Fig. 20**. Most of the employees in CommCorp has a degree in electrical and electronics engineering since the company is active in electronics development and manufacturing. Since there are no two large groups as in previous targets it is not possible to make similar comparisons. Nevertheless, the mean values indicate that the electrical and electronics engineers have opposite attitudes to the rest of the organization with the exception mechanical engineers.

Table 44. Educational Background of Employees - CommCorp

Undergraduate Degree	Abbreviation	No. of Employees
Electrical-Electronics Engineering	EEE	19
Mechanical Engineering	ME	1
Others	Other	7

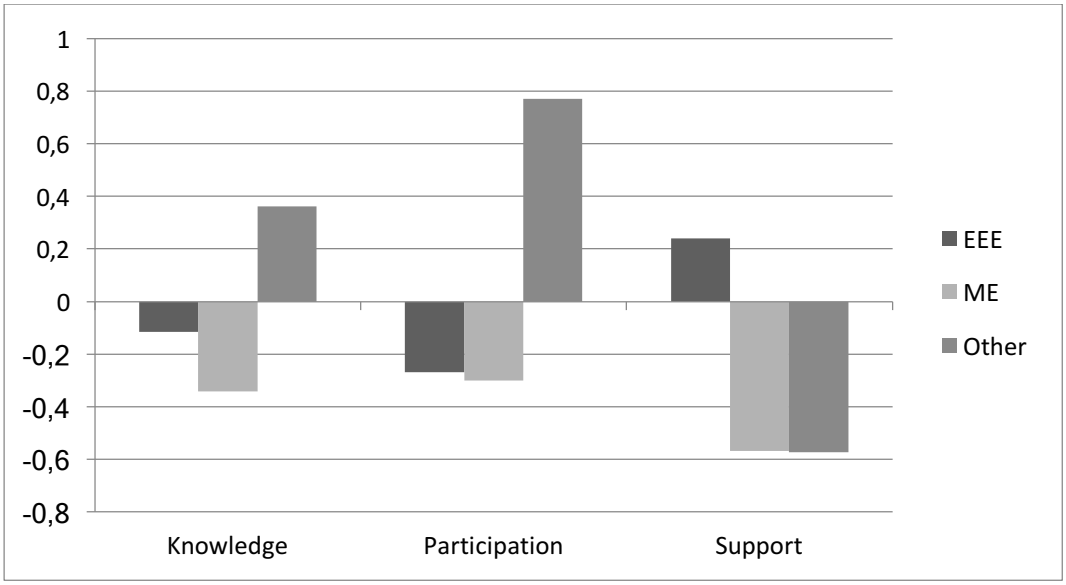

Fig. 20. Factor Mean Values Based on Education – CommCorp

4.5.3. Analysis of the Interviews

There were 3 conversational partners from CommCorp that participated in this study. Each interview took about half an hour and the main questions given in **Table 6** were used. The list of participants and brief introductions about them are given in **Table 45**.

Table 45. Conversational Partners from CommCorp

Pseudonym	Description
Jody	A business administration graduate who has been working as a management consultant at CommCorp for three years.
Barbara	An electronics engineer by education, she has been working as a quality assurance engineer at CommCorp for three years.
Thomas	A senior system engineer who has been worked at CommCorp through most of his career of more than 20 years

The interviewees from CommCorp have different thoughts regarding the continuity of process improvement activities. Jody thinks that processes are improved continuously while Thomas thinks that improvement suggestions are very rare and only submitted by quality assurance engineers. Jody also recognizes the importance of quality department in process improvement but states that there is no difference between other departments. Barbara on the other hand thinks that systems engineers have high contribution. Therefore, it seen that the interviewees all have conflicting views regarding the continuity and role-based participation.

The opposing views of Jody and Thomas is also evident when we look at the effect of the experience. Jody says;

> *The new generation who has not lost its enthusiasm, people working for up to 5 years, and idealist engineers participate more.*

While Thomas believe that experience is important for participating to process improvement.

A common issue that has been raised by both Jody and Thomas is the dissatisfaction of employees when they are assigned to process improvement duties by the management. Thomas complains as;

> *When I was assigned to CMMI team I had important project milestones so I was bothered. If they had asked me beforehand I would not prefer that. After all I am not a quality guy. This is a job that should be done by a certain group. There should be a process improvement responsible role definition.*

Here we again see the complaint regarding workload and the thought that not everybody should work in process improvement activities.

Regarding the distribution of suggestions over the processes Barbara thinks that employees only submit suggestions for “their” processes and processes that are risky

for upcoming appraisals and audits are prioritized. This highlights our previous findings about the relationship process improvement and discrete appraisals.

Again, the views of interviewees regarding training do not align. Jody and Barbara believe that training is important while Thomas thinks that training has no benefit unless it is put to use.

The issue of personal traits affecting participation is also highlighted by the interviewees from CommCorp. Jody thinks that the personal traits of an employee is more important than his or her role or experience.

In order to improve continuity and participation all interviewees mention the importance of awareness. They all believe that the organizational awareness regarding process improvement is low and it should be improved. Thomas has an original idea for increasing awareness, he thinks that all employees and projects of the company shall be subject to appraisal instead of a sample set as is normal done. Furthermore, Jody suggests using a reward system. This is in line with DefSys interviewees who has also suggested such a system.

The summary of views of all conversational partners is presented in **Table 46**. Key views are listed together with whether each interviewee agrees with that view.

Table 46. Summary of Views from CommCorp

Views	**Jody**	**Barbara**	**Thomas**
Process improvement is continuous.	A	N/A	D
All process areas are covered uniformly.	D	D	N/A
Participation is affected by role.	N	A	A
Participation is affected by education.	D	N/A	N/A
Participation is affected by experience.	A	A	A
Continuity is affected by the employment of a maturity model.	N/A	N/A	N/A
Participation is affected by the employment of a maturity model.	A	A	A
Employment of a maturity model has a positive effect on employee satisfaction.	N	D	N/A
Employment of a maturity model has a positive effect on innovation.	N	N/A	N/A

*A: Agree, D: Disagree, N: Neutral, N/A: No information given

4.5.4. Summary of the Findings

Similar to other target organizations the participation ratio of different role groups to process improvement is quite different. Again, the discrepancies between the ratios of different groups may be explained by the fact that the quality engineers are usually employed at maturity level assessment activities within the companies thus gaining a higher level of understating of the processes within the companies. Furthermore, their duties usually include ensuring that the activities within the company are performed in accordance with the defined processes. These two factors might form the basis for their high level of contribution to process improvement activities. The higher contribution of quality assurance engineers also came up in interviews.

The lowest contributing group in CommCorp are the systems and design engineers. Their participation is way lower than the groups of quality assurance engineers and project managers. Therefore, the finding of a *process-wise oligarchy* rather than a *process-wise democracy* also holds true for CommCorp and organization-wide process improvement commitment is not enabled by using maturity models.

Similar to other target organizations more experienced employees participate more in software process improvement activities although having some minor variations. However, the actual contribution measured as the average submission per employee does not increase significantly with increasing experience. The interviewees also have contradicting views on the effect of experience. Therefore, CommCorp differs from other organizations in that respect.

It was observed that process improvement suggestions are concentrated before the maturity level appraisal related activities. This results in approximately half of the database entries being submitted in only 4 months over 4 years. Therefore, it is not possible to state that the staged model based approach results in continuous process improvement for CommCorp. Some of the interviewees think the opposite while some are aware of that situation. It can be said that the *illusion of continuity* is seen for some of the CommCorp employees.

Similar to previous targets, the content-wise analysis findings reveal that the staged maturity models have failed to result in a balanced distribution of process improvement activities over the range of process categorizations. The very high difference across different categorizations shows that improvement across the range of processes cannot be obtained.

For CommCorp the factor analysis produced three factors. The factor analysis outcomes are the knowledge an employee (*Knowledge* factor), the reluctance of an employee to participate in SPI teams (*participation* factor), and the belief that there is no need to improve processes continuously (*Support* factor).

In the first phase, I had observed that the submission counts of the employees and seen that their participation to process improvement increases with the experience of the employee. The analysis of the factors revealed that only the participation factor is affected by the experience. Only the experience in CommCorp affects the nonparticipation attitude. However, it is interesting that with increasing experience in CommCorp the participation attitude decreases. The interviewees also have conflicting views regarding the relationship of experience and process improvement participation.

Again, the relationships regarding the employee's role and education could not be analyzed exhaustively due to the uneven distribution of answers from the conducted survey. The first phase of this study has shown that quality assurance engineers and project managers have much higher participation to process improvement than other groups. The second phase findings failed to correlate with this outcome since the design engineers and systems engineers have positive attitudes and quality assurance engineers and project managers have negative attitudes for all three factors. This finding is the opposite of all other target organizations.

Most of the employees in CommCorp has a degree in electrical and electronics engineering. Since there are no two large groups as in previous targets it is not possible to make similar comparisons.

The analysis findings for CommCorp regarding role, participation and contribution differs from the other target organizations. The underlying reasons behind that may be the subject of a future study.

