A Framework for Implementing Software Measurement Programs in Small and Medium Enterprises

Aftab Ahmad Mughal

Supervised by

Professor Stephen MacDonell

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This thesis is dedicated to

the loving memory of my father, M. Akram (late), who was my best friend, greatest role model, amazing father, coach, mentor, and soldier.

Gone but not forgotten!

And

My mother, Kausar, for her constant love and support,

And

My brother Aamir Mughal, for supporting my family back home,

And

My wife Zainab and Daughters Annayah Aftab, Haram Fatima and Sons Anas Abdullah and Muhammad Abdullah for their patience, and for sacrificing their comforts in Pakistan in support of my journey in this Ph.D.

Abstract

The economies of numerous nations, including New Zealand, rely heavily on the contributions of small and medium enterprises (SMEs). In the last decade a shift to the provision and use of software services, rather than products, has seen these offerings developed and delivered by multiple parties working in distributed and possibly transient networks, indicating that software SMEs could not only survive but can, in fact, thrive long-term at a small scale.

Most research on software success and failure, however, has been conducted in large organizations working on large-scale projects. Given the new work context described above, it is imperative that we also understand the circumstances that enable SMEs to be successful in software development. In general terms, software measurement has been considered to be one of the keys to success. The use of measurement is common in everyday life, such as checking the shortest path to your destination or weighing your luggage before taking a flight. It is also accepted in many science and engineering disciplines such as electrical and mechanical engineering. In spite of its acknowledged importance and rather obvious benefits, the use of measurement in software engineering has been variable. Software measurement is particularly conceived as a complex procedure, and therefore as a challenging and potentially costly endeavour, by software SMEs (SSMEs).

The aim of this research is to comprehensively understand and then contribute to more effective planning, deployment, operation and management of measurement programs specifically in the context of SMEs. The research reported in this thesis explores in detail the particular challenges that are encountered by SMEs when they embark on a software measurement initiative. It then proceeds to identify ways in which SMEs could effectively and efficiently implement light-weight software measurement programs (SMPs). In doing so the research combines elements of observation, design, intervention and evaluation under the umbrella of a Design Science Research (DSR) methodology. In three DSR the research conducts 1) problem identification through a literature review (via a mapping study) and an industrial review (via practitioners' interviews), 2) solution design through field studies, and 3) evaluation through a survey. A mix of quantitative and qualitative methods is used as appropriate for each phase.

In the first phase, a comprehensive systematic mapping study is first conducted to review prior literature that had addressed SMPI in SMEs, to understand the state-of-the-art. The mapping

study leads to the identification of a research gap which is further investigated through an industrial review. In the industrial review, 22 face-to-face interviews are conducted with professionals from SMEs. Hereafter, data analysis methods based on Grounded Theory (GT) enable the development of exploratory frameworks of four aspects of software measurement program implementation – challenges, obstacles, benefits and success factors – which forms one of the primary contributions of this research.

Based on these intermediate findings the second phase of this research involves the development of a novel framework which is intended to overcome (or at least reduce the severity of) measurement implementation challenges faced by SMEs. Implementing and sustaining a framework for the efficient planning and management of measurement programs remains a challenge for many software organizations, and particularly SMEs. Therefore, in this research phase, a comprehensive framework is proposed and refined, based on field studies that consider its adequacy in relation to the identified challenges and obstacles. The framework, referred to as the Software Measurement Framework for SMEs (SMF4SME), as developed and enhanced in the field over three cases, is a further novel contribution of this research.

The last major research phase validates the SMF4SME by seeking the insights of a sample of software practitioners working in SMEs, with respect to its perceived usefulness. An industrial survey is designed and distributed to potential participants to get their feedback. More than 100 respondents provide favourable indications regarding the coverage and potential utility of the framework in SSMEs.

Overall, this research work contributes to both theory and practice by providing an improved understanding of SMPI in SMEs along with a validated SMF4SME intended to overcome (or at least reduce the severity of) measurement implementation challenges in SMEs.

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Table of Contents

List of Tables

List of Figures

Acronyms and Abbreviations

Term	Description
AUTEC	Auckland University of Technology Ethics Committee
ABC	Medium-Sized Company Where Case 1 and 2 were Conducted
CCM	Constant Comparison Method
CMMI	Capability Maturity Model Integration
COMP	Complete
CEO	Chief Executive Officer
CTO	Chief Technical Officer
Chk.L	Check List
CP	Current Practice
DBA	Database Administrator
DSR	Design Science Research
EUM	Easy to Use and Manage
EFL	Effortless
GDP	Goal Driven Process
GQM	Goal Question Metric
GQ(I)M	Goal Question Indicator Metrics
GQM-DSFMS	GQM-Decision Support Framework for Metrics Selection
GT	Grounded Theory
HMP	Hybrid Measurement Process
IS	Information System
ISO	International Organization for Standardization
IEEE	The Institute of Electrical and Electronics Engineers
INF	Informative
INTP	Integration into Process
LS	Lean and Sustainable
LSEs	Large Scale Enterprises
MDM	Measurement Data Management
Mgmt	Management
MIS-PyME	Marco Metodológico para la Definición de Indicadores de Software oriented a PyME
MMM	Measurement Maturity Model
MCMM	Measurement Capability Maturity Model
Obj	Objective
OT	One Time
PAK	Pakistan
PSM	Practical Software and System Measurement
PMBOK	Project Management Body of Knowledge
PM	Project Management

PM1	Project manager in company ABC
PICO	Population, Intervention, Comparison, Outcome
PIS	Participant Information Sheet
QA	Quality Assurance
RAPID	Rapid Assessment for Process Improvement for Software Development
RE	Requirements Engineering
ReLEASS	Research Laboratory for Empirical Analytics and Software Services
RQ	Research Question
SA	Systems Analyst
SERL	Software Engineering Research Laboratory
SDEs	Software Development Enterprises
SDLC	System Development Life Cycle
SM	Software Measurement
SMP	Software Measurement Program
SMPI	Software Measurement Program Implementation
SPI	Software Process Improvement
SMEs	Small and Medium Enterprises
SSMEs	Software Small and Medium Enterprises
SMPI in SMEs	Software Measurement Program Implementation in SMEs
SMF	Software Measurement Framework
SMF4SME	Software Measurement Framework for SMEs
SMK	Software Measurement Knowledge
SWEBOK	Software Engineering Body of Knowledge
SE	Software Engineering
SLR	Systematic Literature Review
SMP	Systematic Mapping
SQM	Software Quality Manager
TC	Time & Cost efficient
TL	Team Lead
UAE	United Arab Emirates
WBS	Work Breakdown Structure
XP	Extreme Programing
XYZ	Small-Sized Company Where Case 3 was Conducted

PART 1: BACKGROUND

This thesis comprises four parts. This first part, made up of three chapters, provides the necessary background to the research conducted during this PhD and reported in this thesis. The central topic of Software Measurement Program Implementation in Small and Medium Enterprises (SMPI in SMEs) is motivated and introduced in the first chapter, general related work is considered in the second, and the research methodology and design are presented in the third.

Chapter 1 Introduction

Chapter 1 introduces this thesis, which has been conducted on the topic of Software Measurement Program Implementation in Small and Medium Enterprises (SMPI in SMEs). In this chapter, the research background, motivation, and research questions are first presented, the main contributions of the research are next described, and finally a high-level description of the structure of the thesis is provided.

1.1 Background and Motivation

1.1.1. Background

The use of measurement is common in everyday life, such as checking the shortest path to a destination or weighing luggage before taking a flight. In spite of its obvious benefits and its common application in many sciences and engineering disciplines (such as electrical and mechanical engineering), measurement has been perceived as being particularly complex and multi-faceted in software development, and therefore as a challenging and potentially costly endeavour for software SMEs (SSMEs).

Yet, there is a strong and enduring body of evidence that systematic Software Measurement Programs (SMPs), often integrated within software process improvement (SPI) practices, can play a vital role in software organizations (Bouwers et al., 2012; Wangenheim et al., 2009; Iversen Mathiassen, 2000; Morisio, 1999; Niessink & Vliet, 1998). Soundly designed measurement practices and programs help users to understand, control and improve both processes and products (Bieman, 1997; Fenton & Pfleeger, 1998). Benefits can accrue in a range of ways, such as in ensuring software quality (Alexandre et al., 2006; Lincke et al., 2008; Solingen & Berghout, 2001; Wangenheim et al., 2009; Wallace & Sheetz, 2014; Wang et al., 2011); to enable more effective requirements management (Loconsole & Borstler, 2007); for understanding, controlling, and predicting various software attributes (Jacquet & Abran, 1997; Wallace & Sheetz, 2014; Westfall, 2005b), leading to better project plans for the development team, and enabling them to make the best use of resources (Gwak & Jang, 2006b); in increased productivity and reduced cycle times (Daskalantonakis, 1992); in project decision making (Soini, 2011; Staron, 2012; Staron et al., 2009); in achieving organizational goals (Bouwers et al., 2012); and in improving organizational maturity (Abran, April, & Buglione, 2010).

The key role of measurement in effective software management has long been acknowledged (Feigenbaum, 2001). In 1986 DeMarco captured this succinctly: “You can’t control what you can’t measure” (DeMarco, 1986). There is, in fact, an ongoing cycle of management linked to measurement, in that process improvement clearly relies on adequately measured baselines in the first instance, and sound measurement of change in the second (Bourque et al., 1999; Gardner, 2001).

Despite all of these reported benefits, many organizations – reportedly as high as 70% - are not implementing SMP (Bourque et al., 2004; Soini, 2011; Wallace & Sheetz, 2014), and even then it has been suggested that most of them are using it as an additional validation method only as opposed to a formal or systematic endeavour (Popović & Bojić, 2012). This is because there are some genuinely significant impediments to the adoption and sustenance of SMPs. According to Díaz-Ley, García, and Piattini (2008d) implementing software measurement is not a straightforward task. Sometimes, it fails because the required data is difficult to obtain, which directly affects the utility and timeliness of its inferences. It has been suggested that approximately 80% of measurement programs fail due to indecision (Bundschuh & Dekkers, 2008; Goethert & Hayes, 2001): first, organizations face difficulties in deciding what should be measured; second, they make improper use of measurement data in decision-making, which debilitates organizational success and progress; and third, many managers are unaware of measurement’s fundamental concepts (Dekkers & McQuaid, 2002; Wallace & Sheetz, 2014), meaning that they decide not to use measurement in the first place or they use it inappropriately. More generally, the lack of a *systematic* approach to SMP is held responsible for the high failure rate of SPI initiatives (Iversen & Ngwenyama, 2006). In addition, measurement programs traditionally started by measuring what is easy to measure as opposed to what is needed (Fenton, 1991). Defining an SMP without considering stakeholders’ needs and opinions is almost certain to mean they will not engage meaningfully in its use. Measurement programs are more likely to fail if they are perceived as having been ‘added on’ – rather, they should be integrated into the corporate culture of organizations (Selby, 2005). Finally, the software measurement process itself carries a cost (Diaz-Ley et al., 2008), and can require significant effort to develop and sustain. Thus, even when started, 50% to 80% of software measurement programs may not continue beyond 2 or 3 years (Howard, 1991).

In order to improve the uptake and use of SMPs, many standards, models and prescribed approaches have been designed. For example, the ISO/IEC 15939 standard (ISO/IEC, 2007) identifies a set of recommended activities and tasks to identify, define, select, apply and improve software measurement. In keeping with an industry standard, however, it is inherently generic and high-level in nature. Several goal-based approaches to measurement and metric selection have therefore been introduced, and the Goal Question Metric (GQM) framework is one of the most well-known and widely adopted (Fenton & Bieman, 2014). The key principle underpinning such approaches is that measures should be chosen and collected based on the particular goals of the organization at that particular point in time. While software engineers have generally accepted that measurement should indeed be goal-oriented, some reservations have been expressed over the efficiency of GQM (Latum et al., 1998). One of the criticisms, for instance, is that the measures chosen through GQM are often more than are actually needed to enable goal achievement (Dekkers & McQuaid, 2002). Furthermore, although GQM and other GQM-based frameworks have resolved some measurement issues, they also have some limitations. For example, defined goals can be subject to inconsistent interpretations, and stakeholders may have different perspectives on the same goals (Fenton, 1991).

Though a non-trivial body of research exists relating to SMPI in general, relatively few research publications have specifically addressed the context of SMPI in SMEs. A full review of these studies is reported in Chapter 4, but a few are highlighted here for illustration of the topics covered. For instance, two studies measured particular aspects of SMES performance (Ho et al. 2015) or their measurement data management (Tihinen and Järvinen 2006a). Examples of SMPI in small organizations were provided by Meredith et al. (2012), who presented a four-step framework, and the Adept assessment framework small software companies promoted by Caffery et al., (2007). Only a handful of studies have sought to address SMPI in SMEs in general and to provide multi-use solutions. These include the GQM-Lightweight Method (Wangenheim et al., 2003) and MIS-PyME (Marco metodológico para la definición de Indicadores de Software oriented a PyME) as reported in a series of studies (Diaz-Ley et al., 2009; Diaz-Ley et al., 2008; Díaz-Ley et al., 2008; Díaz-Ley et al., 2007, 2008b, 2010a). The results of the literature review undertaken to date indicate that approaches need to be structured, controlled and integrated to enable effective software measurement (Diaz-Ley et al., 2008; Niessink & Vliet, 1998).

1.1.2. Motivation

The economies of many countries, including New Zealand, rely heavily on the effective working of SMEs. Furthermore, relatively recent shifts to the provision and use of software service ecosystems indicate that SMEs can not only survive in competitive contexts but can, in fact, thrive long-term even at a small scale.

However, most of the existing research on the workings of software companies has been conducted in large-scale organizations working on large-scale projects. Given the new work context described above, it is imperative to understand the processes that enable SMEs to be successful in software development. In the general case, software measurement has been considered to be one of the keys to success.

The results of the reviews of the research literature and industrial practice reported in this research show that SMEs continue to face challenges in undertaking SMPI. These include limited awareness and expertise, high costs of implementation, extensive time commitment, and a steep learning curve for SMPI. Resource limitations are the root cause for some of these identified challenges, and as such, many SMES practitioners are reluctant to implement software measurement programs in their organizations. Moreover, this study has also concluded that current approaches to SMPI in SMEs are insufficient, and would require improvement to address the identified challenges. In brief, some of the drawbacks of existing solutions for SMPI in SMEs have been found to be the following:

- They are not easy to use.
- Roles and responsibilities are not defined.
- They do not involve all relevant stakeholders.
- None includes a communication model.
- There is an absence of metrics dashboards.

Above all, the existing solutions do not address the software process initiation, definition and management requirements of SMPs that are relevant to SMEs in particular. A detailed review of existing solutions' strengths and weaknesses is presented in Chapter 6, section 6.2.3.