Furthermore, the idea that personality traits are important in understating the participation variations also come up with CommCorp interviews. This emphasizes the need for a future study that focus on that idea.

CHAPTER 5

CONCLUSION AND DISCUSSION

5.1. Conclusion

Revisiting my goals from the introduction;

- Are software process improvement activities continuous?
- Is there an organization wide commitment to software process improvement activities?
- Do the process improvement activities cover all process areas of software development?
- What is the relationship between the software process improvement contribution and an employee's education, experience and role within the organization?
- Can we develop a systematic approach to identify the above relationships in multiple target organizations?

These aspects of process improvement have not previously studied in detail. Some of these questions are controversial in the sense that they challenge the foundations of staged maturity models. I formed a methodology for a case study involving three phases to answer the research questions.

The aim of the first phase of the methodology was to analyze the relationship between the staged models and the continuity, range, and commitment of software process improvement activities. The overall results show that the adoption of a staged model does not have a direct positive effect on the continuity and the range of process improvement suggestions.

It was observed that the process improvement suggestions are generally submitted in accordance with the maturity level assessment periods. The submission rates increase while the assessment deadlines approach, then decrease rapidly after the assessment is completed; thus, disrupting the continuity of the process improvement activities.

The range of the submissions is further analyzed in two aspects; the range of the submitters and the range of the content. It was observed that the suggestions are not distributed over the range of employees evenly. With some minor exceptions, the quality assurance engineers have much higher participation to process improvement in all target organizations. Therefore, a minority group comprising of mainly quality

assurance engineers submit the majority of process improvement suggestion forming a *process-wise oligarchy*. The content of the suggestions displayed an uneven distribution over a categorization of processes such as the CMMI process areas.

The aim of the second phase was to identify the possible relationships between software process improvement contribution and an employee's education, experience, and role within the organization. While recruiting new employees for a specific role the experience and education are the foremost characteristics that are evaluated. The analysis of the relationship of these characteristics to the process improvement contribution may as well be beneficial in making that evaluation. I have been able to identify different sets of attitudes for different target organizations forging the contribution of an employee.

Although being slightly different the determined factors are mainly related to the employees' support of process improvement and the answer to the question "Who should participate in process improvement activities?". Factors in the knowledge, support and participation dimensions come up in nearly all of the cases. I have observed that the selection of questions used in the survey greatly affect the factors. It is possible that a survey conducted by using different sets of question might result in different factor categorizations. It should also be noted that the factors that cannot be named due to the incoherence of the loaded questions have low reliabilities and therefore not used in the later analyses of the case studies.

In the first phase, I had observed that the submission counts of the employees and therefore their commitment to process improvement increases with the experience of the employee. The analysis of the relationship between the determined factors and the experience of the employees yielded different results for each target organization. Therefore, it's not possible reliably generalize these findings. Nevertheless, these relationships provide a valuable insight to each target separately.

The relationships regarding the employee's role and education with factors could not be analyzed exhaustively for neither of the organizations due to the uneven distribution of participants to the conducted survey. The first phase of our study has shown that configuration managers, quality assurance engineers, and – to a lesser extent – support personnel have much higher contribution to process improvement suggestions than software engineers. In most of the target organizations the distribution of factor scores based on role supported this finding. The role groups that have high participation values also had positive attitudes regarding software process improvement. Therefore, the claim of the existence of a *process-wise oligarchy* within the target organizations still holds. It should also be noted that nearly for all the factors the quality assurance engineers have opposite attitudes to the software engineers.

The analysis regarding educational background faced challenges since the most significant outcomes belonged to groups with small number graduates and distributions were far from being similar. Nevertheless, it is interesting that computer

engineering and electrical-electronics engineering graduates, which are the largest groups in most of the targets, usually have opposite approaches to the determined factors.

After the quantitative analyses were performed I performed qualitative interviews in order to validate the findings. Most of the interviewee opinions aligned with the findings with one interesting exception. Nearly all of the interviewees told me that the process improvement activities were performed continuously in their organization which is not the case as detailed in the findings of previous phases. It can be said that the organizations unintentionally maintain an *illusion of continuity* regarding process improvement. This illusion prevents the employees from taking action to increase continuity and participation.

Another interesting outcome of the interviews was the emphasize put by participants on employee personal traits while explaining continuity or participation issues. This was a dimension not foreseen by me and was not even part of the research questions. After all it became evident that most of the participants think of that as a success factor for process improvement.

The overall results show the problems faced in organizations employing a staged maturity model with respect to the contribution of employees to the process improvement activities. Although it is difficult to generalize the findings from only four companies, the findings constitute an evidence of the shortcomings of staged models as I had observed in my professional and academic career. I believe that this evidence should generate the incentive to more deeply analyze these shortcomings and determine improvement opportunities for staged models.

I have proposed a preliminary set of solutions for these problems but the actual implementation and validation of these solution proposals is a future work.

5.2. Impact of the Study

By discussing the answers to my questions, I presented shortcomings in the software process improvement life of organizations that employ maturity models. Despite some findings may not be surprising to all software researchers and practitioners, the study itself is unique and controversial in documenting the irregularities in continuity and low employee participation regarding software process improvement. Thus, the study may be beneficial in the development of new models or the update of existing models in the long run.

The systematic methodology developed is presented in a well-structured manner throughout the dissertation. The detailed documentation enables other researchers to replicate this study in other target organizations. The information gathered by the replication of the study may be used by decision makers and process improvement project managers for more effective and satisfying process improvement activities in their organizations.

Furthermore, I let the voice of the software practitioners from the studied organizations be heard. These opinions might also be helpful in more effective implementation of process models since these engineers are the main recipients of the processes being improved.

5.3. Solution Proposals

In order to form a sound solution to the presented problems, I explored the causes to the problems of continuity and participation in process improvement activities. I postulate that the underlying cause of the problems we have encountered so far is the lack of three separate but interrelated dimensions as given in **Fig. 21**. These are the lack of *awareness* of the employees regarding the processes of the organization and process improvement in general, lack of *motivation* of the employees to participate in process improvement and the lack of established *model support* for continuous process improvement in the organization (Uskarci & Demirörs, 2015).

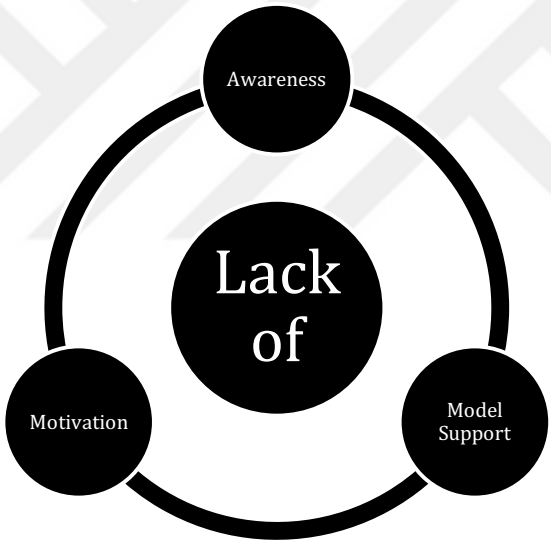

Fig. 21. Root Causes of Documented Problems

5.3.1. Awareness

Revisiting the questionnaire findings from our target companies, it is seen that the general view of the employees seems to support the process improvement activities

and the continuity of these activities. The mean values of the answers to all questions are presented in **Table 47** and **Table 48** for both versions of the questionnaire. The questions coded as SPIRequired and SPIContinous have the highest mean values in both tables. However, it shall be noted that the SPIKnowledge mean value is much lower than these values. This shows that the employees support continuous process improvement even if they think that their SPI knowledge is not high. Furthermore, there seems to be some confusion among employees regarding participation in process improvement activities. The average view supports both large scale (AllParticipate), role based (RoleBased) and seniority based (SeniorityBased) participation but these views are expected to be contradictory. Also, the mean value for the answer to the smaller team size for process improvement (SmallTeam) is quite high.

Table 47. Questionnaire Version I Answers' Mean Values

Code	*Mean Value*
SPIRequired	4.31
SPIContinous	4.14
AllParticipate	3.81
RoleBased	3.70
PTIBeneficial	3.65
SeniorityBased	3.24
PTIKnowledge	3.23
PTIContent	3.23
PTIEvaluation	3.22
HeavyWorkload	3.17
SPIKnowledge	3.17
SmallTeam	3.08
PTISufficient	2.77
ProcessesMature	2.16
NotJustified	1.95

Table 48. Questionnaire Version II Answers' Mean Values

Code	*Mean Value*
SPIRequired	3.90
SPIContinuous	3.85
ProcessMature	2.39
AllParticipate	3.59
SmallTeam	2.93
RoleBased	3.52
SeniorityBased	2.97
ParticipateSpareTime	2.45
NotJustified	2.33
TrainingEffect	3.56
PerformedContinuously	3.19
ModelHinderance	2.92
SameLevel	2.58
HeavyWorkload	3.06
IndependentProfile	2.80
EducationalEffect	2.97
RolesEffect	3.43
SeniorityEffect	3.26
MaturityEffect	3.20
SPIKnowledge	3.37
EmployeeSatisfaction	3.20
OrganizationInnovation	3.06

Combining these mean values with the findings from the previous analyses, it is seen that contradicting views are observed among the employees and different approaches are predominant between different role groups. I believe that training is an important tool for resolving these problems. The TrainingEffect mean value also shows that training is an effective tool in increasing the participation ratio. Another point worth mentioning is the role-based variation. As proposed in previous case study findings a strong candidate for explaining this variation is the exposure of the different roles to process improvement activities either through their daily activities or the periodic appraisals performed in the organizations. The training and exposure factors given here are collectively named as *awareness* dimension given above. Furthermore, the validation interviews resulted in suggestions from employees to increase the awareness and the importance of training. Therefore, it is postulated that by increasing effective training and exposure to processes and process improvement activities, the overall awareness of the employees will be increased. This will also have side benefits such as the alignment of personal goals of employees with that of the organization (Lepmets & Ras, 2011). The specific suggestions for overcoming the problems in the *awareness* dimension are presented as follows.