As such, the development of an alternative, light-weight solution is preferred to initiate, define and manage SMP. This solution should give practitioners more understanding of the process, especially those who are reluctant to implement SMP due to the shortage of resources.

The purpose of this research is to comprehensively explore the particular challenges encountered by SMEs when they embark on a software measurement initiative, in order to identify ways in which we could better support SMEs to implement and sustain software measurement programs (SMPs). As a major contribution, this research has led us to propose, refine and validate a novel Software Measurement Framework for SMEs (SMF4SME) which is intended to overcome measurement implementation challenges in SMEs.

1.2 Research Goal and Objectives

The high-level goal of this research is "*To provide a comprehensive understanding of how SMPs should be implemented, and to provide a light-weight framework to support SMP implementation in practice in SMEs*". Therefore, this research focuses on the establishment of simple, sufficient and straightforward software measurement programs in SMEs – lean and sustainable SMPs rely on organized initiation, clear and planned definition, managed execution, by appropriate people. The research first needs to establish a baseline, by specifying the SMP needs of SMEs and by assessing existing approaches in terms of their being lean and sustainable. Thereafter, the core objective becomes: "*define a light-weight software measurement framework (SMF) to better support SMEs in establishing and sustaining measurement programs*". The SMF should consider SMPI challenges/obstacles encountered by SMEs when they undertake software measurement.

To achieve this particular research objective, the following milestone objectives were defined.

Obj1: To study the current state-of-the-art of the research context through an in-depth literature review.

Obj2: To study the current state-of-practice through an in-depth industrial review in SMEs.

Obj3: To compare the state-of-the-art and state-of-practice in order to identify the main challenges faced in the context of SMPI in SMEs.

Obj4: To develop a framework to enable SMEs to implement simple, sufficient and straight-forward SMPs.

Obj5: To validate and evaluate the perceived utility of the SMF4SME.

1.3 Research Questions

As discussed in preceding section, the goal of this research is "*To provide a comprehensive understanding of how SMPs should be implemented, and to provide a light-weight framework to support SMPI in practice in SMEs*." To attain this goal, the research was divided into three parts as per the DSR paradigm: problem identification, solution design and development, and evaluation. Further detail of DSR and the specific approach taken here is provided in Chapter 3, Methodology. The research addresses five research questions as listed in Chapter 1 and explained as follows:

RQ1: What is the state-of-the-art of SMPI in SMEs?

The RQ1 is divided into further sub-questions as follow:

RQ 1.1: What software measurement tools, techniques, frameworks, and methods have been developed specifically for SMEs?

RQ 1.1.1: What software measurement tools, techniques, frameworks, and methods are being used by SMEs?

RQ 1.2: What are the main areas of focus in software measurement programs in SMEs?

RQ 1.3: What are the reported success factors in implementing software measurement programs in SMEs that have been identified in previous research?

The aim of RQ1 is to systematically investigate the state-of-the-art of SMPI in SMEs as reported in the literature, with specific attention given to the challenges and success factors of SMPI in SMEs. The intent is:

1) To provide an overview of the specific measurement tools, techniques, frameworks and methods that have been developed specifically for SMEs.
2) To identify the extent to which the above have been adopted for use.
3) To identify research trends in SMPI in SMEs and possible research gaps in the area.
4) To identify factors that cause success and failure for SMPI in SMEs and to inform the development of novel solutions that could improve SMP for SMEs.

To the best of our knowledge, no review has been conducted for SMPI in SMEs to date (although other relevant reviews have been conducted on SMPI in general, such as those of (Gómez et al., 2008a; Kitchenham, 2010b; Tahir & Jafar, 2011; Tahir et al., 2016)).

Based on the findings of the mapping study presented in Chapter 4, a range of challenges and success factors for SMPI in SMEs are identified, and these in turn form the basis of a potential solution.

RQ2: What is state-of-practice (in industry) of SMPI in SMEs?

The aim of industrial review was to identify the challenges and success factors of SMPI in practice. The intent is:

1) to identify deficient and unexplored areas of SMPI in SMEs.
2) to identify SMPI challenges and approaches to overcome them.
3) to identify success factors of SMPI in SMEs particularly.

To further investigate the research context the next phase presents an industrial review. Specifically, this work qualitatively examines the SMPI approaches of a small number of software SMEs. This industrial review is conducted as the second part of the DSR first phase, problem identification. In doing so it investigates the factors that could be considered to impact SMPI in SMEs and outcomes as captured from industry.

RQ3: What are the differences in the challenges and success factors for SMPI implementation as identified in the literature and industrial reviews?

The aim of this question is to compare the findings of the literature and industrial reviews. The intent is:

1) to understand how SMEs operate,
2) to consider SMEs' specific constraints,
3) to understand the reasons why SMEs do not use SMPs, and
4) to propose a cost-effective solution that would better support their efforts.

RQ4: Can SMP be implemented effectively and efficiently in SMEs?

The aim of aim of this question is to determine whether it is feasible to design and develop workable SMPI solutions for SMEs. The intent is:

1) to develop and evaluate a new software measurement framework (SMF) based on the findings determined through the literature and industrial reviews.
2) to develop the SMF by working in real-time with relevant employees.
3) to implement a sustainable software measurement program in SMEs.

RQ5: Does SMF4SMEs fulfil the requirements of SMPI in SMEs?
The aim of this research question is to evaluate the developed SMF. The intent is:

1) to evaluate the SMF by conducting a survey, seeking feedback from industry experts.
2) to evaluate the perceived usefulness of the SMF in the SMES context.
3) to validate SMF independently through industrial specialists' perceptions.
4) to inform potential improvements for the SMF.

1.4 Methodology

As a research endeavour undertaken in order to deliver and evaluate an artefact, this work employs the Design Science research (DSR) methodology, following the guidelines provided by Offermann et al. (2009). For over 40 years, the field of DSR has undergone development and refinement, seeking approaches that combine research and design (Cross, 2007). DSR thus provides transparent guidance and a roadmap for IS research in design sciences (Offermann et al., 2009). The DSR process followed in this research work consists of three major phases: problem identification, solution design, and evaluation. Figure 1-1 depicts the mapping of each DSR phase to the chapters in this thesis.

This research thus begins with the first phase of DSR, i.e., problem identification in the domain of SMPI in SMEs. It requires that the problem has practical relevance or might be of relevance once solved (Benbasat & Zmud, 1999). The state-of-the-art and state-of-practice assessments, conducted via literature review and practitioners' interviews respectively, are the means used to identify and verify contemporary problems (Offermann et al., 2009). These components are presented in Chapter 4 and Chapter 5 respectively. The outcomes provide an overview of the research to date in the areas of SMP in SMEs, along with ongoing challenges and gaps. The findings of the problem identification phase thus lead to the development of new SMF, which should overcome the identified challenges of SMPI in SMEs.

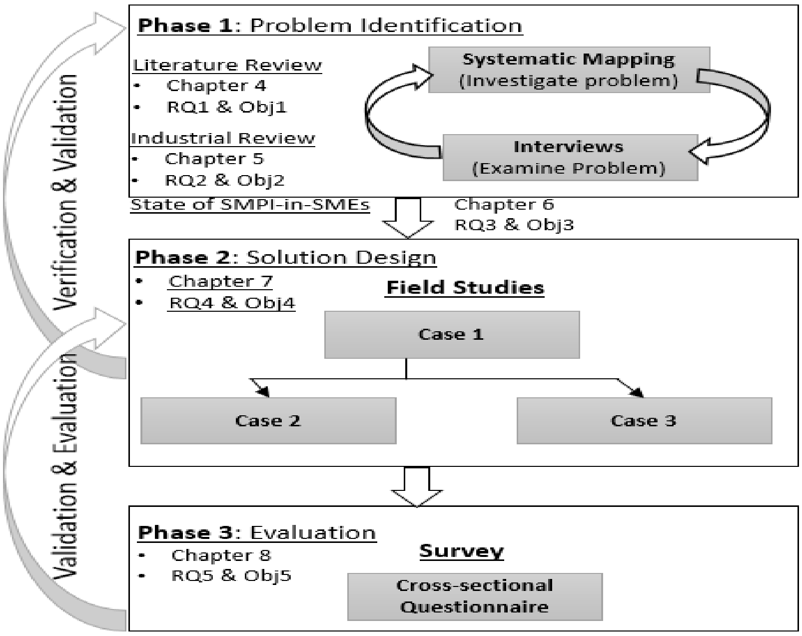

Figure 1-1 Research Design

In the second phase, a solution therefore has to be designed and developed by taking the state-of-the-art and existing solutions into account (Offermann et al., 2009). In this second phase, we worked with two companies to design, develop and refine a light-weight SMF that addressed relevant challenges and obstacles of SMPI in SMEs. Thereafter, a light-weight SMF4SMEs was developed on the basis of three field studies in these selected SMEs. The detailed field studies discussion and outcomes are presented in Chapter 7.

The third phase of solution evaluation could be started only after reaching an adequate state of the proposed solution (Offermann et al., 2009). In this phase of the research, a survey of practitioners from a range of software development enterprises (SDEs) (irrespective of organization size) was conducted to evaluate the perceived usefulness of the developed SMF and to validate its general acceptance. Data was collected from 110 practitioners from multiple

SDEs based in a number of different countries. The detailed discussion of the survey and its outcomes are presented in Chapter 8.

A sequential mixed methods approach, employing both qualitative and quantitative analysis methods, is utilised in this research (Creswell, 2013), wherein quantitative findings are used to revisit, and confirm where appropriate, the qualitative findings. A detailed discussion of the research methodology employed is presented in Chapter 3.

1.5 Contributions

This research contributes primarily to simple, sufficient and straight-forward SMPI, which remains a challenge for many SMEs. The proposed SMF4SMEs should mean that SMPI is more successful, by ensuring that stakeholders do not require any prior software measurement knowledge, extra resources and additional time and cost to implement SMPs. It explicitly addresses the need to initiate, plan and establish cost-effective measurement programs in dynamic environments, where the information needs, their priorities and the constraints of the organization change. In particular, the SMES sector is targeted in this research and so stands to gain most substantially from it. In addition to the thesis, the researcher anticipates that the research outcomes will form the basis of refereed conference and journal publications.

The specific findings of this thesis contribute to the body of knowledge on SMPI in SMEs, as discussed in Chapter 9 in detail and concluded in Chapter 10. There are two key outcomes in this research work; the first is the comprehensive understanding of SMPI in terms of challenges, obstacles, benefits and success factors, as presented in Chapter 5; the second is the validated light-weight SMF4SMEs through which SMEs should be able to implement simple, sufficient and straight forward SMPs, as presented in Chapter 7.

1.5.1. Thesis Structure

This thesis is structured in ten Chapters, presented as follows:

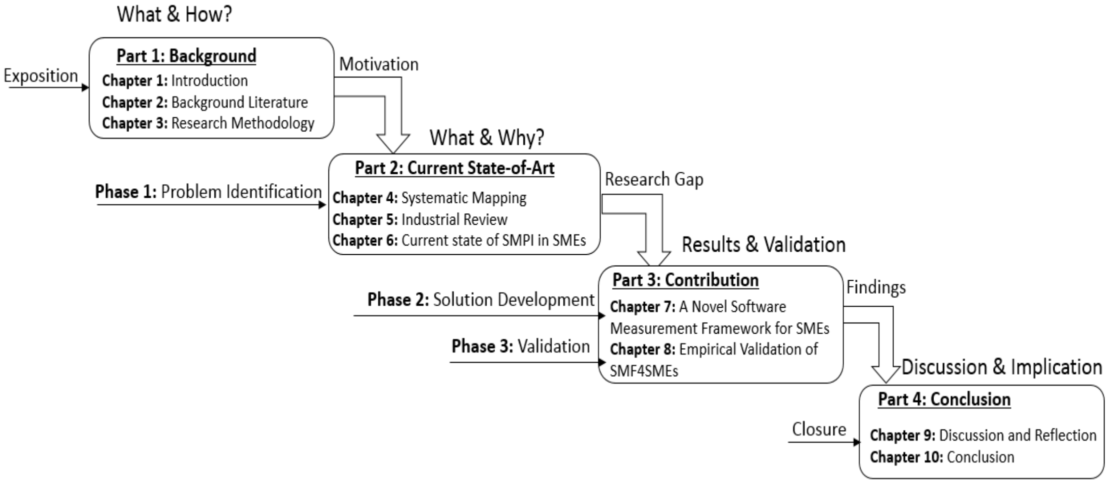

Figure 1-2 Thesis Structure

Chapter 1: Introduction

This is the current Chapter 1 which presents the background to the topic and explains the goals and objectives of this research.

Chapter 2: Background Literature

Chapter 2 presents background literature in a broader context, to provide the reader with an understanding of software measurement history and to then narrow down towards the specific research context of relevance to the work conducted and reported here.

Chapter 3: Research Methodology

This chapter presents the research design and research methods used to achieve the research goals and objectives, as employed in each phase of the DSR research process.

Chapter 4: Systematic Mapping

Via a Systematic Mapping Chapter 4 provides in-depth insight into the research topic as considered in the literature as the state-of-the-art. All the steps conducted in the mapping study are presented and discussed. Resulting research gaps are identified accompanied by a narrative summary of the findings.

Chapter 5: Industrial Review

Chapter 5 presents the industrial review findings and the state-of-practice. It explores the findings of the industrial review and specifies four preliminary exploratory frameworks for SMPI: challenges, obstacles, benefits and success factors.

Chapter 6: Current state of SMPI in SMEs

This Chapter 6 describes SMPI challenges, success factors and existing methodologies of SMPI in SMEs. It compares the literature and industrial review findings to highlight the current state of SMPI in SMEs. Furthermore, it investigates the suitability of current methodologies within the same context. Chapter 6 will clarifies the research gaps and provides greater context to the research contributions.

Chapter 7: A Novel Software Measurement Framework for SMEs (SMF4SME)

Chapter 7 presents the field studies as conducted and describes the evolution of the proposed SMF4SME, followed by a full explanation of the basis of SMF4SME.

Chapter 8: Validation

This Chapter 8 quantitatively assesses whether SMF4SMEs fulfils the initiation, definition and management needs for SMPI in SMEs. It comparatively analyses the survey data, accommodating variance in organization size and participant experience.

Chapter 9: Discussion and Reflection

Chapter 9 discusses the findings of each research phase with respect to the research objectives. In addition, it presents the associated outcomes.

Chapter 10: Conclusion

The conclusion presents the overall findings of the research, reflecting the novel contributions to research and practice. Additionally, it presents the research implications, validity threats and an overview of possible future work.

Chapter 2 Background Literature

This Chapter 2 provides the necessary background on software measurement (SM). It first introduces how SM has evolved and what has been achieved as reported in various forms of literature. It then more generally describes measurement and measures, the latter of which are commonly referred to as metrics in the context of SE. Further, it discusses the place of measurement in software engineering. Later, it considers the relevance of organizational characteristics with respect to the research topic, followed by an explanation of our research questions.