5.3.1.1. Appraisal Team Rotation

The periodic appraisals performed for obtaining and maintaining maturity levels are usually performed by a group of people mostly consisting of the role groups such as quality engineers or configuration managers. This might be a contributing factor for the participation ratio discrepancies between the different role groups.

The appraisal team membership shall be rotated between the role groups and members of the organization. Different persons shall be utilized at each periodic appraisal thus increasing the exposure of different members of the organizations to process improvement related activities. The suggestions from interviews also support this view.

5.3.1.2. Extensive Training

Current organizational training programs usually focus on teaching the employees how to do their jobs. An extensive training approach with a focus on the institutionalized processes might be beneficial in raising awareness.

Training courses that focus on the written-down versions of institutionalized processes will increase the employee's awareness regarding the organizational process assets. These trainings must also focus on the process improvement channels used in the organization so that the employee will be able to participate in the improvement activities.

5.3.1.3. Process Action Teams

Process Action Teams (PATs) are formed cross-functionally to improve a process or to address a process related issue. Experience shows that these teams contribute to

raising process related-awareness in team members who are not usually exposed to organizational processes.

PATs may be formed with goals set by the management. In addition to the quality engineers and configuration managers, employees from engineering groups must be assigned to these teams to increase their awareness.

5.3.1.4. Periodic Reminders

Formal organizational trainings for specific subjects might not be performed with a high frequency. The employees will be accustomed to the daily routine with time and stop referring to the organizational process assets.

Periodic publications such as weekly e-mails or bulletins may be used to remind the employees of the organizational process asset library items. These periodic reminders might also include pop-quizzes related to organizational processes, which might also support the gamification approach presented below.

5.3.1.5. Management Support

Usually process improvement incentives within organizations are assigned to a small group of employees by the management. Organization wide participation requires support on the management side.

Yearly process improvement plans and objectives might be shared with the whole organization and the management might encourage all the employees (not only a small group) to actively pursue these objectives according to the plan.

5.3.2. Motivation

Although the employees support continuous process improvement as presented by the questionnaire answers this support does not result in actual contribution as I have explored in previous phases. This shows that the employees are not motivated to personally engage in process improvement activities despite believing its benefits for the company they work for. This brings us to the motivation dimension I have stated above. A solution proposal for motivation is to employ a gamification approach as mentioned in the validation interviews numerous times.

Gamification is defined as use of game design elements in non-game contexts. Its usage as a term has been increasing during the 2010s although at the same time it has been contested. It has gained ground in a wide variety of fields such as productivity, finance, health, education, sustainability, as well as news and entertainment media (Deterding, Dixon, Khaled, & Nacke, 2011). Groh discusses (2012) the application of three innate needs for intrinsic motivation to gamification as adopted from the work of Deci & Ryan (1985). These needs are relatedness, competence, and autonomy. All three are directly applicable to the problems presented in this study. Therefore, a gamification-based solution to our problem seems to be straightforward. In fact, a

study by Anderson, Huttenlocher, Kleinberg, & Leskovec has approached a very similar problem to ours by using a gamification based solution in the form of a badge system (2013).

Similar to the above study I propose a reputation system where active participation in process improvement activities results in points in the name of the employee. In addition to the points, a badge system will enable the employees to earn badges based on the points accumulated or different tasks completed. The point and badge listings will be publicly available for all employees to see and compare which will hopefully result in competition between employees. Furthermore, the organizational management might use the points and badges as a means of measuring performance or allocating bonus payments, benefits or rewards which was again mentioned numerous times a suggestion during the interviews.

5.3.3. Model Support

The last dimension I have postulated is the support of the employed process models. Since our target companies have been using CMMI, it will be used for explaining this dimension. CMMI-DEV version 1.3 (CMMI Institute, 2010) gives two process areas as related to process improvement activities. Organizational Process Focus (Maturity Level 3) process area states "The organization encourages participation in process improvement activities by those who perform the process" in the introductory notes section. However, the rest of the process area does not clearly enforce participation by those who perform the processes. One of the focuses of this process area is periodic appraisals. It might be possible to support an increase in exposure by modifying the appraisal methods used. The model does not enforce periodicity or the team composure for these appraisals. I suggest that the model might be updated to support our "Appraisal Team Rotation" suggestion detailed above. Overall, this process area fails to enforce continuous and highly participated process improvement. It is our understating that the authors of the model assume that all stakeholders will participate "somehow" by supplying improvement suggestions. Unfortunately, our previous studies have shown that this is not the situation in the target organizations.

The second process area is Organizational Performance Management (Maturity Level 5). This process area extends the Organizational Process Focus practices by focusing on process improvement based on a quantitative understanding. Also, the definitions of improvements are elaborated and much more in focus then Organizational Process Focus. However, it is still assumed that the members of the organization will supply the improvement suggestions. There is no mechanism in place to enforce continuity or large-scale participation. The method suggested for collecting improvement suggestions is based on comparing organizational performance data with business objectives and submit suggestions for negating any shortcomings. One sub-practice in Specific Practice (SP) 2.1 Elicit Suggested Improvements states the following for clarifying sources of suggestions;

> *These suggestions document potential improvements to processes and technologies. Managers and staff in the organization as well as customers, end users, and suppliers can submit suggestions. The organization can also search the academic and technology communities for suggested improvements. Some suggested improvements may have been implemented at the project level before being proposed for the organization.*

This paragraph is one of the rare explanations in the CMMI model that specifically targets our research questions. However, it does not specifically enforce the continuity or range of improvement suggestions.

The general problem with CMMI seems to derive from the fact that the process improvement approach presented relies on the organization performing a gap analysis with the model and then perform the activities to close this gap. However, I believe that the intrinsic improvements originating from within the organization is also highly beneficial but CMMI fails to provide a consolidated mechanism to enable effective participation within the organization. It is interesting that a widely trendsetting model such as CMMI fails to address the problems that we have observed.

I suggest that the Organizational Performance Management process area of CMMI be split in two. Activities that depend on the statistical performance data of the organization be kept at maturity level 5. However, the definition and management of improvements shall be moved to the Organizational Process Focus process area of maturity level 3. Since maturity level 3 establishes institutionalized processes, their improvement shall also start at that maturity level to lay the foundation of a continuous process improvement environment with large-scale participation. I also suggest that the model should focus on the process improvement more thoroughly by defining and encouraging the continuity and participation aspects in sub-practices.

A further improvement opportunity for the maturity models might also be to change the way appraisals are handled by the model. Widely used models usually come together with an appraisal model. In the case of CMMI the appraisal methodology is called SCAMPI (Standard CMMI Appraisal Method for Process Improvement) (CMMI Institute, 2014). I have seen that the periodic appraisals performed based on SCAMPI results in discontinuities in the process improvement activities in the organizations. Instead of a full-scale appraisal performed for all process areas of the organization a new approach for a continuous appraisal of the process areas might be beneficial in overcoming the continuity problems in process improvement. Actually, this was one of the suggestions put forward during the interviews.

5.4. Future Work

The solution alternatives proposed in the previous section may be tried in organizations willing to participate in this kind of a study. However, it should be noted

that since some of the methods presented require a significant change to the processes of an organization it will be difficult to find an organization willing to allocate that effort with unknown outcomes. If these proposals are tried and found to be beneficial they may be incorporated into published maturity models such as CMMI.

It is also possible to further develop the methodology presented in this study and apply it to more organizations that employ maturity models. Increasing the number of organizations that are part of this multi-case study will enable it to be better generalized. I have not used all the data collected through the surveys. Variables such as the gender and the university of the participant, the size and sector of the organizations may be employed in additional analyses performed in future studies that may give additional insight into the process improvement activities.

Furthermore, some interesting points came up during this study such as the importance of character traits and the difference between computer engineers and electronics engineers. These may be subject of further studies incorporating different fields such as psychology, organizational psychology, education sciences.

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APPENDIX

RAW DATA OF SURVEYS

Table 49. Questionnaire Part I – AvioTech

Participant	SPIRequired	SPIContinous	ProcessesMature	AllParticipate	SmallTeam	RoleBased	SeniorityBased	HeavyWorkload	NotJustified	SPIKnowledge	PTIKnowledge	PTIBeneficial	PTISufficient	PTIContent	PTIEvaluation
1	5	5	3	2	5	5	5	3	1	1	1	3	3	3	3
2	5	4	2	3	4	5	3	2	1	4	4	4	3	4	4
3	4	4	3	3	4	4	3	2	2	3	4	3	3	2	3
4	5	4	3	4	4	2	2	3	2	3	3	4	3	3	4
5	5	4	3	4	2	4	4	2	2	2	2	3	3	2	3
6	5	4	3	4	2	4	5	4	1	4	4	4	3	4	4
7	4	4	3	4	4	4	2	3	2	4	4	4	3	4	2
8	5	5	2	4	2	4	1	2	2	2	2	4	2	2	4
9	4	4	3	3	4	5	2	5	2	4	3	3	4	3	3
10	4	4	2	3	2	5	4	3	1	3	4	4	3	4	3
11	5	4	2	4	4	4	3	2	2	3	2	2	2	2	3
12	4	4	2	4	2	5	4	2	2	3	2	3	3	3	4
13	3	4	3	5	4	4	2	4	2	3	2	4	3	2	4
14	4	5	2	3	3	4	4	2	1	4	4	4	3	4	3
15	4	4	2	5	1	4	2	3	2	3	2	4	3	2	3
16	5	4	2	4	2	4	4	2	2	4	4	4	2	4	3
17	5	5	1	4	2	2	2	3	2	4	4	4	3	4	5
18	5	5	1	2	2	2	4	2	2	5	5	4	2	2	4
19	4	4	2	4	2	4	4	2	2	4	4	4	3	4	4
20	5	5	2	4	2	2	4	2	2	4	4	2	2	4	2
21	5	5	2	4	2	4	3	3	2	4	4	4	3	4	4
22	5	5	1	5	5	2	4	2	1	5	4	4	2	4	4
23	5	4	3	5	2	4	4	4	2	3	4	4	3	4	2

Participant	SPIRequired	SPIContinous	ProcessesMature	AllParticipate	SmallTeam	RoleBased	SeniorityBased	HeavyWorkload	NotJustified	SPIKnowledge	PTIKnowledge	PTIBeneficial	PTISufficient	PTIContent	PTIEvaluation
24	5	5	2	5	5	5	3	4	2	3	2	3	3	2	3
25	4	4	2	3	2	2	4	4	2	3	3	4	2	4	4
26	5	4	2	4	2	2	4	3	1	2	3	3	3	3	3
27	3	4	2	5	1	5	4	3	3	2	5	4	4	3	5
28	4	4	3	3	4	4	2	4	2	3	3	4	3	3	3
29	4	4	2	5	4	4	3	4	1	4	4	3	3	4	2
30	5	5	2	4	1	2	4	4	2	4	4	3	2	4	2
31	4	4	3	4	4	3	3	3	2	3	3	4	3	3	4
32	5	5	2	5	2	2	2	2	1	3	3	3	3	3	3
33	4	4	2	3	4	4	4	4	2	4	3	4	4	3	4
34	4	2	4	4	3	4	4	4	2	2	2	3	3	4	2
35	4	4	2	3	4	1	2	2	2	3	3	4	2	3	4
36	4	4	2	4	3	4	4	5	2	4	4	4	2	4	3
37	5	4	2	5	5	5	4	2	2	4	4	3	3	4	3
38	4	5	1	5	4	4	4	4	2	5	5	4	3	4	4
39	5	3	4	3	5	4	3	3	2	2	2	3	3	3	3
40	5	4	2	4	3	4	4	2	2	4	5	5	2	5	4
41	5	5	1	4	2	4	4	4	1	4	5	4	2	5	3
42															

Table 50. Questionnaire Part II – AvioTech

Participant	Gender	University	Department	TargetExp	MaturityExp	NonMaturityExp	Role	PTISubmission
1	M	TOBB ETU	CENG	1	4	0	SW	0
2	M	Ankara	EEE	120	72	48	SW	0
3	F	Hacettepe	CENG	5	0	5	SW	0
4	M	TOBB ETU	CENG	2	0	11	SW	0
5	M	Atilim	CENG	3	0	0	SW	0
6	M	METU	EEE	14	0	114	SW	0
7	M	Baskent	CENG	38	0	8	SW	1
8	M	TOBB ETU	CENG	6	0	14	SW	0
9	F	Baskent	STAT	12	0	0	SU	0
10	M	METU	EEE	46	0	0	SW	0
11	M	TOBB ETU	CENG	13	0	6	SW	0
12	M	Hacettepe	EEE	10	0	0	SW	0
13								
14	M	ITU	CENG	60	0	0	SW	3
15	M	METU	CENG	47	0	0	SW	0
16								
17	M	METU	ME	45	0	183	SU	2
18	F	METU	EEE	212	0	60	QA	30
19	F	Gazi	EEE	75	75	0	QA	34
20	M	Baskent	CENG	20	0	60	SW	1
21	M	METU	EEE	0	0	0	SW	0
22	M	METU	CE	42	48	36	SW	2
23	F	DEU	CENG	47	0	10	SW	0
24	M	METU	EEE	40	0	25	SW	0
25	M	Atilim	CENG	14	22	0	SW	0
26	F	TOBB ETU	CENG	2	0	7	SW	0
27	M	TOBB ETU	CENG	13	0	0	SW	0
28	F	Bilkent	CENG	46	0	0	SW	0
29	M	Atilim	CENG	38	0	0	SW	0
30	M	METU	STAT	132	0	3	SW	8

Participant	Gender	University	Department	TargetExp	MaturityExp	NonMaturityExp	Role	PTISubmission
31	F	TOBB ETU	CENG	1	0	7	SW	0
32	M	METU	STAT	6	5	0	QA	0
33	M	Yildiz	CENG	52	0	260	SW	0
34								
35	M							
36	M	Hacettepe	CENG	110	0	20	SW	33
37	F	METU	CENG	11	79	3	SW	0
38	M	Bilkent	EEE	72	144	72	SW	39
39	M							
40	F	METU	CENG	180	0	0	CM	61
41								
42	M	Bilkent	CENG	20	0	0	SW	1

Table 51. Questionnaire Part I – TeleSoft

Participant	SPIRequired	SPIContinous	ProcessesMature	AllParticipate	SmallTeam	RoleBased	SeniorityBased	HeavyWorkload	NotJustified	SPIKnowledge	PTIKnowledge	PTIBeneficial	PTISufficient	PTIContent	PTIEvaluation
1	4	4	2	4	5	4	4	2	2	3	3	4	3	4	4
2	4	4	2	4	3	4	4	2	2	3	3	4	4	4	4
3	4	5	3	4	5	5	3	4	2	3	3	3	3	2	3
4	5	5	2	3	3	3	4	3	2	2	2	3	3	2	3
5	5	5	1	1	1	2	2	4	2	5	5	4	2	4	4
6	4	4	1	5	3	4	2	4	2	3	3	4	2	3	1
7	3	3	2	2	4	2	3	4	4	2	4	2	2	2	4
8	4	4	3	3	2	4	2	2	2	3	4	4	3	4	3
9	4	4	2	5	1	4	3	4	2	3	2	4	3	2	3
10	4	5	2	4	3	3	4	4	1	4	4	4	2	4	3
11	5	5	1	4	3	3	4	4	1	2	2	4	1	4	4
12	4	4	1	4	2	3	2	4	2	3	4	4	2	4	3
13	4	4	2	4	2	2	2	4	2	3	4	4	2	4	3
14	4	4	3	4	4	4	3	2	2	4	3	4	4	3	3
15	4	4	2	2	3	5	4	2	2	4	5	5	3	5	4
16	5	4	2	4	1	3	2	2	1	4	2	4	4	2	3
17	5	2	2	5	2	4	4	5	1	2	2	4	2	2	1
18	4	3	3	5	4	4	3	2	1	4	4	4	3	3	4
19	4	5	2	4	5	4	4	5	2	4	4	4	2	4	3
20	4	4	2	4	4	4	3	4	2	2	2	4	3	3	3
21	5	5	1	4	1	3	4	3	1	4	3	5	2	4	4
22	5	5	1	5	1	1	1	1	1	4	4	4	3	1	4
23	1	3	2	4	4	4	4	5	5	2	4	4	4	4	4
24	4	4	2	4	2	4	2	2	2	4	3	3	3	3	3
25	4	4	2	4	2	3	4	4	3	2	2	3	3	3	4
26	4	4	2	3	5	5	2	4	2	3	3	4	4	4	4
27	4	4	3	4	5	5	3	4	2	3	3	4	3	3	3
28	4	4	1	2	3	4	4	3	2	2	2	4	3	2	3
29	5	5	2	4	2	4	4	3	1	4	4	3	3	4	3
30	5	5	2	4	4	4	4	4	2	4	4	4	3	3	3