2.1. The Emergence of Software Measurement

Since the late 1960s Software Engineering (SE) has been accepted by some as a branch of engineering. As such it is considered to be young compared to other engineering branches, such as civil, electrical, mechanical and others. Just as in those other engineering fields, software measurement (SM) is held to be one of the vital processes in software engineering. Harrington highlighted the importance of SM as follows: “Measurement is the first step that leads to control and eventually to improvement. If you cannot measure something, you cannot understand it. If you cannot understand it, you cannot control it. If you cannot control it, you cannot improve it” (Harrington, 1987). The Institute of Electrical and Electronics Engineers (IEEE) defines Software Measurement as, “a standard that describes the characteristics of evaluating a process of product” (IEEE, 1991, p.129).

To date, many software development enterprises (SDEs) have implemented software measurement programs (SMP). However, implementation of successful SMPs remains a significant challenge (Tahir et al., 2016). Several researchers have underlined the practical problems and challenges that can arise in the initiation and application of SMPI in software development enterprises (SDEs). For instance, a well-known and widely cited empirical study on software measurement initiation and implementation, reported by Michael and Daskalantonakis (1992), presented a case study which was conducted within Motorola. Rifkin et al., (1991) developed recommendations for successful metrics programs. Dekkers also listed the ‘secrets’ of highly successful measurement programs (Dekkers, 1999). Iversen and Kautz drew on these prior works to put forward ten principles for metrics implementation efforts (Iversen & Kautz, 2000). Furthermore, Westfall defined 12 steps of useful software metrics programs, based on her experience as a software quality engineering training and consulting services provider (Westfall, 2005a). More recently, Mitre-Hernández et al., and Perla (2014) reported their experiences designing a strategic SMP for SDEs, where they mainly highlighted the difficulties and problems. They note that, despite several successful SMPI stories that have been presented in literature, there are still concerns about SMP initiation and implementation in SDEs.

There have also been efforts to develop standard measurement programs that can help organizations to implement efficient and effective measurement processes. In particular, the International Standards Organization (ISO) has introduced multiple SM-related standards that suit different types of projects or organizations. For example, ISO/IEC 15393 includes steps such as "establish and maintain measurement capability", "plan measurement," "perform the measurement," "evaluate measurement" and "improve measurement." Moreover, ISO 25000, intended to measure software quality, is based on ISO/IEC 9126 (Software product quality) and ISO/IEC 14598 (Software product evaluation). Another well-established model used to assess the capability of software development organizations is the Capability Maturity Model Integration (CMMI). This model has four main process groups: Project Management, Process Management, Support, and Engineering. Measurement is a part of the Measurement and Analysis process area, which is a part of the Support group (Ruiz et al., 2011). This process area is intended to develop and sustain measurement capability, which could be used to satisfy management information needs.

Adoption of these standards and approaches is not free – it requires extra training resources, commitments of effort, time and cost, and requires patience and persistence for successful implementation (Díaz-Ley et al., 2007; Haddad et al., 2012; Laporte & April, 2006; Laporte et al., 2006a; Ruiz et al., 2011). Many such solutions are considered to consume an excessive amount of resources when considered against the benefits to be gained, and several are very complex in themselves. To overcome such issues, researchers have proposed more informal process improvement approaches (Albarracin et al., 2014) which facilitate the implementation of these formal models (Haddad et al., 2012). An example of these informal methods includes Goal Question Metrics (GQM), Goal Question Indicator Metrics (GQ(I)M), GQM lightweight, Rapid Assessment for Process Improvement for Software Development (RAPID), and MIS-PyME. Most of these methods are designed for SMPI generally, whereas some, such as GQM-lightweight (Wangenheim et al., 2003), and MIS-PyME are specifically designed to overcome the measurement challenges faced particularly by SMEs.

As the body of literature on software measurement grew several literature surveys on the topic of SMPI were reported. Gómez et al. (2008a) conducted a systematic literature review to provide a summary of trends in SM research work. Kitchenham (2010b) reported a mapping study to identify the trends in software metrics. Tahir and Jafar (2011) investigated SMPI solutions and success factors. Maretto and Barcellos explored the measurement architectures described in the literature to come up with eight different architectures (Maretto & Barcellos, 2013). A mapping study conducted by Fonseca et al., (2015) explored tool integration to support SMP, wherein they analysed 12 proposals and report their characteristics. One of the latest reviews to date was conducted by Tahir et al. (2016) – this study reviewed the SMP literature with respect to investigating the success and failure factors of SMPI, and the mitigation strategies for challenges.

The mainstream nature of software measurement is also evident in its treatment in monographs and student tests. To the best of our knowledge, the first book on SMP was written by Halstead (1977), in which author described the elements of software science and sought to establish the first analytic laws of computer software. He suggested that the measurements might be applied to design or code completion. “A framework for software measurement” was written by Zuse (1998) to depict multiple views of software measurement, such as its theoretical, evaluative and practical aspects. The specialist text “Software Metrics: A Rigorous and Practical Approach”, written by Fenton and Bieman (2014), comprehensively discussed SMP from very basic measurement knowledge to its applicability in software engineering. Measurement is a core topic in the two principal SE textbooks, by Somerville and Pressman (Sommerville).

Finally, the Guide to the Software Engineering Body of Knowledge (SWEBOK) (Abran et al., 2001; Bourque, 2004; Bourque and Fairley, 2014) drew on many of the above sources in highlighting the applicability of various measurement techniques and methods depending upon the different stages of SDLC with respect to management expectations.

2.2. Measurement and Measures (or ‘Metrics’)

An early IEEE definition of the concept of a measurement standard noted it as “A standard that describes the characteristics of evaluating a process or product” (IEEE, 1991, p.129). In 1998 the IEEE (1998, p.2) adopted a new definition, as “the act or process of assigning a number or category to an entity to describe an attribute of that entity”. Further, ISO states that “Measurement supports the management and improvement of processes and products. A measurement is a primary tool for managing system and software life cycle activities, assessing the feasibility of project plans, and monitoring the adherence of project activities to those plans" (ISO/IEC, 2007, p.2).

Software measures, often referred to as metrics, were developed primarily to support those making quantitative managerial decisions (Alexandre, 2002). "Formally, we define measurement as a mapping from the empirical world to the formal, relational world. Consequently, a measure is the number or symbol assigned to an entity by this mapping in order to characterize an attribute" (Fenton, 1996, p.28). Further, Fenton and Neil define software metrics as "a collective term used to describe the very wide range of activities concerned with measurement in software engineering. These activities range from producing numbers that characterize properties of software code (these are the classic software 'metrics') through to models that help predict software resource requirement and software quality. The subject also includes the quantitative aspects of quality control and assurance - and this covers activities for example recording and monitoring defects during development and testing" (Fenton & Neil, 2000, p.360). Fenton thus notes that software metrics may be defined to evaluate attributes of products, processes or resources.

2.3. Measurement and Software Process Improvement (SPI)

Organizations frequently use SMPs to improve software processes, initially through the establishment of baselines, through benchmarking, and through the assessment of change. SMP and SPI are therefore closely linked (Morisio, 1999; Wangenheim et al., 2003; Allen et al., 2003; Basili & Caldiera, 1995; Grady, 1997; Humphrey, 1989; Kitchenham, 1996), and SM is acknowledged as a key factor to facilitate successful SPI (Dybå, 2005; Hall et al., 2000); Easterbrook et., 2008; Goldenson et al., 1999). Moreover, at an organizational level, SM enables the assessment of SPI policies and strategies (Mathiassen et al., 2005). Having said all of this, it is not a trivial exercise to choose and implement a SMP that provides the relevant information for making decisions (Brown & Goldenson, 2004; Mathiassen et al., 2005), and the lack of a systematic and reliable SM approach has been held to be responsible for a high failure rate in SPI initiatives (Iversen & Ngwenyama, 2006).

2.4. Measurement Methods, Standards, and Models

In order to be most effective in terms of improving organizational maturity measurement program adoption should adhere to accepted standards and/or models (Díaz-Ley et al., 2007) – relevant literature shows a strong positive relationship between the use of international standards and software measurement success (Díaz-Ley et al., 2007; Haddad et al., 2012; Ruiz et al., 2011). Díaz-Ley et al. (2007) go as far as to say that adoption and implementation of such standards, for example, CMMI and ISO/IEC 15939, is a guarantee of best measurement practice. This section presents some of the most well-known SMPI methods and standards which support the definition and improvement of software processes.

2.4.1. Goal Based Measurement Approaches

In the SMPI literature strong emphasis is placed on the importance of goal-based measurement. The first major contribution towards goal-based measurement was made by Basili (1992) who proposed the Goal Question Metric (GQM) approach, and it has become something of a de facto standard in software engineering. A guide by Park et al., (1996) explains the goal-based measurement process in depth. A GQM-based approach proposed by Briand et al., (2002) defined measures of product attributes in SE. Their proposed approach was driven by measurement goals, expressed through GQM, and a set of empirical hypotheses. Several SMPI solutions have also been developed based on GQM, for example, a template-supported GQM subsidiary known as Goal Question Indicator Measure (GQ(I)M) (Boyd 2002). Huang and Far (2006) proposed so-called intelligent software measurement systems for automating the GQM process. An extended version of GQM was also presented by Berander and Jönsson (2006), where the authors' claimed contribution was in the prioritization of goals and questions and also the categorization of question types. In 2007, Basili et al. proposed GQM+Strategies to bridge the gap between business strategies and software development (Basili et al., 2007; Basili et al., 2013). This particular approach was built on by Petersen et al., (2015), where they developed an elicitation instrument said to completely and accurately identify GQM+Strategies elements from measurement stakeholders in order to build a GQM+Strategies grid. Another related goal-based SM solution, developed in part by the researcher as part of a prior study, is the GQM-Decision Support Framework for Metrics Selection (GQM-DSFMS) (Gencel et al., 2013).

2.4.2. Goal Question Metrics (GQM)

As just noted, GQM has become a well-known SMPI approach which was first defined by Basili and Weiss (1984) and was extended by (Basili, 1992), initially to evaluate and reduce the incidence of defects in NASA projects. The approach was further refined by Wangenheim and Rombach (1995) based on process (Basili et al., 1994b) and (Basili et al., 1994a) 'software factory' experiences. van Solingen and Berghout (2001) further improved the GQM by implementing it at multi-national manufacture Schlumberger. The method provides guidelines to support the definition of a measurement program which includes context, objectives, and a measurement process plan. Additionally, it provides guidelines for data collection, analysis, results interpretation and improvement identification.

GQM first refines the stated goals into a set of quantifiable questions. This set of questions is then used to identify which data needs to be collected, which guides the selection of appropriate metrics. The intent is that the data collected should be used for decision making, and to analyse whether the defined goals have been achieved. Hence, the metrics in GQM are defined from a top-down perspective, whereas they are analysed from a bottom-up perspective.

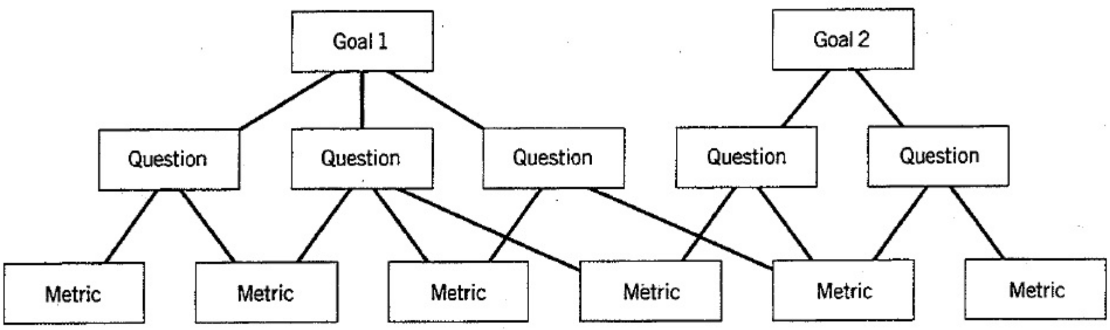

Figure 2-1 GQM method (Victor R Basili, Caldiera, & Rombach, 1994b)

2.4.3. ISO/IEC Standards

The Practical Software and System Measurement (PSM) approach, based on ISO[1]/IEC[2] 15939 (ISO/IEC, 2007), is said to identify the activities and tasks which enable users to define, apply and improve SMPs. The activities of the SM process as defined by ISO/IEC 15393 include establishing and maintaining measurement capability, then planning, performing, evaluating and improving measurement. Furthermore, each activity defines a set of tasks, and each task specifies a set of norms. According to ISO/IEC 15939, to manage the processes and to objectively demonstrate the quality of projects, SM processes must be used. Figure 2-2 shows the highest level process as defined in ISO/IEC 15939 (ISO/IEC, 2007).

The international standard ISO/IEC 25000, also known as SQuaRE[3], was developed by ISO Joint Technical Committee ISO/IEC JTC 1, Information Technology, to measure software quality. The main objective of ISO/IEC 25000 is to guide software product development through the specification of quality requirements and the evaluation of quality characteristics.

[1] International Standard Organization for Standardization.
[2] International Electro technical Commission.
[3] System and Software Quality Requirements and Evaluation.

This standard in fact comprises a series of standards based on ISO/IEC 9126 (Software product quality) and ISO/IEC 14598 (Software product evaluation) (ISO/IEC, 2007).