Participant	SPIRequired	SPIContinous	ProcessesMature	AllParticipate	SmallTeam	RoleBased	SeniorityBased	HeavyWorkload	NotJustified	SPIKnowledge	PTIKnowledge	PTIBeneficial	PTISufficient	PTIContent	PTIEvaluation
31	4	3	2	4	2	4	3	3	2	3	3	3	3	3	3
32	4	4	2	4	4	4	4	3	2	2	2	4	2	4	3
33	4	4	2	2	4	4	4	4	3	2	2	4	3	3	2
34	2	2	4	1	1	3	3	5	5	1	1	1	1	1	1
35	5	5	2	4	4	5	4	2	2	4	4	4	4	4	3
36	4	4	2	4	4	4	2	4	2	2	2	4	2	3	2
37	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4
38	4	2	1	4	3	4	2	2	3	3	4	2	2	2	2
39	5	5	2	5	4	4	4	4	2	2	2	4	3	2	4
40	5	4	2	4	2	5	3	2	2	3	2	4	3	3	3
41	4	4	4	4	5	4	3	3	2	2	3	3	2	3	3
42	4	4	3	4	4	2	2	4	3	2	4	4	3	3	3
43	4	4	2	4	2	4	2	2	1	4	3	3	3	3	3
44	4	4	2	4	4	4	4	4	2	2	2	3	3	3	3
45	5	4	3	3	5	5	4	4	2	4	4	4	2	3	3

Table 52. Questionnaire Part II – TeleSoft

Participant	Gender	University	Department	TargetExp	MaturityExp	NonMaturityExp	Role	PTISubmission
1	F	METU	CENG	50	15	3	SW	2
2	M	Keçiören Lisesi	Matematik	150	0	0	SU	0
3	M	Hacettepe	EEE	21	0	0	SU	0
4	M	METU	EEE	34	0	0	SW	0
5	F	METU	SE	49	0	20	SW	15
6	F	Süleyman Demirel Üniversitesi	EEE	120	0	0	SW	0
7	F	Kirikkale Üniversitesi	EEE	168	12	0	SW	0
8	F	Karadeniz Teknik Üniversitesi	EEE	45	20	7	SW	2
9	F	Hacettepe	Information Management	26	0	0	SU	0
10	M	Hacettepe	EEE	84	0	0	CM	0
11	M	Baskent	EEE	20	72	6	SW	0
12	F	Bilkent	EEE	216	0	0	SW	4
13	M	Bilkent	CENG	192	0	0	SW	0
14	M	Bahçesehir	EEE	20	0	5	SW	0
15	M	Bilkent	CTIS	20	0	0	SU	0
16	M	METU	EEE	20	0	130	SU	0
17	M	METU	EEE	60	0	0	SW	0
18	M	ATILIM	EEE	8	0	9	SU	0
19	M	METU	EEE	30	24	60	SU	3
20	M	METU	EEE	58	0	0	SW	0
21	M	University of Pennsylvania	Applied Science	88	24	60	SW	0
22	M	Bilkent	CTIS	29	0	0	QA	5
23	M	Bilkent	EEE	48	0	0	SW	0
24	M	Bilkent	EEE	40	0	0	SU	0
25	M	Baskent	EEE	41	0	0	SW	0
26	F	METU	CENG	42	0	0	SW	0
27	M	METU	EEE	180	0	0	SW	0

Participant	Gender	University	Department	TargetExp	MaturityExp	NonMaturityExp	Role	PTISubmission
28	F	Anadolu Üniversitesi	EEE	39	0	17	QA	3
29	F	METU	CENG	37	24	0	SW	0
30	M	METU	EEE	156	0	0	SW	2
31	M	METU	EEE	32	0	30	SW	0
32	M	Bilkent	CENG	22	0	0	SW	0
33	M	ODÜ	EEE	58	0	0	SW	0
34	M	Hacettepe	CENG	48	120	0	SU	1
35	M	METU	EEE	190	0	50	SU	12
36	F	Atatürk Kiz Meslek Lisesi	Elektronik	272	0	0	SW	0
37	M	METU	EEE	180	0	0	SW	2
38	M	METU	EEE	15	0	0	SW	0
39	M	Baskent	EEE	175	0	11	SW	0
40	F	Cankaya Universitesi	EEE	21	0	36	SU	0
41	M	Hacettepe	EEE	8	0	4	SW	0
42	M	Hacettepe	EEE	50	0	18	SW	0
43	M	Bilkent	EEE	40	0	0	SU	0
44	M	Baskent	EEE	23	0	0	SW	0
45	M	METU	EEE	66	18	0	SW	0

Table 53. Questionnaire Part I – Open Survey

Participant	SPIRequired	SPIContinuous	ProcessMature	AllParticipate	SmallTeam	RoleBased	SeniorityBased	ParticipateSpareTime	NotJustified	TrainingEffect	PerformedContinuously	ModelHinderance	SameLevel	HeavyWorkload	IndependentProfile	EducationalEffect	RolesEffect	SeniorityEffect	MaturityEffect	SPIKnowledge	EmployeeSatisfaction	OrganizationInnovation
1	5	5	1	5	2	5	2	2	1	4	2	2	1	2	1	4	5	4	4	2	4	4
2	4	4	2	4	3	4	2	2	2	4	3	3	2	4	2	4	4	4	4	4	2	4
3	3	5	1	2	4	5	2	2	1	5	3	2	1	2	1	1	3	3	4	4	3	1
4	5	5	1	4	2	5	4	2	1	5	4	2	2	2	4	4	4	4	2	4	4	4
5	5	4	2	4	4	4	2	2	2	4	2	2	2	3	3	2	4	4	2	3	4	3
6	5	5	1	5	2	2	2	1	1	4	1	2	2	2	1	2	2	2	2	4	4	4
7	5	5	2	5	2	4	2	2	1	4	3	2	3	4	2	4	4	4	4	2	4	4
8	5	5	2	5	4	3	3	4	2	4	3	3	2	3	4	4	2	2	2	2	4	5
9	5	5	1	5	1	4	1	1	1	5	3	3	2	1	3	2	4	2	4	5	5	5
10	4	4	2	5	4	4	2	1	2	2	4	2	4	3	4	2	2	4	3	3	4	3
11	5	5	1	5	1	5	1	1	1	5	3	4	1	1	2	4	4	4	4	2	2	2
12	3	4	1	4	3	4	3	3	3	2	1	2	2	2	2	3	3	3	3	2	2	1
13	4	4	1	4	1	4	4	4	2	4	1	3	2	4	4	4	4	4	4	4	3	3
14	5	5	2	5	2	4	3	3	1	5	3	2	2	3	4	3	4	4	4	5	4	4
15	4	2	3	4	2	4	4	2	2	4	4	2	4	2	4	2	5	3	3	4	2	2
16	5	4	1	4	2	5	5	2	2	3	3	3	2	4	2	2	5	4	3	2	3	3
17	4	4	4	4	2	2	2	2	1	4	2	1	4	2	4	2	1	1	4	4	5	5
18	4	4	3	5	3	3	2	2	2	5	3	3	2	2	3	3	4	4	3	2	4	4
19	4	4	2	4	4	5	4	2	2	4	3	2	2	3	3	3	4	4	4	3	3	4
20	5	5	2	5	1	2	1	2	2	4	2	4	2	2	2	2	2	2	2	4	2	2
21	5	5	2	4	1	4	3	1	1	5	3	2	2	2	1	4	4	3	2	3	3	2
22	4	4	2	5	4	5	5	2	1	4	3	3	2	3	2	4	4	4	3	3	4	4
23	4	3	2	4	4	4	2	2	2	4	2	2	2	3	2	4	4	4	3	2	3	3
24	4	4	4	4	2	5	5	2	1	4	4	4	2	2	4	4	5	4	4	4	4	4
25	5	4	2	5	2	4	4	1	1	4	3	2	2	1	4	4	4	5	4	5	4	4
26	5	5	2	5	3	4	3	2	2	4	3	2	1	4	1	3	4	4	3	4	3	3
27	4	3	3	5	2	4	3	4	4	4	3	3	2	2	2	4	5	5	3	4	3	4
28	5	5	1	4	2	2	2	2	1	4	2	2	2	2	2	2	4	4	3	3	3	3