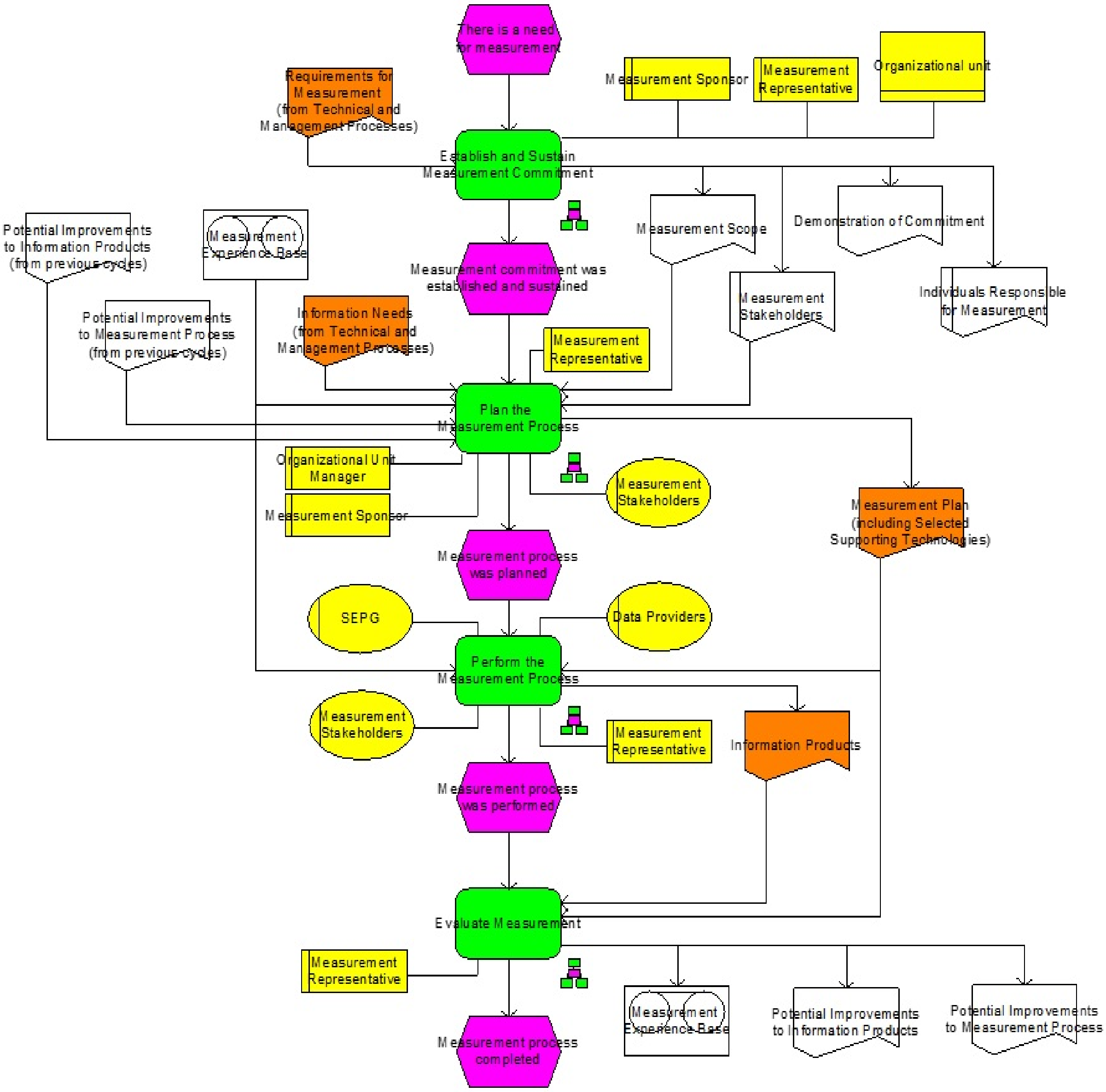

Figure 2-2 ISO/IEC 15939 (ISO/IEC, 2007)

2.4.4. Capability Maturity Model Integration (CMMI)

The CMMI is a general model used to assess the capability maturity of software organizations. It contains four main groups of processes: Project Management, Process Management, Support, and Engineering. Measurement features within these processes; for instance, under the Support process is a measurement and analysis process area (MAPA) (Ruiz et al., 2011). The MAPA specifies measurement practices which are said to guide organizations on how to align their measurement objectives with results that need to be used in decision making and in order to inform appropriate actions.

CMMI is structured into five maturity levels, where a maturity level indicates the extent to which a set of processes is implemented and institutionalized (Jones & Soule, 2002; Jones, 2002). These five maturity levels include: Initial (informal processes), Managed (basic project management), Defined (standard process(es) across projects), Quantitatively Managed (quantitative management of processes) and Optimizing (continual process improvement). Measurement is said to be essential at level 2 and above. Figure 2-3 shows the measures types defined for each CMMI maturity level (Díaz-Ley, et al., 2008d).

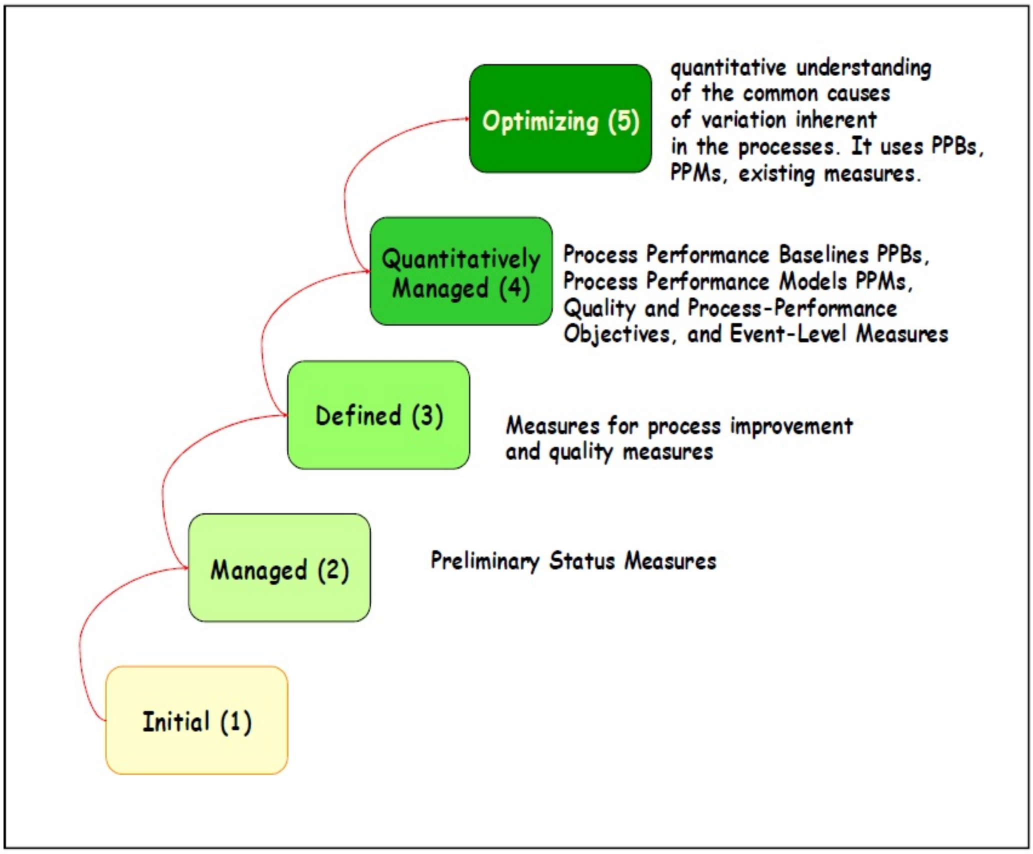

Figure 2-3 CMMI and SM (Díaz-Ley, et al., 2008d)

2.5. Software SMEs (SSMEs)

In general, larger organizations tend to have more mature practices and more adequate budgets to implement measurement processes and standards. Moreover, simply by virtue of their larger size, the need for process tends to be higher. In contrast, SMEs (who all the same make major contributions to the software development sectors of many countries), typically lack or even avoid such processes (Diaz-Ley, et al., 2008). Some suggest that this inevitably contributes to project failure (Niazi & Babar, 2009), which may be especially disastrous for an SME that is reliant on a single product or service. Therefore, there is a need to understand how SMEs operate, to consider their specific constraints and the reasons why they do not use measurement programs, and to propose a cost-effective solution that would better support their efforts. Research shows that there are numerous differences between SMEs and large organizations, relating to employee knowledge, enterprise structure, and level of capabilities (Sahran et al., 2010; Taylor & Kane, 2005).

Richardson and Wangenheim remark that companies with fewer than 50 employees are fundamental to many national economies' growth (Richardson & Wangenheim, 2007). Furthermore, they note that in Brazil, China, India, Canada, Finland, Ireland, and Hungary, and in many other countries, small companies represent up to 85 percent of all software organizations. Other studies have reached similar conclusions (Cater-Steel, 2001; Laporte et al., 2006b; Richardson & Wangenheim, 2007). According to the New Zealand Government, 97% of enterprises have 19 or fewer employees, and SMEs dominate most industries (459,300 enterprises have either no employees, 1-5 employees (micro-enterprises), or 6-19 employees (small enterprises)) (Joyce, 2014).

To date the research literature addressing software measurement has not been focused on such enterprises (Fayad et al., 2000; Pino et al., 2008; Richardson & Wangenheim, 2007). This research thus focuses on SMPI approaches in SMEs, in light of their substantial contribution to software development worldwide (Anacleto et al., 2004; Diaz-Ley et al., 2008; Díaz-Ley et al., 2007; Haddad et al., 2012; Laporte et al.,, 2008; Laporte et al., 2005; Caffery et al., 2007; Ross & Haddad, 2010) and the relative absence of attention given to them in the literature on software engineering and SPI (Fayad et al., 2000; Pino et al., 2008; Richardson & Wangenheim, 2007).

2.5.1. Software Measurement Solutions for SMEs

This section presents only solutions that have been proposed for SMPI in SMEs in general and excludes solutions that address only a single aspect of measurement or estimation.

2.5.1.1. GQM-Lightweight (Wangenheim et al., 2003)

To the best of our knowledge, GQM-lightweight is one of the first solutions to be proposed in the literature for SMPI in SMEs (Wangenheim et al. 2003). GQM-lightweight applies GQM based methodologies, such as those described by Park et al. (1996) and Solingen & Berghout (1999), which were in turn built upon the GQM approach of Basili (1992), to SMPI in SMEs. GQM-lightweight consists of five main phases, shown in Figure 2-4 and described as follows.

Planning

GQM-lightweight has a planning phase similar to its parent GQM approach; the only difference in the GQM-lightweight case is that there is no need for a separate team to be established due to the limited number of employees and informal structure of SMEs. A single person can work on planning, on a part-time basis. Communication channels should be minimized. GQM-lightweight encourages kick-off sessions for establishing SMP in SMEs and recommends that clear statements of motivation for SMP are provided to emphasise the value that be achieved during implementation.

Definition

The definition phase of GQM-lightweight is also similar to the GQM definition phase. Additionally, in GQM-lightweight, the definition phase introduces the reuse of quality and resource models, to reduce the definition effort at this stage. Reuse is a core focus of GQM-lightweight. Another contribution of the GQM-lightweight framework is lower time consumption and effort. Therefore, during this phase, there will be a reduction in the review activity, which is divided among the project team and the main person who is responsible for SMPI. The project team only reviews the abstraction sheets and data collection instruments, whereas the person responsible for SMPI will review the planning and analysis plan.

Data Collection

To reduce the data collection time, GQM-lightweight proposes the development of a suitable collection instrument, which should be integrated into the development process. The collected data could be stored in any database or on spreadsheets.

Interpretation

The proposal in this phase by GQM-lightweight for SMEs is to neither to keep the data analysis interval too short, to save the time and effort, nor make it too long to avoid losing focus and to provide feedback on time. Thereby, it seeks to maintain an equilibrium between time intervals of data analysis and providing feedback. Moreover, GQM-lightweight proposes to avoid the use of measurement data for employees' evaluation. Feedback sessions are to be as concise as possible.

Packaging

Additionally, GQM-lightweight proposes the packaging phase, which was not present in GQM. This phase mainly involves the packaging of all the SMPI related information; including the collected data and analysis results for future reuse.

Phases	Approach for SMEs *GQM Lightweigh*	GQM method [vSB99]	Goal-driven measurement [PGF96]
Planning	Introduce measurement program	Establish GQM team, Create project plan, Training and promotion	
		Select improvement areas, Select application project & establish project team	Identify business goals, Identify what to know or learn
Definition	Define measurement goals, Goal formalization	Define measurement goals, Conduct GQM interview, Review or produce software process models	Identify subgoals, Identify entities and attributes, Formalize measurement goals
	Define questions	Define questions & hypothesis and Review	Identify quantifiable questions
		Produce analysis plan	Identify indicators & data elements
Reuse of Qua-lity & Resource models	Define metrics	Define measures and Review	Define measures
	Produce GQM plan, Define data collection procedures, Define data instruments	Produce GQM plan, Produce measurement plan	Identify the actions needed to implement measures, Prepare a plan
	Produce data collection plan Create metrics base	Trial period, Hold a kick-off session	
Data collection	Collect and validate data	Create metrics base	
	Store data collected	Collect and check data collection form, Store measurement data in metrics base	
Interpre-tation	Data analysis	Define analysis sheets and presentation slides	
	Data interpretation – Feedback session	Prepare feedback session, Organize and hold feedback session, Report measures resulting	
Packaging	Packaging results		

Figure 2-4 GQM-lightweight (Wangenheim et al., 2003)

2.5.1.2. MIS-PyME (Marco metodológico para la definición de Indicadores de Software oriented a PyME)

MIS-PyME is another major SMPI in SMEs endeavour found in the literature, proposed in a series of publications by Diaz-Ley et al., (2009); Diaz-Ley et al., (2008); Díaz-Ley, et al., (2008); Díaz-Ley et al., (2007); Díaz-Ley, García, et al., (2008b); and Díaz-Ley et al., (2010a). MIS-PyME was designed to define measurement programs based on software indicators relevant to SMEs. Initially, MIS-PyME was classified into three main modules (Díaz-Ley, et al., 2008b) – the methodology and roles, the work products to support the methodology, and the measurement maturity model. In the most recent publication/version of MIS-PyME (Díaz-Ley et al., 2010a), the authors formed it into two major parts: the MIS-PyME software measurement program definition methodology and the MIS-PyME measurement capability maturity model (MCMM). These components are described as follows.

The Program Definition Methodology

The MIS-PyME module was designed to define basic indicators for SMEs, based on GQM (Solingen & Berghout, 1999) and GQ(I)M (Goethert & Siviy, 2004; Park et al., 1996). The identified basic indicators were adapted to the measurement maturity of the SMEs setting.

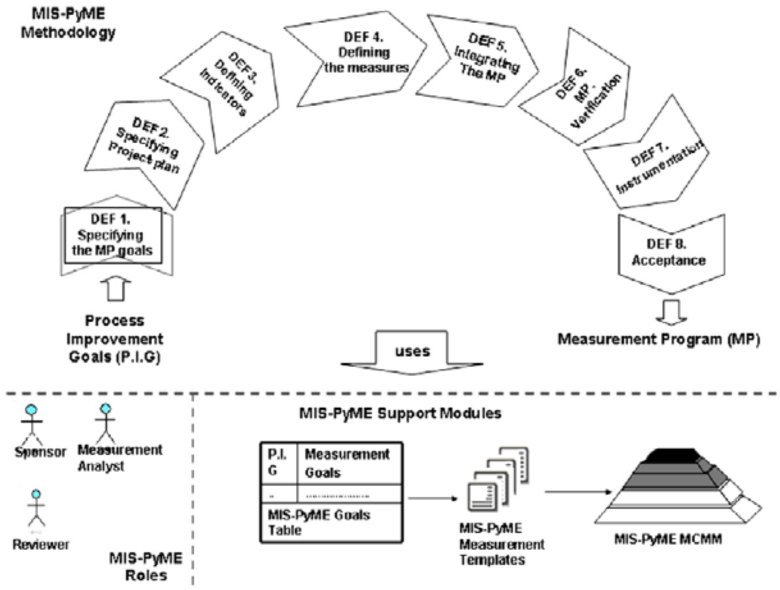

Figure 2-5 MIS-PyME Methodology (Diaz-Ley et al., 2008).

MIS-PyME provides three work products. First, it provides the set of structured measurement goals, which are normally required for SPI-related activities. The proposed set of SPI goals is based on practices, processes, and goals specified in COMPETISOFT software process model. The second work product is an indicator template definition, which is provided to assist in defining the indicators. The third product is an indicator database, where MIS-PyME provides a set of previously used indicators, to assist MIS-PyME users in reusing measurement programs definition.

The Measurement Capability Maturity Model (MCMM)

The second major part of MIS-PyME is the MCMM, which mainly assesses the measurement maturity of the company. It comprises three features and services. The first is 'the maturity levels and their attributes', which describes the requirements to achieve certain maturity levels. The second is 'an assessment process', to determine the measurement capability of the organization by using a questionnaire to obtain measurement-related data. The third is 'an interface', to the MIS-PyME methodology. It provides the relevant information to define measurement programs adapted to the company's measurement maturity. The authors claim that the MCMM could be used in any size company, but the provided interface is said to make it easy to use MIS-PyME in SMEs.

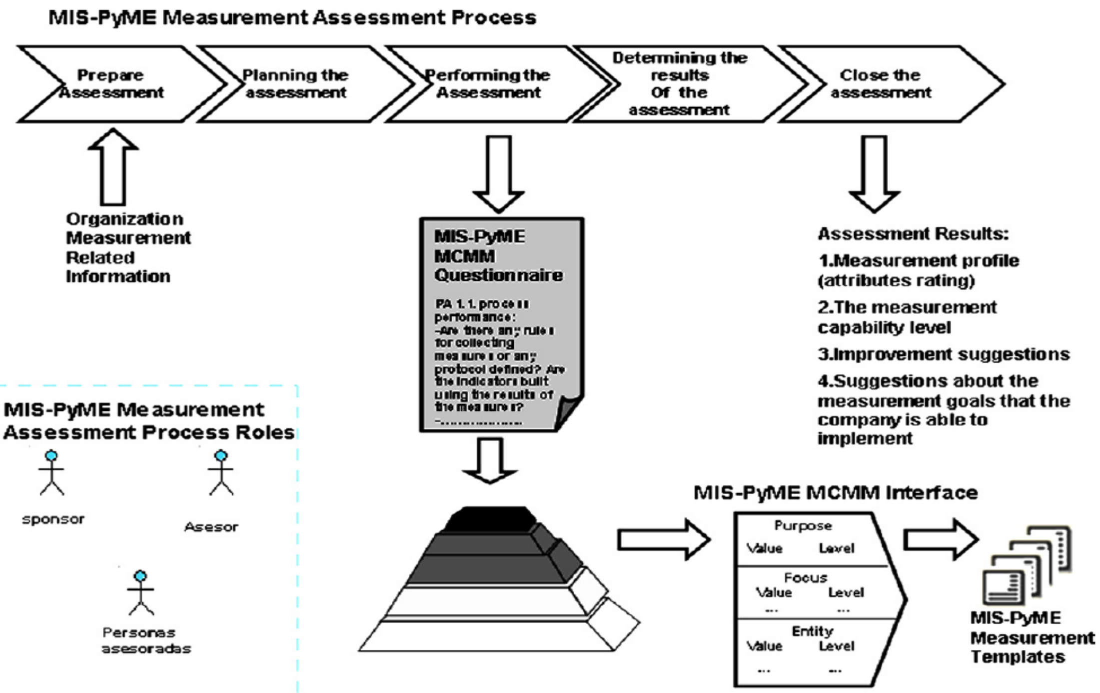

Figure 2-6 MIS-PyME measurement capability maturity model (MCMM) Diaz-Ley et al., (2008).

2.5.1.3. Hybrid Measurement Process (HMP) for ISO/IEC 15504 ISO/IEC 12207:2008 and CMMI Dev 1.3(Ruiz et al., 2011)

An impression observed in the literature and industry suggests that SMEs are seen as being at fault for not adopting international standards such as ISO/CMM for measurement implementation, due to their scale and complexity. As a result there have been some efforts to tailor these standards mechanisms for SMPI in SMEs. An attempt made by Ruiz et al. (2011) is made to describe "*a proposal for hybrid measurement process for the ISO/IEC 15504-ISO/IEC 12207:2008 standards and CMMI Dev 1.32 model in SMEs*".

The proposed HMP is based on CMMI Dev 1.2 (Team, 2006) and ISO/IEC 15504 (ISO, 2004). The CMMI classifies processes into four main groups 1) Process management, 2) Project Management, 3) Engineering, and 4) Support, the latter of which includes measurement and analysis. The HMP mainly allows migrating from one quality model to another one. Furthermore, it satisfies the specific practices of CMMI Dev 1.3 (CMMI, 2010) and the outcomes of ISO/IEC 15504-ISO/IEC 12207:2008, where there is a great similarity in both. Figure 2-7 presents the proposed HMP activities.

Description of the proposed hybrid process.

ID	Role	Activity	Description	Entries	Outcomes
T1	ED,G E, RA	Define organizational objectives	The development team together with the management establish the organizational objectives and the strategic priorities to be obtained	Mission, Vision, Objectives	Organizational Objectives
T2	ED,G E, RA	Identify measurements, objectives, required information, priority and indicators	Through the application of the GQ (I) M methodology [19], the measurement model to be used is produced.	GQ(I)M Methodology	Measurement model to be u (organizational objectives, conc to be measured, entities to measured, measurements, plans measurement gatherings, etc)
T3	ED	Establish the measurements	The development team registers the corresponding measurements for the measures requested. These are establish in the base template for measurement data. The time where the measures will be collected are establish within the period of time agreed in the measurement model, which contains a complete specification on how to get the measurement and interpret it.	Base templates for measurements gathering (Empty)	Registers the measurem established in the templates
T4	RA	Carry out the gathering of the measurements	In the corresponding period of time, the measurements are collected in the base templates. This is done for every project. Then, the measurements are added to the organizational report, which is a template that contains all the measurements of projects.	Base templates measurement gathering (Filled out)	Organizational report of gath measurements
T5	RA	Analyze the measurements and interpret results	The information provided by the measurements, either from the indicators provided in the measurement templates or from the generation of the established indicators in the measurement model with the information provided by the project reports.	Base indicators, generated indicators	Actions to be carried out based the obtained results
P6	RA	Generate or update performance base lines	A measurements report is generated within the period of time established in the measurement model with the indicators defined therein and the performance base lines to be taken as a reference in the tasks of future projects are defined.	Base indicators, generated indicators	Measurement report, performa base lines to be taken as a refere in the tasks of future projects
T7	ED,G E, RA	Show and communicate results	The maintenance responsible communicates the results of the measurements in the team maintenance reports.	Generated reports	Final measurement results

Figure 2-7 Hybrid Measurement Process (Ruiz et al., 2011)

Chapter 3 Research Methodology

This Chapter presents the research methodology used to guide the conduct of this doctoral research. It describes the overall methodology as well as the specific research methods used in performing a comprehensive review of Software Measurement Program Implementation in Small and Medium Enterprises (SMPI in SMEs) and in developing a novel framework to aid SMPI in SME. This Chapter expounds the general research context in software engineering, and the specifics of the Design Science Research (DSR) methodology, as described by Offermann et al. (2009), employed at each stage of this research.

Three questions should be borne in mind while reading this chapter:

- What research methods were selected?
- Why were particular methods selected?
- How were the selected methods applied?

This chapter principally addresses the first two questions and provides an overview response to the third question; details of the application of the methods are provided in subsequent chapters. The remainder of this chapter is structured as follows: Section 3.1 presents an initial overview of research in Software Engineering (SE), Section 3.2 presents Design Science Research (DSR), Section 3.3 presents the research design, and Section 3.4 presents a summary of the this chapter.

3.1. Research in Software Engineering

Practitioners have been developing software for around 70 years (Glass, 1997) but in academia, research in the field of Software Engineering (SE) has spanned less than five decades (Glass et al., 2002). While it is thus a relatively young research discipline there are now many high-impact conferences reporting SE research, including the European SE Conference that is frequently collocated with the ACM SIGSOFT Symposium on the Foundations of SE (ESEC/FSE), the IEEE/ACM International Conference on SE (ICSE), Evaluation and Assessment in SE (EASE) and the IEEE/ACM International Conference on Automated SE (ASE). Similarly, there are several well-regarded journals specific to SE knowledge areas, such as Empirical SE, IEEE Transactions on SE, ACM Transactions on SE and Methodology (TOSEM) and the Journal of System and Software (JSS). A list of journals and conference proceedings that address topics related to SM and software process improvement research is presented in Appendix 4.1.

As an engineering sub-discipline SE is inherently applied; as a creative process reliant on people it can also require a diversity of research approaches, including quantitative methods (for example, surveys and (quasi-)controlled experiments), qualitative methods (for example, action research, case studies, and ethnography) or a mix of both. These methods, which had their origins in other disciplines within the Natural and Social Sciences, have been adopted, and perhaps adapted, for use in SE (Dominguez, 2009; Uysal).

As a field that emphasises problem-solving and design it also draws on methods used in the so-called science of the artificial. A specific example related to the SE research domain is Design Science Research, or DSR. For over 25 years IS researchers have utilised DSR in order to explore and explain phenomena of interest (Peffers et al., 2006). A small number of papers, published in the early 1990s, first proposed the use of DSR in Information Systems (IS) and related fields (March & Smith, 1995; Nunamaker et al., 1990; Walls et al., 1992). Since then multiple studies have advocated DSR's application in these domains (Gregor & Hevner, 2013; Hevner & Chatterjee, 2010; Hevner, 2007; Vaishnavi & Kuechler, 2015; Alan et al., 2004), in order to support the delivery of research results that are both relevant to (general) practice and rigorous in derivation (Alan et al., 2004; Benbasat & Zmud, 1999; Rosemann & Vessey, 2008).

3.2. Design Science Research

DSR is an approach that seeks to inform the design of research and that provides the means through which research and design can be usefully combined (Cross, 2007). The following are some of the reasons why DSR has gained traction in IS and SE research and why it is considered a relevant approach for the current study:

1. The focus of DSR is on the creation of artefacts to resolve real life problems (Alan et al., 2004).
2. While it is an applied research approach DSR can provide contributions to practice as well as the generation of more general insights (Chamberlain et al., 2007; Smaczny, 2001).
3. DSR provides transparent guidance and a roadmap for IS research in design science (Offermann et al., 2009).
4. More specifically, DSR provides detailed guidance about methods, roles and artefacts, so that research can deliver research outcomes that are simultaneously rigorous and relevant (Benbasat & Zmud, 1999; Rosemann & Vessey, 2008; Alan et al., 2004).
5. Problems faced by IS practitioners can be addressed in research using DSR (March & Smith, 1995).

The DSR methodology followed in this research work adheres to the guidelines of Offermann et al. (2009), consisting of the three major phases of problem identification, solution design, and evaluation. Each phase is discussed with respect to this research, as outlined below.

3.2.1. Problem Identification

This research started with the identification of SMPI in SMEs as the domain of interest. In order to be suited for a DSR approach it is required that the problem has practical relevance, or might be of relevance once solved (Benbasat & Zmud, 1999). Literature reviews and practitioners' interviews are the tools most commonly used to identify such problems (Offermann et al., 2009). Literature-based research can help to determine the state-of-the-art of the research context, and interviews with practitioners in the relevant industry can help to identify and verify the relevant problems. As such, the problem identification phased in this research comprises two parts: problems are first identified based on a review of the literature (Chapter 4) and are then further investigated and validated through the conduct of interviews with experts in industry (Chapter 5). As a result of this phase, a central research objective is typically specified. Successful achievement of this objective, through the design, development and evaluation of a solution, should deliver both knowledge insights for research as well as practical advances.

3.2.2. Solution Design and Development

In this phase a solution is designed and developed, taking the state-of-the-art and industry needs into account (Offermann et al., 2009). In this research, drawing on the results of the problem identification phase, a software measurement framework (SMF) solution is developed in conjunction with two companies – medium-sized ABC and small-sized XYZ – to address the challenges and obstacles encountered by SMEs implementing software measurement programs, as described in the literature and through industry interviews. In addition, all existing solutions should be studied in depth and compared (Chapter 6) in order to identify weaknesses and strengths in existing solutions in terms of addressing any identified needs, opportunities and challenges.

3.2.3. Evaluation

Given a set of objectives and associated criteria it is essential that any new solution be evaluated against these expectations once adequately developed (Offermann et al., 2009). This could be achieved through a variety of means – a case study, a broad expert survey or laboratory experiments. In the evaluation phase of this research, a broad survey of experts from SMEs is conducted to evaluate the perceived usefulness of the solution and to verify their general acceptance of the developed SMF. The intent is to ascertain whether the developed SMF provides a viable solution to the research problem identified prior.

At the end the results will be summarised which could be in the form of conference or journal articles or a Ph.D. thesis (Offermann et al., 2009). In this research, the complete results are published in the latter form, although the intent is that specific aspects of the thesis will also be published separately: a literature review publication reporting the results of the systematic mapping, an industrial review publication reporting the outcomes of the practitioners' interviews, and an action research report detailing the field studies and practitioners' survey. Figure 3-1 depicts the DSR methodology as employed in this research.

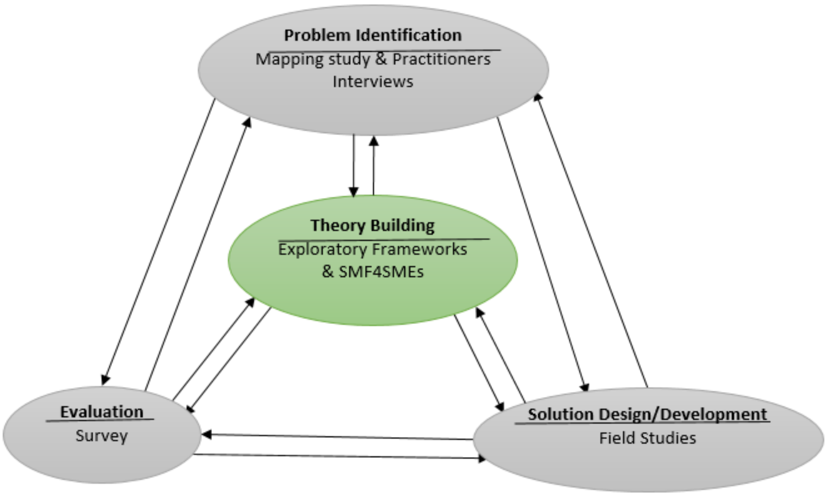

Figure 3-1 Design Science Research Implementation (Adapted from Venable, (2006))

3.3. Research Design

The preceding section provides an overview describing how this research employs the DSR methodology. This section elaborates how research methods are selected and applied at each phase of DSR, acknowledging that each phase of DSR requires different research methods and approaches in order that its objectives are achieved. Overall, this research work adopts an empirical approach. The research methods employed in all phases of DSR thus include the collecting and synthesizing of evidence, through literature research, industrial practices or both. The primary motivation behind adopting an empirical approach is its relevance to software measurement as a set of practices, as per the research guidelines of Kitchenham (2010a).