Participant	SPIRequired	SPIContinuous	ProcessMature	AllParticipate	SmallTeam	RoleBased	SeniorityBased	ParticipateSpareTime	NotJustified	TrainingEffect	PerformedContinuously	ModelHinderance	SameLevel	HeavyWorkload	IndependentProfile	EducationalEffect	RolesEffect	SeniorityEffect	MaturityEffect	SPIKnowledge	EmployeeSatisfaction	OrganizationInnovation
29	5	4	2	5	3	4	4	2	2	4	4	3	2	4	2	4	4	4	4	3	3	4
30	5	4	2	4	4	5	2	2	2	5	3	4	4	5	2	4	4	4	4	4	4	4
31	5	5	2	5	4	4	2	2	1	4	3	2	3	4	2	4	4	4	4	4	5	3
32	5	5	1	5	5	5	5	1	1	5	5	5	5	5	4	4	4	4	4	4	4	4
33	5	4	1	4	3	2	2	1	1	4	1	3	2	4	1	3	3	3	3	4	4	4
34	5	4	1	5	2	4	2	2	1	4	2	2	2	4	2	2	4	3	4	2	4	4
35	5	5	4	4	2	5	4	5	2	4	4	2	2	3	3	4	4	4	3	2	4	4
36	5	5	1	5	4	4	2	2	1	4	3	2	2	4	2	3	4	3	3	3	3	3
37	5	5	2	5	2	4	4	1	2	4	2	3	2	4	2	3	3	4	3	4	3	4
38	5	5	2	4	2	5	4	2	1	4	2	4	2	1	2	2	4	2	3	2	2	3
39	5	5	2	4	2	4	4	1	1	5	5	4	2	4	3	3	4	4	5	4	2	2
40	5	5	4	4	3	4	4	2	2	4	4	2	4	3	2	2	4	4	4	3	5	5
41	5	5	5	4	2	4	4	2	2	5	5	1	2	4	4	2	3	2	2	4	4	4
42	5	5	2	5	1	3	2	2	1	4	4	2	2	2	3	3	3	2	3	5	3	4
43	4	4	1	4	1	4	4	2	2	4	1	2	1	4	4	3	4	4	3	4	2	1
44	5	4	2	4	5	5	3	2	2	5	3	2	2	2	2	3	4	2	3	3	4	4
45	5	5	1	5	1	5	5	1	1	5	1	1	1	1	1	5	5	5	5	5	5	5
46	5	5	1	5	1	3	2	2	1	5	4	1	3	2	5	4	4	5	2	5	5	2
47	5	5	1	5	1	3	3	1	1	5	5	1	2	1	5	3	3	3	5	5	5	5
48	4	5	2	3	3	5	4	1	2	2	1	3	1	4	4	2	2	4	3	4	2	1
49	5	4	2	3	4	4	4	2	3	5	3	2	3	3	4	4	4	3	4	3	4	3
50	5	5	1	4	4	4	2	1	1	5	5	1	5	2	3	4	4	5	4	2	4	4
51	4	4	2	4	2	2	2	2	2	4	4	4	2	4	4	3	3	2	4	4	2	2
52	3	4	1	4	4	4	3	2	4	4	5	4	3	3	2	4	3	2	3	4	4	4
53	5	4	1	4	4	2	2	2	3	4	2	3	2	2	2	4	4	4	4	3	2	2
54	4	5	2	4	2	3	2	2	2	4	3	4	2	4	3	4	4	4	2	4	3	3
55	5	3	1	5	4	3	3	1	1	4	4	3	5	2	5	1	1	1	3	4	4	4
56	4	4	2	3	3	5	4	1	5	4	2	5	5	5	4	3	3	3	5	5	4	2
57	5	4	2	3	4	5	5	5	4	5	5	2	3	3	4	4	5	4	4	2	3	5
58	4	4	2	3	2	3	2	2	3	3	2	4	2	3	2	3	4	4	3	2	2	1

Table 54. Questionnaire Part II – Open Survey

Participant	Gender	UnderGraduate	UnderGradCode	TargetExp	MaturityExp	NonMaturityExp	Model	CurrentRole	WeeklyHoursSPI	OrganizationSize	DeparmentSize	WorkArea
1	M	lisans/bilkent/bilgisayar	CENG	14	0	26	3	SW	0	45	42	Telecom
2	M	Başkent Üniversitesi		33	31	6	3	TE	1	40	40	Telecom
3	F	Odtu/Istatistik	STAT	11	48	24	3	TE	1	50	48	Telecom
4	M	Bilkent Bilgisayar	CENG	49	96	40	3	PM	0	45	40	Telecom
5	M	hacettepe universitesi bilgisayar muhendisligi	CENG	30	0	70	3	SW	0	50	50	Telecom
6	M	atılım üni bilgisayar müh	CENG	36	120	0		SW	0	25000	1000	Telecom
7	M	bilkent universitesi/CS	CENG	10	1	1	3	SW	2	50	30	Telecom
8	F	Çankaya Üniversitesi - Bilgisayar Mühendisliği	CENG	9	18	0	3	TE	5	57	42	Defence
9	F	Çankaya Üniversitesi/ Bilgisayar Mühendisliği	CENG	19	0	0		QA	10	100	45	IT
10	M	Başkent Üniversitesi Bilgisayar Mühendisliği	CENG	9	34	0	3	SW	1	42	40	Telecom
11	F	ORTA DOGU TEKNIK UNIVERSITESI		13	42	0	3	SW	5	50	40	Telecom
12	F	-		30	30	0	3	SW	0	40	40	Telecom
13	M	Bilgisayar Mühendisi	CENG	96	42	0	3	SW	0	300	80	Defence
14	F	Bilgisayar Mühendisliği	CENG	32	0	0	3	QA	8	47	40	Telecom
15	M	Bilkent Bilgisayar Mühendisliği	CENG	48	12	0	3	SE	0	48	48	Telecom
16	M	Bilgisayar Mühendisliği	CENG	28	6	32	3	SW	0	47	40	Telecom
17	M	Odtü Bilgisayar Mühendisliği	CENG	10	60	48	3	SW	8	50	40	Telecom
18	F	Hacettepe Universitesi / Bilgisayar Muhendisligi	CENG	9	0	0		SW	0	48	45	Telecom

Participant	Gender	UnderGraduate	UnderGradCode	TargetExp	MaturityExp	NonMaturityExp	Model	CurrentRole	WeeklyHoursSPI	OrganizationSize	DeparmentSize	WorkArea
19	M	bilgisayar muhendisligi	CENG	6	30	0	3	SW	1	50	25	Software
20	M	Hacettepe Bilgisayar Muhendisligi	CENG	18	12	66		TE	0	4000	3700	Consultancy
21	M	hacettepe universitesi/bilgisayar muh.	CENG	60	0	12	3	SW	5	130	30	Government
22	F	Bilgisayar Mühendisliği	CENG	2	33	0		SW	1	50	15	Telecom
23	M	Hacettepe Universitesi / Bilgisayar Mühendisliği	CENG	9	0	10	3	SW	0	40	38	Telecom
24	M	Hacettepe / Bilgisayar	CENG	16	16	12	3	SW	4	45	40	Telecom
25	M	Lisans/Erciyes Üniversitesi/Bilgisayar Mühendisliği	CENG	108	12	15		OP	15	35000	600	Telecom
26	F	KTÜ/Elektrik Elektronik Müh.	EE	6	30	6		TE	1	46	44	Defence
27	M	başkent		12	18	18	3	SW	0	45	40	Telecom
28	F	Marmara Üni		68	0	76		TE	0	150	80	Finance
29	M	ytü		50	17	-		SW	5	20000	70	Retail
30	M	Yazılım Mühendisliği	CENG	96	0	96	0	SW	0	2500	5	Government
31	M	Yüksek lisans / elektronik	EE	48	120	240		TE	3	40	15	Software
32	M	Fatih Üniversitesi/ Bilgisayar Müh.	CENG	4	0	0	0	SW	8	2000	75	Entertainment
33	M	ODTU Bilgisayar Mühendisliği	CENG	30	0	50	0	SW	3	150	40	Government
34	M	Ankara Üniversitesi		18	26	18	3	SW	0	200	80	Automotive
35	M	ODTÜ/Bilgisayar Müh.	CENG	30	0	0	5	SW	0	200	150	Defence
36	M	.		60	18	36		SW	0			
37	M	Bilgisayar Muhendisligi	CENG	15	15	0	3	SE	5	47	40	Telecom
38	F	Baskent Universitesi/endustri muhendisligi	IE	48	3	12	3	SE	10	44	40	Telecom
39	M	Anadolu Üniversitesi İİBF Fakültesi	BA	48	180	12	3	PM	2	2000	1500	Defence

Participant	Gender	UnderGraduate	UnderGradCode	TargetExp	MaturityExp	NonMaturityExp	Model	CurrentRole	WeeklyHoursSPI	OrganizationSize	DeparmentSize	WorkArea
40	M	Çankaya üni. Bilg. Müh.	CENG	108	0	0	3	SW	6	30000	80	Telecom
41	M	Orta Doğu Teknik Üniversitesi Elektrik Elektronik Mühendisliği	EE	93	0	0	3	SW	0.5	5000	500	Defence
42	M	ODTÜ Bilgisayar Mühendisliği	CENG	168	0	6	3	SW	5	350	70	Space
43	M	ODTÜ/Bilgisayar	CENG	11	129	3	3	SW	1	44	40	Defence
44	F	Bilkent/ Uluslararası İlişkiler	IR	28	16	0	3	PM	1	46	42	Software
45	M	BS		24	60	60	3	SW	0	40	40	Telecom
46	F	Mühendislik		8	8	0	0	PM	10	10	2	Education
47	M	yüksek lisans		36	36	36		QA	40	10	2	Education
48	M	METU CENG	CENG	26	60	24	3	SW	0	40	37	Telecom
49	M	METU		96	0	0		SW	20	1500	50	Finance
50	F	Baskent University		56	3	2	3	TE	2	100	100	Manufacturing
51	M	METU CENG	CENG	24	120	12		PM	0.5	150	150	Defence
52	F	odtu		9	0	0	3	SW	0.15	40	10	Telecom
53	F	METU/Software Management	CENG	160	0	0	3	SW	0	250	200	Government
54	M	University of Montreal			60	180		PM	0	3000	1000	Government
55	M	Qazvin Azad University, Iran		9	15	15		PM	20	35000	5,000	Travel & Hospitably
56	M	bogazici		50	120	60		PM	5	1000	200	Retail
57	M	abc college		160	160	180		QA	10	5000	1000	Digital Media
58	F	Quaid-i-Azam University, Computer Science	CENG	15	240	0	4	QA	40	15000	5,000	Healthcare