A research design comprises a detailed plan and set of procedures that span from the abstract to the specific methods of data collection and analysis (Creswell, 2013). All empirical research should be based on such a design, which is explicitly defined before conducting each research phase (Yin, 1994). The phases of the current research (shown in Figure 3-2) are listed here. Each phase is discussed in further detail in forthcoming sections:

1. Chapter 4 presents a systematic mapping study that follows its own defined and robust research method. The core findings of this chapter are evidence-based specifications of SMPI challenges and success factors, along with a comparison of existing SMPI solutions.
2. Chapter 5 utilises data analysis methods derived from grounded theory (GT) research, in order to identify challenges, obstacles, benefits and success factors of SMPI in SMEs. The core findings of this Chapter 5 are exploratory evidence-informed frameworks of SMPI challenges, obstacles, benefits, and success factors that are specifically relevant to SMEs.
3. Chapter 7 employs field studies to both develop and evaluate the SMF, addressing relevant implementation issues. The result is an industry-informed framework, namely: the software measurement framework for SMEs (SMF4SME).
4. Chapter 8 validates the developed SMF4SMEs using a field survey to ascertain the perceptions and opinions of a range of software practitioners.

Thus overall this research follows a mixed methods approach, employing both qualitative and quantitative methods as appropriate to each research phase and/or activity.

3.3.1. Selection of Mixed-Methods approach

Proponents of both qualitative and quantitative methods research appreciate the value of using these methods to develop a deep(er) understanding of a theory or phenomenon of interest (Venkatesh, 2013). Mixed-methods are particularly powerful when the researchers' main challenge is extensive data collection, and when thorough or vigorous data analysis is required within a limited time (Easterbrook et al., 2008). This research employs sequential mixed methods (Creswell, 2013), in that findings emerge and are used in stages over time. Figure 3-2 shows how these methods have been employed in this research.

1. Adoption of a mixed methods approach supports a Concurrent Triangulation Strategy (Bryman & Cramer, 2005; Easterbrook et al., 2008). In this research the results obtained from qualitative and quantitative methods are complementary.
2. Venkatesh (2013) asserts that in order to develop rich insight into various phenomena of interest the use of mixed methods is required; it cannot be developed using only a qualitative or quantitative method (Venkatesh, 2013).

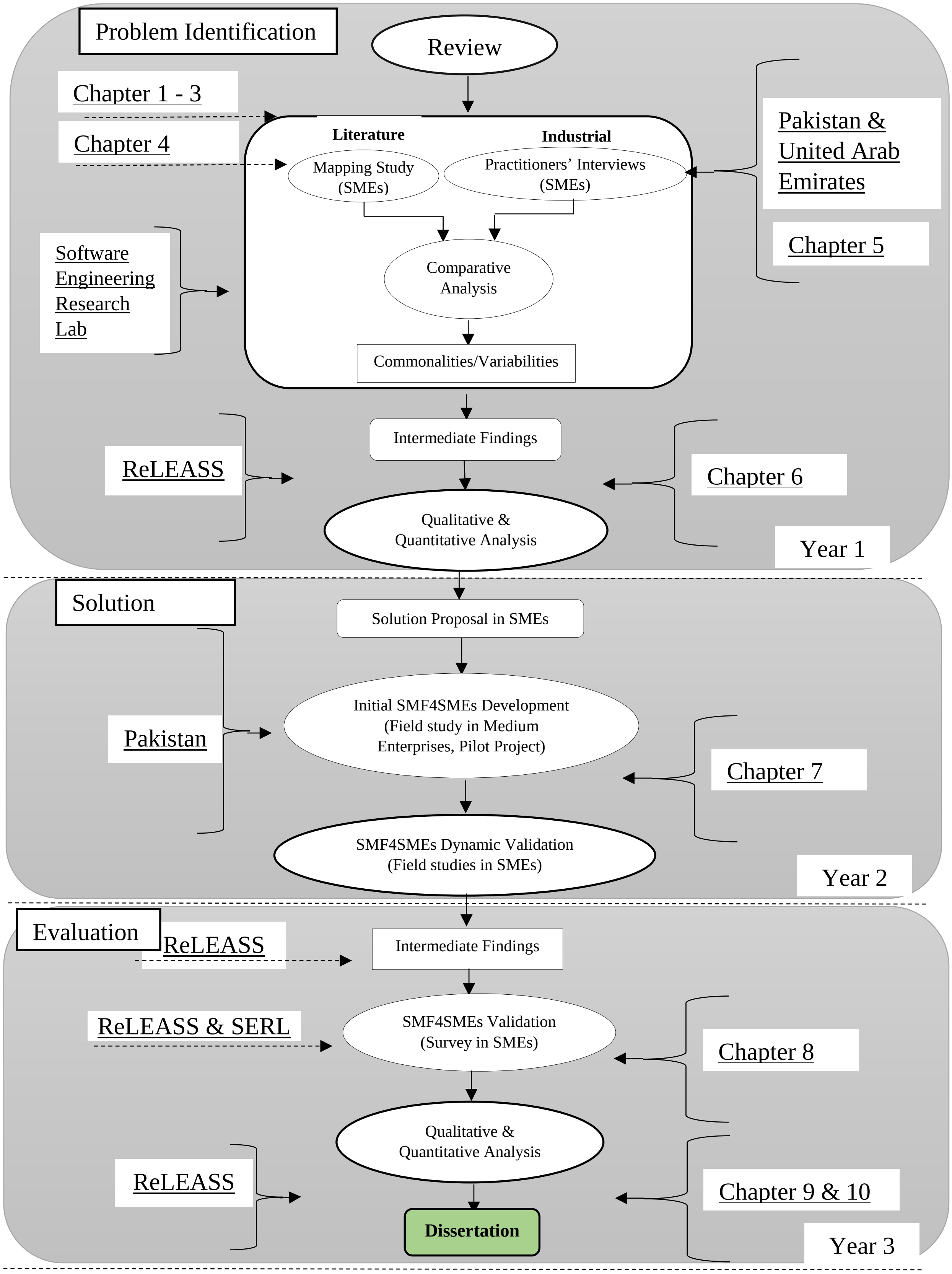

Figure 3-2 Ph.D. Research Plan

3. Teddlie and Tashakkori similarly suggest that “Mixed-Methods research can simultaneously address a range of confirmatory and exploratory questions with both the qualitative and quantitative approaches. Mixed methods research provides stronger inferences. Mixed Methods research provides the opportunity for a greater assortment of divergent views” (Teddlie & Tashakkori, 2009). Combining both methods can offset the disadvantages that each method may have by itself (Greene & Caracelli, 1997). “The goal of mixed methods research is not to replace either of these approaches but rather to draw from the strengths and minimize the weaknesses of both in single research studies and across studies” (Johnson & Onwuegbuzie, 2004).
4. Some specific qualitative methods are often (though perhaps unfairly) criticised for a lack of generalizability. By adopting a mixed methods approach the findings of qualitative methods may be validated through the use of a quantitative method on a sample from the population (Easterbrook et al., 2008).

3.3.2. Problem Identification: Literature Review

The first phase of DSR recommends the conduct of a literature review and practitioners’ interviews to support problem identification (Offermann et al., 2009). In any research endeavour it is important to summarize the state of existing knowledge, as expressed in the literature, before embarking on further investigation. Such an activity is a form of secondary study, in that it does not involve the collection or analysis of primary data. Many disciplines have specific procedures for the conduct of such secondary studies (also known as evidence-based studies): for the last decade software engineering one such discipline (Kitchenham, 2004a; Kitchenham et al., 2004). There are two methods for conducting secondary studies in SE, the systematic literature review (SLR) and the systematic mapping (SMP). “Systematic mapping studies are used to structure a research area while systematic reviews are focused on gathering and synthesizing evidence” (Petersen et al., 2015).

1. **Systematic Literature Reviews (SLR):** In the last decade SLRs have received much attention in SE (Kitchenham, 2007; Kitchenham et al., 2009; Kitchenham et al., 2010). Compared to the common narrative literature review, the SLR follows a well-defined reported methodology that tends to reduce bias, supports the determination of more general conclusions and considers studies collectively rather than in isolation (Kitchenham, 2007). SLRs synthesise the existing literature taking into account study quality because the main goal is to establish the current state of evidence (Petersen et al., 2008a). Therefore, in SLRs, a very specific research question has to be addressed (Vakkalanka, et al., 2015).

Additionally, SLRs can in some cases enable subsequent use of meta-analytic synthesis techniques (Kitchenham et al., 2009).

2. **<u>Systematic Mapping (Sys-Map):</u>** Just as for the SLR, the Sys_Map methodology in SE was adopted mainly from the medical sciences. According to Kitchenham et al., (2011) and Vakkalanka, et al., (2015), Sys_Map provides a visual summary of the results of a literature survey; it can support the identification of evidence about a topic as well as the classification of the relevant literature according to a range of pre-defined categories (such as the research method employed).

In this initial phase of the research the Sys_Map methodology is selected, to enable the preliminary investigation of the relevant research context and to establish the state-of-the-art regarding SMPI as reported in the research literature. The reasons for using the Sys_Map methodology to identify the problem (as per the DSR methodology) are as follows.

1. It is recommended that mapping studies be conducted for research areas where there is an emerging body of relevant, high-quality primary studies (Kitchenham, 2007). According to the initial literature review conducted for this research it is found that this is the case for the research context considered here; that is, the body of literature addressing SMPI in SMEs is emerging rather than definitive.
2. The intent of this phase of the research, to investigate the state-of-the-art of SMPI in SMEs, is generic rather than specific; mapping studies are well-suited to dealing with such aims in terms of establishing current research trends (Vakkalanka, et al., 2015).
3. The Sys_Map helps to highlight contemporary issues and challenges, and so provides baselines to inform new research efforts and possible research directions (Kitchenham et al., 2009; Kitchenham et al., 2011; Petersen et al., 2008b).

Based on the evidence just described, the Sys_Map is seen to be suitable in the current situation. The following Figure 3-3 provides an overview of the conduct of the mapping study.

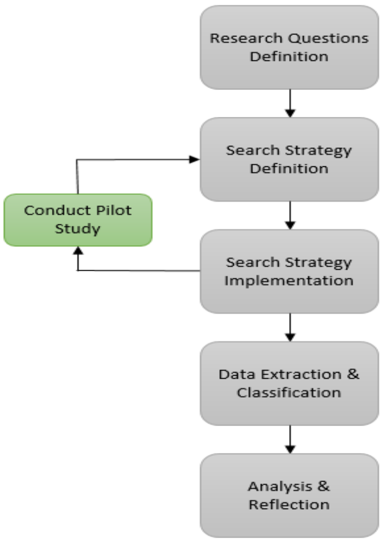

Figure 3-3 Systematic Mapping Study Design

3.3.3. Ethics Approval

As a study centred on observation and empiricism the consideration of research ethics was given substantial consideration before going to industry. The researcher thus applied for ethical approval to the Auckland University of Technology Ethics Committee (AUTEC[4]) in relation to conducting interviews, field studies and a survey in industry. A participant information sheet (PIS) (Appendix 5.5), explaining the project and its target companies, and a consent form (CF) (Appendix 5.6), seeking the agreement of participants for data elicitation and use, were prepared and submitted to AUTEC, who granted their permission. These documents were shared with participants well before the time they were engaged, so that they could understand the research context. All participants were assured of the confidentiality of the sought information. Moreover, the participants were informed that they were allowed to withdraw from the process at any time, during any phase of the research (though none chose to do so).

3.3.4. Problem Identification: Industry Interviews

This research phase is carried out by applying grounded theory (GT) methods to informal semi-structured interviews with professionals from small- and medium-sized software development companies. Specifically, this research activity investigates the challenges and success factors of SMPI in SMEs with a qualitative focus as applied through GT guidelines, as reported by (Glaser & Strauss, 2009; Hoda et al., 2012). The primary motivation to conduct this activity phase is to validate the literature review findings from an industry practice perspective.

Interest in the use of qualitative research methods in SE has increased in line with the recognition that software development is a socio-technical phenomenon – such methods focus on understanding social phenomena in their natural setting (Darke et al., 1998). There are multiple qualitative research methodologies which include case study research (Darke et al., 1998), action research (Kaplan & Maxwell, 2005), and GT (Glaser & Strauss, 2009). While in this case GT methods are used the other possible approaches are also now considered.

1. **Action research:** there are numerous definitions of action research such as “systematic inquiry that is collective, collaborative, self-reflective, critical and undertaken by participants in the inquiry” (McCutcheon & Jung, 1990); or “action research aims to contribute both to the practical concerns of people in an immediate problematic situation and to the goals of social science by collaboration within a mutually acceptable ethical framework (Rapoport, 1970)”. Holter & Schwartz-Barcott (1993) note that, in action

[4] The initial work as reported in this thesis was undertaken while the researcher was a Ph.D. candidate at AUT.

research, the researcher identifies the existing problems and issues and presents an intervention, then the practitioners get involved in facilitating the researcher in intervention implementation. Such an approach is most appropriate when the researcher is working in situ in an organisation that is seeking to effect change, and requires a substantial commitment from the host organisation.

2. **A case study** examines phenomena of interest in their real world context (Wieringa, 2013). The case study method is widely used in IS research (Alavi & Carlson, 1992; Myers, 1997; Orlikowski & Baroudi, 1991) and is suitable for understanding the interactions between IT-related innovations and organizational context (Darke et al., 1998). As such they often need to be conducted over extended periods of time. In the current phase of this research a method that is used frequently in case studies, the semi-structured interview' is employed, while due to limited access the other methods of document analysis and observation (Runeson & Höst, 2008) were minimally used.
3. **Ethnography:** Easterbrook et al. consider ethnography as a research methodology with substantial potential in SE (Easterbrook et al., 2008). Ethnographic studies typically require a long duration and numerous participants (Klein & Myers, 1999) because it requires the researcher to be immersed within a specific context to then observe the cultural and social aspects of that context (Lewis, 2004). This approach was again not considered to be feasible for this Ph.D. research given time constraints and the desire to consider the work practices of more than one organisation.

3.3.4.1. Selection of Grounded Theory (GT) methods

In this phase the use of GT methods of analysis are adopted, for the following reasons:

1. GT is primarily an inductive process where the researcher formulates a theory by systematically gathering and analysing data (Glaser et al., 1967).
2. "The rationale for this approach is to keep the researcher open to the concepts and relationships that will emerge from the data, and to avoid derailments in the form of assumptions about what ought to be found in the data (Pace, 2004)."
3. "Grounded Theory is well suited to exploring how software practitioners collaborate and engineer software (Pace, 2004)."
4. GT is an inductive approach which allows theory to emerge based on the experiential accounts of software development practitioners.
5. GT is well-known for its application to human behaviour, software development is a labour-intensive activity, and SMPI heavily relies on human acquiescence.

6. There is evidence of successful GT application in SE/IT in the context of SPI (Carvalho et al., 2005; Myers, 1997; Seaman, 1999).
7. The limited availability of prior studies in the literature on this research topic (as shown in the results of Chapter 4), support the use of an inductive research approach.

In inductive research, data is used to build theory, create relations and finally engage evolving theory with existing theory (Coleman & O'Connor, 2007; Elo & Kyngäs, 2008; Pace, 2004; Urquhart, 1997; Urquhart, 2000, 2001). It is ideal to use when there is no existing knowledge about the domain being investigated, or when that knowledge is fragmented (Elo & Kyngäs, 2008; Orlikowski, 1993).

In GT it is recommended that the researcher should not formulate a specific research problem; rather, it is recommended that the researcher choose a general area of interest (Hoda et al., 2012). In the case of this research, the area of interest chosen was 'SMPI in SMEs'. The researcher had acquired some prior knowledge of the area of interest in broad terms, based on the initial mapping study (Chapter 4). This prior knowledge was also gathered due to the requirement to obtain ethical approval, where some engagement with the literature is needed to produce such an application. So at this stage the more specific substantive topics investigated here are the challenges and success factors for SMPI in SMEs according to practitioners, which reflects the research objectives of this phase. Therefore, in this case we applied *grounded theory-lite* which involves using the techniques of grounded theory for the development of categories, sub-categories and relationships among them (Pidgeon & Henwood, 1997). In contrast, a full grounded theory implementation requires the use of multiple iterations of a full range of grounded theory procedures through to the point of theory saturation.

Grounded theory-lite and thematic analysis (TA) are similar; both may be used to produce codes and generate broader patterns in data. One difference is in terminology, such as the use of the term "categories" in GT as opposed to "themes" in TA. The key difference between TA and GT (full or lite) is that GT is a *methodology* as other analytic approaches, whereas TA is just a method. Thus, GT has an in-built theoretical framework which is followed in this research phase – using the recommended method of data collection (qualitative interviews), as well as a particular set of analytic procedures such as coding, sampling, and memoing. However the results of contextualist TA and contextualist GT-lite could be rather similar. Figure 3-4 provides a pictorial overview of the conduct of the industrial review.

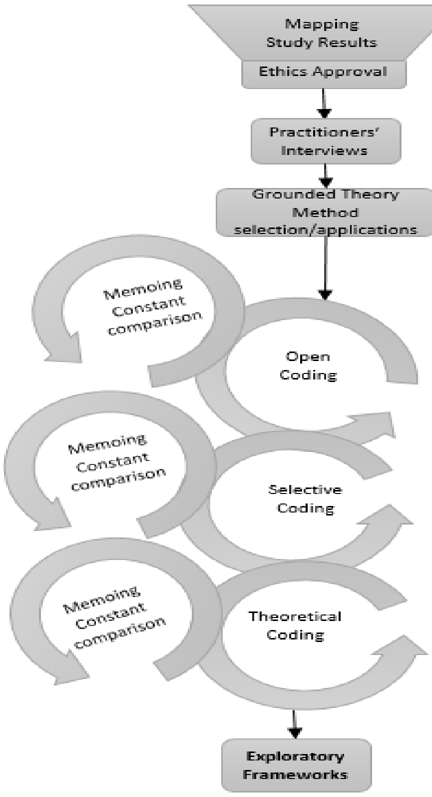

Figure 3-4 Industrial review and Grounded Theory Implementation

3.3.5. Solution Design and Development

The aim of this phase is to investigate the previously identified gaps, challenges and obstacles of SMPI and to design and develop a software measurement framework (SMF) that addresses those same gaps, challenges and obstacles. To develop the SMF two software development organizations are selected; one medium-sized organization (ABC Company) and one small organization (XYZ Company). The following subsections explain the methodology selection and application to achieve the said objective of this phase.

3.3.5.1. Selection of Field Studies

As their name implies, field studies involve the collection of data outside an experimental lab setting, in natural settings or environments. These studies can use one or more well-defined research methods, such as interviews or focus groups, for one case or multiple cases. Field studies enable researchers to examine people within their social and natural settings (Orlikowski & Baroudi, 1991), and they can be used individually or combined to understand different aspects of real-world environments (Lethbridge et al., 2005).

In this research three "cases" are designed to conduct field studies in real time environment with practitioners, involving group discussion and focus group observation held at particular stages. The detail of these cases is discussed in Chapter 7. Figure 3-5 depicts an overview of the conduct of the field studies where the respective abbreviations are for project manager (PM), team lead (TL), software quality manger (SQM) and chief executive officer (CEO). Further details regarding the conduct of each study are provided in Section 7.2.

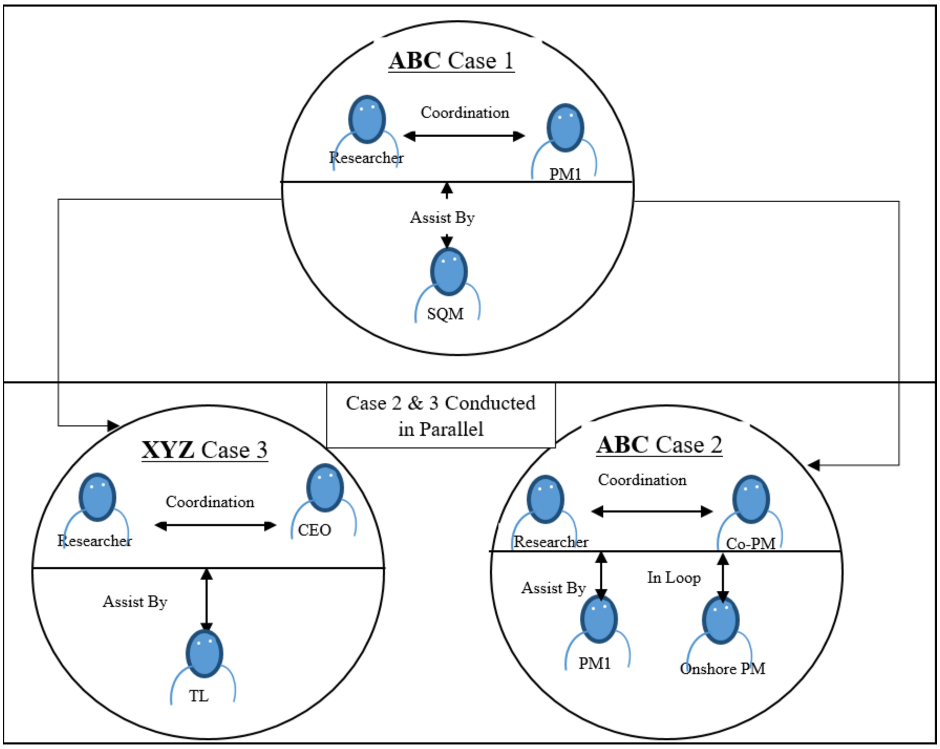

Figure 3-5 Case organizations and Field Studies Conducted.

3.3.6. Evaluation

This research phase quantitatively evaluates the proposed SMF4SME. The intent of this phase was to validate the SMF4SMEs with a large sample and to evaluate the perceived usefulness of the proposed framework according to software practitioners working in SMEs. To validate SMF4SME, a quantitative survey method was selected. Creswell (2013) notes that surveys quantify trends, attitudes, and opinions of a population and Easterbrook et al. (2008) remark that "The survey research design is concerned with establishing what is true of developers in general." Details of the survey design and implementation are presented in Chapter 8.

A cross-sectional survey instrument was designed to conduct this phase and the data were collected in one iteration. The survey inquired about demographics information to ensure the participants' relevance to the topic and it investigated the usefulness of SMF4SME by sharing its activities and other implementation and supporting guidelines, including material specifying activities vs. roles and responsibilities, activities vs. checklists, activities vs. precautions, and the proposed SMF4SME benefits and success factors. The survey was distributed worldwide through contacts of the researcher and supervisors. All participants were assured of confidentiality. After a specific time of one month and a response target of 100 users, the survey was closed. A total of 110 responses were received. A range of descriptive data analysis techniques were employed to arrive at the results and to validate the proposed framework. Details of the survey results are presented in Chapter 8, while Figure 3-6 depicts the process of this research phase.

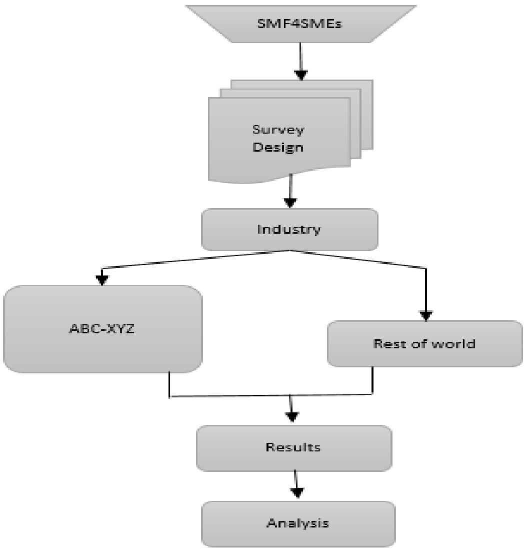

Figure 3-7 Industrial Survey to Evaluate SMF4SME

3.3.7. Participant Selection

The basic criterion for participant selection for interviews and field studies was the organizational size of the SMEs and the business type that is software development. The survey was distributed without such limitations; the only check was to ensure that the selected industry is within software development industry. Additionally, in the survey, there was a check about company size to classify at the time of data analysis. The ethics approval retrieved from AUTEC allowed us to conduct research work in the industry. Furthermore, a Participant Information Sheet (PIS) was prepared to share information about project and type of targeted companies, with participants. Moreover, a Consent Form (CF) was shared to get some basic agreement from participants, regarding data and information elicitation and use later on for research. The participants had the option to withdraw at any stage during interviews, field studies, and survey. Kitchenham et al. (2002) say “Surveys often make mistakes with the experimental unit when questionnaires are sent to multiple respondents in an organization, but the questions concern the organization as a whole.” Though SMPI is a group work, in the survey, the intention was to get individuals feedback upon SMPI in general and their views upon SMF4SMEs individually, because diverse issues were found during field studies conduct observed and reported by the individuals during the field studies conducted. So, it was more important to get feedback individually.

The participants companies for interviews were from Pakistan and United Arab Emirates (UAE). The field studies conducted in Pakistan and surveys were distributed to several SDEs in several countries. The participant's companies involved in interviews mostly were working on the outsourced project. One of the two companies selected for field studies were medium-sized which were working on an outsourced project. However, the small-sized one was developing their own product. Such information was not retrieved from the survey participant companies because it was not a focus of this research work.

3.3.8. Participants Validation

This research work shows SMPI is still not that common in SMEs as much as it is encouraged in the literature. The problem was initially investigated through existing literature about SMPI in SMEs and later on investigated through SMEs in Pakistan and UAE. Though SMPI is not common and well-known to our selected companies, they were good in software process improvements (SPIs). Because most companies were working on outsourced projects from the USA and pushed for better quality products development, this could also be one of the reasons for them to agree to participate in this research work. It is difficult to say how serious the participants were, but CF and PIS documents were an attempt to match the participants’ interest. Also, the formal and informal discussions with participants during the interviews and field studies were adequate to ensure the participant's interests. The results of all empirical phases show the minimum qualification of participants was bachelor degree.

3.4. Summary

This chapter has presented the methods and approaches employed in the three phases of the DSR methodology, where the outcomes of each phase are considered before moving to the next phase: problem identification (mapping study, practitioners’ interviews), solution design and development (field studies) and evaluation (survey). The next chapter presents the findings of the mapping study that was conducted, being a review of the state-of-the-art on software measurement as represented in the research literature.

Part 2: Current State-of-the-art

This part of the thesis reflects the problem identification phase of DSR. It first considers the problems identified through a review of the literature (Chapter 4) and these and other issues are further investigated through the conduct of interviews with experts in industry (Chapter 5). Chapter 6 then presents the current state of SMPI in SMEs based on the literature and industrial review findings.

Chapter 4 Systematic Mapping

This Chapter presents a systematic mapping study on Software Measurement Program Implementation (SMPI) in Small and Medium Enterprises (SMEs). This mapping study was conducted as part of the Problem Identification phase of the Design Science Research Methodology. Mapping studies aid in the identification of relevant literature and help to highlight research gaps, which in turn can provide a foundation for further research.

This Chapter 4 explains the design, implementation, and findings of the mapping study. Section 4.1 presents the mapping study design and implementation; Section 4.2 presents the results; Section 4.3 presents the analysis of those results; Section 4.4 presents the discussion; and Section 4.5 presents the summary.

4.1. Systematic Mapping Study Design and Implementation

This section describes the design and implementation of the mapping study. Mapping studies (also known as scoping studies) are used to explore an area of research and classify work in the area to highlight possible future research directions (Petersen et al., 2008b; Kitchenham et al., 2009; Kitchenham et al., 2011).

This systematic mapping follows the guidelines proposed by Kitchenham (2004b). These guidelines are well-cited, and they have been widely used in the context of software engineering research. The aim of this mapping study was to systematically classify prior research contributions that have addressed SMPI in SMEs. Specifically, the intent was to identify any solutions that had been proposed for SMPI in SMEs and their associated challenges and success factors.

The remainder of this section is structured as follows: Section 4.1.1 explains the review protocol followed by the mapping research questions in Section 4.1.2. Literature search procedures are discussed in Section 4.1.3, Section 4.1.4 presents the pilot study used to examine search strings, and Section 4.1.5 describes the study filtering process. Section 4.1.6 explains the criteria used to extract data from selected articles and discusses the quality assessment procedures performed during the review protocol implementation, along with the classification scheme used for data extraction.