Table 55. Questionnaire Part I – DefSys

Participant	SPIRequired	SPIContinuous	ProcessMature	AllParticipate	SmallTeam	RoleBased	SeniorityBased	ParticipateSpareTime	NotJustified	TrainingEffect	PerformedContinuously	ModelHinderance	SameLevel	HeavyWorkload	IndependentProfile	EducationalEffect	RolesEffect	SeniorityEffect	MaturityEffect	SPIKnowledge	EmployeeSatisfaction	OrganizationInnovation
1	4	4	2	3	5	5	4	2	2	4	4	3	2	2	2	4	4	3	1	4	3	3
2	5	4	2	3	2	3	4	2	2	4	4	4	2	4	2	2	3	4	3	3	2	2
3	4	4	2	3	3	4	4	3	2	5	3	3	1	5	2	3	3	4	3	3	2	2
4	4	4	2	3	2	4	2	2	2	3	3	4	2	3	2	2	3	3	3	4	3	3
5	4	5	2	4	2	2	3	2	2	3	5	5	3	4	2	1	4	3	3	5	3	2
6	5	2	1	5	1	2	1	1	2	4	3	2	2	5	1	2	4	4	3	4	2	2
7	4	4	2	3	3	4	2	2	2	3	4	3	2	3	3	2	4	4	3	4	3	4
8	5	5	4	5	3	5	2	2	1	4	3	4	3	3	4	3	4	3	4	2	3	3
9	5	5	1	4	2	4	1	1	1	5	4	4	1	5	2	4	4	4	4	5	4	4
10	5	5	2	2	4	4	5	2	1	5	4	4	5	1	3	3	3	3	3	5	5	5
11	4	4	2	4	2	4	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3
12	4	4	1	5	1	5	1	3	3	3	3	3	4	4	3	3	4	4	3	2	3	1
13	5	5	2	3	4	2	4	2	2	4	4	4	2	4	2	2	4	3	3	4	4	3
14	5	5	1	5	1	2	1	1	1	4	4	4	2	2	2	4	5	3	4	4	4	2
15	5	5	1	5	4	1	4	2	1	4	5	4	2	2	4	1	4	4	2	4	4	4
16	5	5	1	4	2	2	4	2	1	4	4	5	1	2	1	3	5	4	3	4	2	5
17	5	5	2	5	2	6	4	1	2	4	3	4	2	2	3	3	4	3	4	4	3	3
18	5	5	1	5	1	6	2	1	1	4	4	5	2	4	2	2	4	4	4	4	5	4
19	4	4	2	5	2	4	2	2	2	4	3	3	2	5	2	3	4	4	3	4	3	3
20	5	4	2	3	3	4	4	2	2	4	4	4	3	2	2	3	4	4	3	4	3	4
21	5	5	2	2	4	3	3	2	1	3	4	5	3	4	2	3	4	3	4	4	3	3
22	4	4	2	4	3	4	3	2	2	4	4	4	3	3	2	4	4	3	3	4	3	3
23	5	5	2	4	2	4	4	2	2	4	4	3	2	5	1	1	4	4	1	2	3	3
24	5	5	2	2	4	4	4	2	2	4	4	4	2	2	2	2	4	4	4	4	4	4
25	1	2	1	3	5	4	4	5	5	1	3	1	1	3	3	2	3	3	2	2	1	1
26	4	4	3	4	4	3	3	3	2	4	3	4	3	4	3	3	3	3	3	4	4	3
27	4	4	2	2	4	4	4	2	2	4	3	4	2	4	2	3	3	4	4	2	3	4
28	4	4	1	4	3	1	5	4	2	5	3	4	3	5	3	1	1	2	1	3	4	4

Participant	SPIRequired	SPIContinuous	ProcessMature	AllParticipate	SmallTeam	RoleBased	SeniorityBased	ParticipateSpareTime	NotJustified	TrainingEffect	PerformedContinuously	ModelHinderance	SameLevel	HeavyWorkload	IndependentProfile	EducationalEffect	RolesEffect	SeniorityEffect	MaturityEffect	SPIKnowledge	EmployeeSatisfaction	OrganizationInnovation
29	4	4	2	2	5	3	4	2	1	4	4	4	2	4	2	2	4	4	2	4	3	2
30	4	4	1	4	3	5	4	3	2	2	4	4	2	4	2	2	4	4	3	4	4	4
31	5	5	2	3	3	3	3	3	2	4	3	3	2	5	2	2	3	2	3	3	2	2
32	5	5	3	2	4	5	4	1	1	5	2	3	2	4	2	2	5	3	3	4	3	3
33	5	5	4	4	4	5	2	2	2	4	4	4	2	4	2	2	4	2	4	3	3	3
34	5	5	2	3	4	2	4	2	2	3	4	3	2	3	2	2	4	4	2	2	2	1
35	4	4	2	2	4	5	2	2	2	4	3	4	1	2	2	2	4	4	4	1	4	4
36	4	5	2	2	3	4	3	2	2	3	4	3	2	3	2	4	4	3	2	4	3	3
37	5	5	2	5	2	4	4	2	2	4	3	3	3	2	2	3	3	3	3	1	3	4
38	4	4	2	4	2	4	4	2	2	4	3	3	1	2	2	3	4	4	3	2	3	3
39	5	5	2	4	2	3	3	2	2	4	4	3	1	2	1	1	4	2	1	1	3	2

Table 56. Questionnaire Part II – DefSys

Participant	Gender	UnderGraduate	UnderGradCode	TargetExp	MaturityExp	NonMaturityExp	CurrentRole	WeeklyHoursSPI	PTISubmission
1	M	Hacettepe	Other	142	0	42	SW	1	2
2	M	Orta Dogu Teknik Universitesi	EEE	66	0	0	SW	0	1
3	F	Odtü bilgisayar mühendisli	CENG	84	40	0	SW	1	1
4	M	bilkent üniversitesi elektri	EEE	78	0	20	SW	1	2
5	F	Hacettepe Üniversitesi Elekt	EEE	180	0	0	SW	2	3
6	M	ODTÜ EE	EEE	41	0	0	SW	0	1
7	M	Sabancı Universitesi Mikroel	EEE	53	30	0	SE	2	4
8	F	Lisans/Hacettepe/istati stik	Other	24	24	0	TE	1	1
9	M	ODTÜ Bilgisayar Mühendisli	CENG	150	0	0	SW	4	15
10	M	-/-/-	Other	0	0	0	TE	0	1
11	M	Bilkent Üniversitesi Bilgisa	CENG	24	0	0	TE	0	1
12	M	Bilkent Üniversitesi Bilgisa	CENG	12	0	0	SW	0	1
13	M	Hacettepe Üniv. Bilgi.Müh.	CENG	52	0	96	SW	1	1
14	M	ODTÜ Bilgisayar Mühendisli	CENG	100	0	0	SW	3	2
15		Hacettepe Elektronik	EEE	120	120	12	QA	5	3
16	F	HACETTEPE/BİLGİ SAYAR MÜH.	CENG	80	36	36	QA	8	2
17	F	ODTÜ/İSTATİSTİK	Other	51	48	24	QA	21	0
18	F	ODTÜ ENDÜSTRİ MÜH.	Other	240	0	0	QA	2	16
19	M	ODTÜ EEE	EEE	134	0	0	SW	4	5
20	M	SABANCI ÜNİVERSİTESİ Mİ	EEE	53	89	0	SE	2	3
21	M	ODTÜ MAKİNA MÜH.	ME	110	0	0	SE	4	0
22	M	ODTÜ MAKİNA MÜH.	ME	26	0	84	PM	4	0
23	M	ODTÜ MAKİNA MÜH YÜK.LİS	ME	120	0	0	PM	0	0
24	M	ODTÜ / EE	EEE	170	0	0	SW	1	0
25	M	BİLKENT BİLGİSAYAR MÜH.	CENG	180	180	0	SW	0	0

Participant	Gender	UnderGraduate	UnderGradCode	TargetExp	MaturityExp	NonMaturityExp	CurrentRole	WeeklyHoursSPI	PTISubmission
26	M	HACETTEPE/BİLGİ SAYAR MÜH.	CENG	126	0	0	SW	0	0
27	F	HACETTEPE/BİLGİ SAYAR MÜH.	CENG	101	0	0	SW	0	0
28	M	ODTÜ / BİLGİSAYAR MÜH.	CENG	50	0	24	SW	0	0
29	M	BİLKENT ÜNİVERSİTESİ Bİ	CENG	62	4	8	SW	0	0
30	M	HACETTEPE/BİLGİ SAYAR MÜH.	CENG	90	11	0	SW	0	0
31	M	HACETTEPE ÜNİVERSİTESİ B	CENG	144	0	0	SW	0	0
32	M	HACETTEPE ÜNİVERSİTESİ B	CENG	228	0	0	SW	0	6
33	M	ODTÜ / BİLGİSAYAR MÜH.	CENG	171	3	15	SW	0	0
34	M	BİLKENT ÜNİVERSİTESİ Bİ	CENG	90	0	0	SW	0	0
35	M	İTÜ ÜNİVERSİTESİ BİLG	CENG	48	0	12	SW	0	0
36	M	HACETTEPE/BİLGİ SAYAR MÜH.	CENG	96	0	20	SW	0	0
37	F	HACETTEPE ÜNİVERSİTESİ EL	EEE	8	0	0	SW	0	0
38	F	ODTÜ - ELEKTRİK - ELEKTRON	EEE	78	0	0	SW	0	0
39	M	BİLKENT ÜNİVERSİTESİ ELE	EEE	101	0	0	SW	0	0

Table 57. Questionnaire Part I – CommCorp

Participant	SPIRequired	SPIContinuous	ProcessMature	AllParticipate	SmallTeam	RoleBased	SeniorityBased	ParticipateSpareTime	NotJustified	TrainingEffect	PerformedContinuously	ModelHinderance	SameLevel	HeavyWorkload	IndependentProfile	EducationalEffect	RolesEffect	SeniorityEffect	SPIKnowledge	EmployeeSatisfaction	OrganizationInnovation
1	5	4	1	4	2	3	2	2	1	4	2	2	2	2	2	4	4	3	4	4	4
2	4	4	2	4	3	4	4	2	1	5	4	4	3	2	3	4	4	4	2	3	4
3	5	5	1	3	4	4	2	1	1	4	3	3	2	4	1	1	4	2	2	3	3
4	5	5	1	4	2	4	2	2	1	4	2	4	2	2	3	3	5	4	2	4	4
5	5	4	3	4	1	2	5	2	2	4	3	4	3	2	2	2	4	3	4	4	4
6	4	2	1	4	2	4	4	3	2	4	1	2	1	3	1	3	3	3	2	3	3
7	5	5	1	4	2	4	2	2	2	3	3	4	3	2	3	3	3	3	2	4	4
8	4	4	3	4	2	4	4	2	2	4	3	4	3	4	2	3	4	4	2	4	4
9	3	4	2	3	4	4	4	3	3	4	3	3	2	2	3	4	4	3	4	3	4
10	5	4	3	5	2	3	3	2	1	5	3	3	3	4	3	3	3	3	2	3	3
11	5	5	2	2	2	4	3	2	2	3	4	4	2	4	2	2	4	4	4	4	5
12	1	2	3	1	3	1	4	3	4	2	3	2	2	1	3	3	2	2	5	2	3
13	4	4	1	5	2	4	3	1	1	5	2	3	2	4	1	3	5	5	3	3	3
14	5	5	2	5	2	5	4	2	2	5	3	4	3	3	3	3	3	3	1	3	4
15	5	4	1	5	2	2	2	1	1	5	1	3	1	1	1	1	2	5	1	2	1
16	5	5	2	4	2	4	4	3	2	4	4	3	2	3	2	2	4	4	3	2	3
17	3	4	2	3	4	4	4	3	3	4	3	3	2	4	3	4	4	3	4	3	4
18	4	4	2	4	2	2	4	2	2	4	4	4	4	2	4	2	2	2	4	4	4
19	5	4	1	3	2	4	4	2	2	4	3	4	2	2	3	3	4	4	2	3	4
20	5	5	2	4	2	3	1	1	1	4	4	4	2	2	2	2	2	2	4	3	4
21	5	3	1	5	2	4	4	2	2	4	3	3	2	4	2	3	3	4	2	4	4
22	4	4	1	4	2	4	4	2	1	4	2	4	3	4	2	3	4	4	3	3	3
23	4	3	2	5	1	2	4	1	2	4	3	3	3	4	2	3	3	3	2	3	3
24	5	4	2	5	4	3	4	2	2	4	2	3	2	2	2	3	4	4	2	3	2
25	5	5	2	4	4	4	5	3	1	5	4	5	3	4	4	4	4	4	2	3	4
26	5	5	2	3	4	4	2	2	1	4	3	3	3	4	1	1	4	2	2	3	3
27	5	5	2	5	2	5	3	2	2	4	4	3	2	4	2	2	4	4	4	4	4

Table 58. Questionnaire Part II – CommCorp

Participant	Gender	UnderGraduate	UnderGradCode	TargetExp	MaturityExp	NonMaturityExp	CurrentRole	WeeklyHoursSPI	PTISubmission
1	M	Industrial Eng	Other	35	18	0	PM	3	20
2	M	Administrative Science	Other	180	0	0	PM	1	5
3	M	Electric-Electronics Engineer	EEE	228	0	0	DE	0	0
4	M	Electric-Electronics Engineer	EEE	80	0	0	PM	0	0
5	F	Electric-Electronics Engineer	EEE	36	0	0	QA	8	20
6	F	Industrial Eng	Other	127	0	18	PM	0	0
7	F	Electric-Electronics Engineer	EEE	12	0	0	PM	0	0
8	M	Mechanical Eng	ME	116	0	0	SE	3	0
9	M	Electric-Electronics Engineer	EEE	120	216	24	PM	5	0
10	M	Electric-Electronics Engineer	EEE	5	0	0	SE	0	0
11	F	Electric-Electronics Engineer	EEE	38	0	0	QA	25	3
12	F	Administrative Science	Other	18	24	12	PM	0	0
13	F	Electric-Electronics Engineer	EEE	120	0	0	PM	2	3
14	M	Electric-Electronics Engineer	EEE	120	0	0	DE	0	0
15	M	Electric-Electronics Engineer	EEE	27	204	0	SE	0	0
16	M	Electric-Electronics Engineer	EEE	307	0	24	DE	0	0
17	M	Electric-Electronics Engineer	EEE	84	0	60	PM	0	0
18	F	Industrial Eng	Other	37	0	19	QA	20	3
19	F	Administrative Science	Other	26	0	12	PM	1	2
20	M	Electric-Electronics Engineer	EEE	19	60	24	SE	3	2
21	F	Electric-Electronics Engineer	EEE	10	0	0	SE	0	2
22	F	Electric-Electronics Engineer	EEE	132	0	0	SE	0	0
23	F	Industrial Eng	Other	5	0	28	PM	0	0
24	M	Electric-Electronics Engineer	EEE	180	0	18	SE	0	2

Participant	Gender	UnderGraduate	UnderGradCode	TargetExp	MaturityExp	NonMaturityExp	CurrentRole	WeeklyHoursSPI	PTISubmission
25	F	Electric-Electronics Engineer	EEE	21	0	0	SE	1	0
26	M	Electric-Electronics Engineer	EEE	214	0	0	DE	0	0
27	M	Electric-Electronics Engineer	EEE	225	0	41	SE	0	0

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Uskarcı, Algan

Nationality: Turkish

Date and Place of Birth: 13 February 1979, Ankara

Marital Status: Single

Phone: +90 532 514 73 23

e-mail: algan.uskarci@gmail.com

EDUCATION

Degree	Institution	Year of Graduation
MS	METU Electrical and Electronics Engineering	2004
MS	METU Information Systems	2004
BS	METU Electrical and Electronics Engineering	2001
High School	Atatürk Anadolu High School, Ankara	1997

WORK EXPERIENCE

Year	Place	Title
2005- present	AYESAŞ	Technical Leader
2001 - 2005	METU Electrical and Electronics Engineering Dept.	Research Assistant

FOREIGN LANGUAGES

Advanced English

PUBLICATIONS

1. Uskarcı, A., & Demirörs, O. (2017). Do Staged Maturity Models Result in Organization-Wide Continuous Process Improvement? Insight from Employees. In *Computer Standards & Interfaces 52.* (pp. 25-40). Elsevier Science Publishers BV.

2. Uskarcı, A., & Demirörs, O. (2015). Causes of Continuity and Participation Problems in Process Improvement with Staged Maturity Models. In *Software Process Improvement and Capability Determination* (pp. 177-187). Springer International Publishing.

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7. Uskarcı, A., Alatan, A. A., Dindaroğlu, M. S., & Ersak, A. (2003). Robot mimicking: A visual approach for human machine interaction. In *Computer and Information Sciences-ISCIS 2003* (pp. 474-481). Springer Berlin Heidelberg.

HOBBIES

Travel, Science Fiction & Fantasy Culture, History, Board Games, Role Playing Games