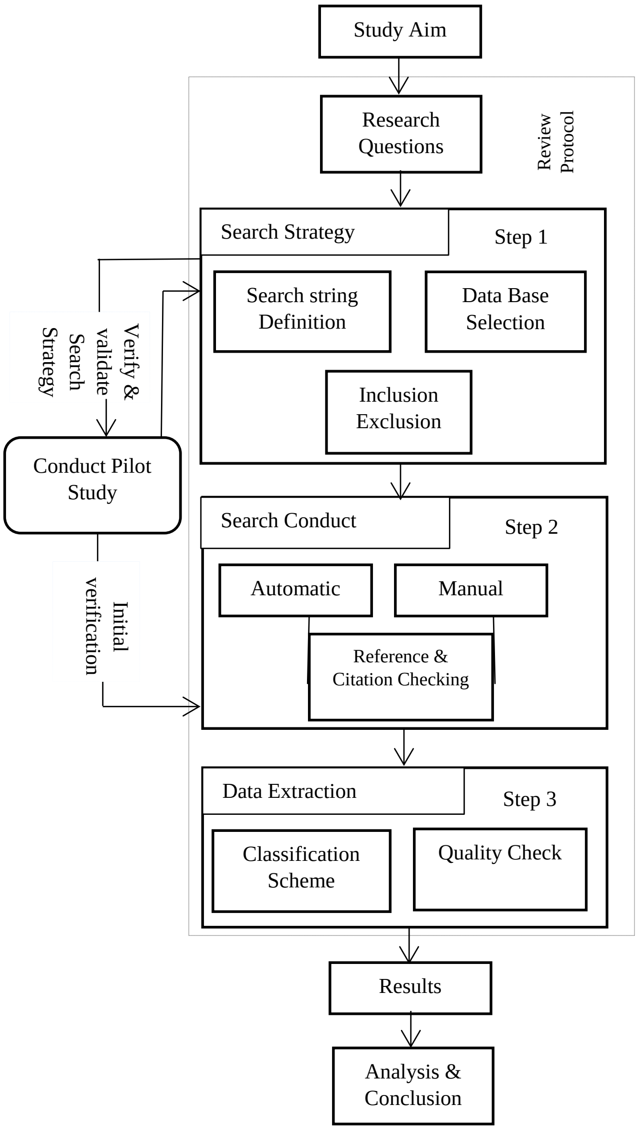

Figure 4-1 Mapping Study Design

4.1.1. Review Protocol

As per the recommendations of Kitchenham et al. (2011) a specific review protocol was designed for the purpose of the mapping study. A visual representation of the review protocol is shown in Figure 4-1. The review protocol clarifies the aim, objective, scope and context of a mapping study. Elements including the Population, Intervention, Comparison and Outcome (PICO), research questions, search strings, inclusion and exclusion criteria and data extraction processes are all defined and elaborated in the review protocol.

Development of the review protocol comprised three main steps. The first step was to define the search strategies, which also contained three parts: the search string, articles' database selection and the inclusion and exclusion criteria. The second step was to select a method to perform an effective search. This can minimize the risk of missing relevant studies. Three search methods are used in this study: automatic search, manual search and reference checking, where reference checking was conducted mainly on the findings of the automatic and manual search (further explained in section 4.1.3). Search results were filtered using the identified inclusion and exclusion criteria. The third step was to define the data extraction process. This process contained two steps: the classification of selected studies, and quality assessment. The classification scheme was that defined by Wieringa & Heerkens (2006).

Table 4.1 Search Strategy Elements

Items	Values
Selected database	Scopus, Google
Population	SMEs, comprising small and medium software enterprises (SSEs)
Intervention	Software measurements process, Software measurement programs, software measurements tools and techniques
Outcome	SMPI challenges and success factors, SMPI existing solutions in SMEs
Experimental design	All empirical analysis studies that meet inclusion criteria.

4.1.2. Research Questions

In this mapping study the researcher addressed the following research questions in order to achieve the study's aims and objectives:

Table 4.2 Research Questions

	Research Question	Motivation
RQ 1.1	What software measurement tools, techniques, frameworks, and methods have been developed specifically for SMEs?	To provide an overview of the specific measurement tools, techniques, frameworks and methods that have been developed specifically for SMEs.
RQ 1.1.1	What software measurement tools, techniques, frameworks, and methods are being used by SMEs?	To identify the extent to which the above have been adopted for use.
RQ 1.2	What are the main areas of focus in software measurement programs in SMEs?	To identify research trends in SMPI in SMEs and possible research gaps in the area.
RQ 1.3	What are the reported challenges and success factors in implementing software measurement programs in SMEs that have been identified in previous research?	To identify factors that cause success and failure for SMPI in SMEs and to inform the development of novel solutions that could improve SMP for SMEs.

4.1.3. Formulation and execution of search queries

Two major steps are involved in the search execution process; search strategy definition and search conduct (Figure 4-1). Prior to its full execution the search strategy was developed and validated through a pilot study, as follows.

4.1.3.1. Search Strategy

Definition of the search strategy was divided into three main steps: search string definition, database selection, and inclusion and exclusion criteria definition. The search string to be run against the Scopus database was initially designed based on PICO, using Boolean logical expressions (i.e., AND and OR) to combine different keywords. The search was later refined based on the findings of the pilot study.

The search conduct was designed to use both automatic and manual methods. Furthermore, to overcome potential limitations in both methods, and to provide greater search coverage, reference checking and citation checking were also undertaken.

To extract the relevant articles from the search results a set of inclusion and exclusion criteria were defined and applied against all potential primary studies. These inclusion and exclusion criteria are shown in Table 4.3. Initial selection decisions on articles were made based on the articles' Title, Abstract, and Keywords. The next step was to review the full-text of the extracted studies and filter these studies by applying the inclusion and exclusion criteria.

Table 4.3 Inclusion and Exclusion Criteria

Criteria	Values
Inclusion	Primary studies that discuss SMPI frameworks, models, tools, techniques and methods for SMEs. Software Process Improvement (SPI) studies conducted for SMEs that explicitly discuss SMP. Studies written in English. Available in full text.
Exclusion	Studies outside of the primary domain (e.g. mechanical/electrical engineering). Duplicated studies, i.e., studies that have used the same data but that are reported in more than one publication venue. Textbooks and Theses.

4.1.3.2. Search Conduct

The search was divided into three main phases. The first phase included an automatic search via the selected search engines (i.e., Scopus and Google Scholar) using the defined search string. In the second phase, a manual search was conducted on a select list of relevant journals and conference proceedings (shown in Appendix 4.1). Finally, we performed a reference and citation check on the articles selected from the automatic and manual searches. Combining all three search mechanisms should have enhanced the search coverage and so minimize the risk of missing relevant, high-quality studies, an outcome that is more likely to occur if only an automatic search was used (Kitchenham et al., 2010). The search process is shown in graphical form in Figure 4-2.

4.1.3.3. Automatic Search

The automatic search was performed on Scopus and Google Scholar. Scopus was selected because it provides access to the outputs produced by over 4,000 international publishers (Tahir & MacDonell, 2012), including a substantial body of literature related to software engineering. published by IEEE, Elsevier, ACM, and Springer (Kitchenham, 2010b). The main purpose of then using Google Scholar was to augment the search process through the identification of articles and technical reports that had been produced by publishers other than those covered by Scopus, or that could not be found by the Scopus search (Tahir & MacDonell, 2012).

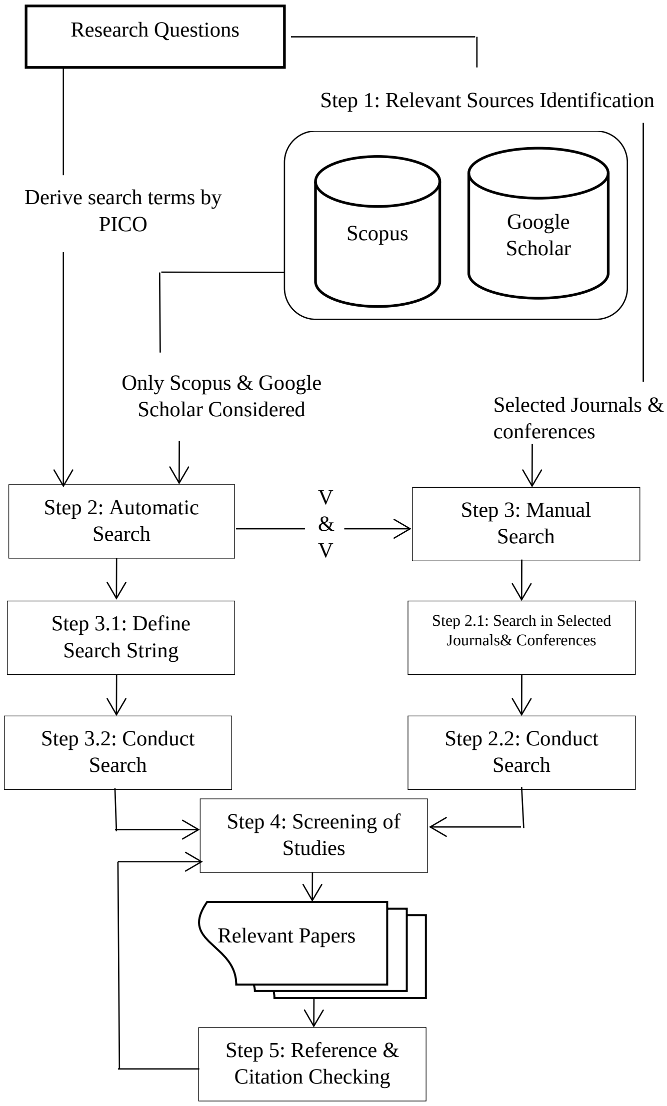

Figure 4-2 Automated and Manual Search Process

As noted above, a search string was needed to enable the identification of potentially relevant studies, based on a set of keywords drawn from the defined research questions (see Section 4.1.2). The final search strings, for Scopus and Google Scholar, are shown in Figure 4-3.

Two different search strings were used because Google Scholar does not support structured search strings (as per the string defined for Scopus). No timeframe was set (i.e., search period) for the automatic search phase, in order to enhance search coverage – initial findings from the pilot study (explained in more detail in Section 4.1.4) suggested that there was a limited number of prior studies in this area.

Scopus String:

("software measure*" OR "software metric") AND (Framework* OR Tool* OR Technique* OR method*) AND ((SME) OR (("small and medium" OR "small to medium" OR "small-medium") AND (enterprise* OR size* OR organization*)))

Google Scholar Strings:

("Software Measurement" SMEs)

("Software Measure" SMEs)

("Software Metric" SMEs)

Figure 4-3 Search Strings

4.1.3.4. Manual Search

Automatic searches are comparatively easy to conduct and can return a large number of candidate papers, but some of those returned can be of poor quality (Kitchenham, 2010b) and studies can be missed by a poorly framed search string. A manual search process can reduce the likelihood of missing relevant studies. Additionally, it can be used to validate the automatic search results.

For this additional search process we identified several journals and conference proceedings that were believed to address topics related to SM and software process improvement research. The list of journals and conference proceedings for the manual search, shown in Appendix 4.1, was finalized based on the experience of the thesis supervisors. In alignment with the outcomes of the pilot study and automatic search the starting year of the manual search was set to 1999, because the first relevant study retrieved via these means was published in 1999.

4.1.3.5. Reference Checking

To further reduce the possibility of missing relevant studies through automatic and manual searches, cross-reference checking was performed. Reference checking has been recommended in systematic review studies to increase the reliability of the search process and to minimize the chance of missing any significant relevant work (Ramesh et al., 2004). In this phase, reference checking was performed on the final set of studies selected from both automatic and manual searches. The process was conducted in an iterative manner by reviewing all references in all listed studies until there were no more potentially relevant studies to be checked.

4.1.3.6. Citation Checking

Finally, a citation check was conducted on all selected studies by checking which newer papers had cited those selected studies. This process was carried out using Google Scholar's citation index, the goal being to improve the outcomes of the search process by providing up-to-date coverage of the publications in the area.

4.1.4. Pilot Study

In systematic review studies, the study selection process is a critical step in terms of achieving the desired results. In light of this, carrying out a pilot study has been recommended (Shull et al., 2002; Teijlingen & VanoraHundley, 2002) before conducting the actual review study, to refine the proposed search strategy and search process. During the pilot study a short search string was used i.e. "Software AND Measure* AND SME*". The pilot study was carried out using two well-known databases: IEEE Xplore and ACM Digital Library. The initially designed inclusion and exclusion criteria were also applied to the search results. As the pilot study returned only a small number of potential primary studies these criteria were amended. The initial search was not designed to include SPI studies that addressed SMPI in SMEs so this inclusion criterion was added. The results of the pilot study are shown in Table 4.4.

Table 4.4 Pilot Study selected studies

	ACM	IEEE
Total number of studies retrieved	283	125
Final number of studies (after screening)	0	3

As the pilot study search returned a very limited number of studies this led us to include the manual search and reference check processes to augment the automatic search.

4.1.5. Screening the Studies

The screening of studies consisted of six steps (shown in Figure 4-4). Automatic and manual searches followed the same number of steps, as they have a similar nature. However, the manual search was performed after conducting the automatic search.

In the first run, the search string was applied on Scopus and Google Scholar. Scopus returned 981 studies, whereas Google Scholar returned 507 studies. (Note that the 507 studies are the aggregation of the results found by the three different search strings for Google Scholar.) In the manual search then researcher examined each journal issue and conference proceedings separately. After retrieving the results of both automatic and manual searches, the researcher filtered the studies based on the inclusion and exclusion criteria, as depicted in Figure 4-4.

Based on the results of both the manual and automatic searches, reference checking was carried out in step five. During the fifth step, the researcher repeated steps two through four until no more relevant studies that met the inclusion criteria were found. As a result of this process, a total of 33 studies were found. Step 6 combined all results for the automatic search, manual search, and reference checking, and then removed duplicated studies. Of the 49 studies identified 16 were found to be duplicated. Therefore, the number of identified candidate primary studies after removing duplicates was 33. The researcher then carried out citation checking on all 33 studies, using Google Scholar's "Cited by" functionality. The results of citations checking are shown as follows:

Total Found	Irrelevant	Non-English	Duplicated	Relevant
642	509	83	50	0

As Google Scholar returns results from multiple databases, so that, for instance, paper ABC could be found three times from three different databases, it is counted here only as one. Even then, our results show 50 duplicates for our total selected studies (33) after filtering results through all previous search methods. The reason behind these duplicates is that some were cited by each other more than once. Ultimately, this step did not result in the additional inclusion of any candidate studies.

4.1.6. Data extraction

Data extraction was performed on the final set of the selected studies, using our predefined classification scheme, followed by a quality check. These two procedures are now explained further.

4.1.6.1. Classification scheme

While there have been several classification schemes proposed and applied to research in software engineering (such as those of Montesi & Lago, (2008), Wieringa et al., (2006)) the comprehensive scheme of Jalali & Wohlin, 2010, which incorporates the research type classification provided by Wieringa & Heerkens, (2006), was followed in this study (and a summary is provided in Table 4.5). This classification scheme has five categories as follows:

1. General information: provides basic information about the selected articles.
2. Research Methodology: divides studies into different categories based on their research types and the nature of the research was conducted.
3. Artefacts representing the form of the articles' key contributions such as Tools/Techniques/Method/Framework/Model, their nature, usage, and performance.

4. Empirical Project Features: under this category, studies are classified by their empirical features and characteristics.
5. Results: information regarding the research contribution of each of the selected studies, such as problem report, recommendations, lessons learned, tools, frameworks, models, and snapshots.

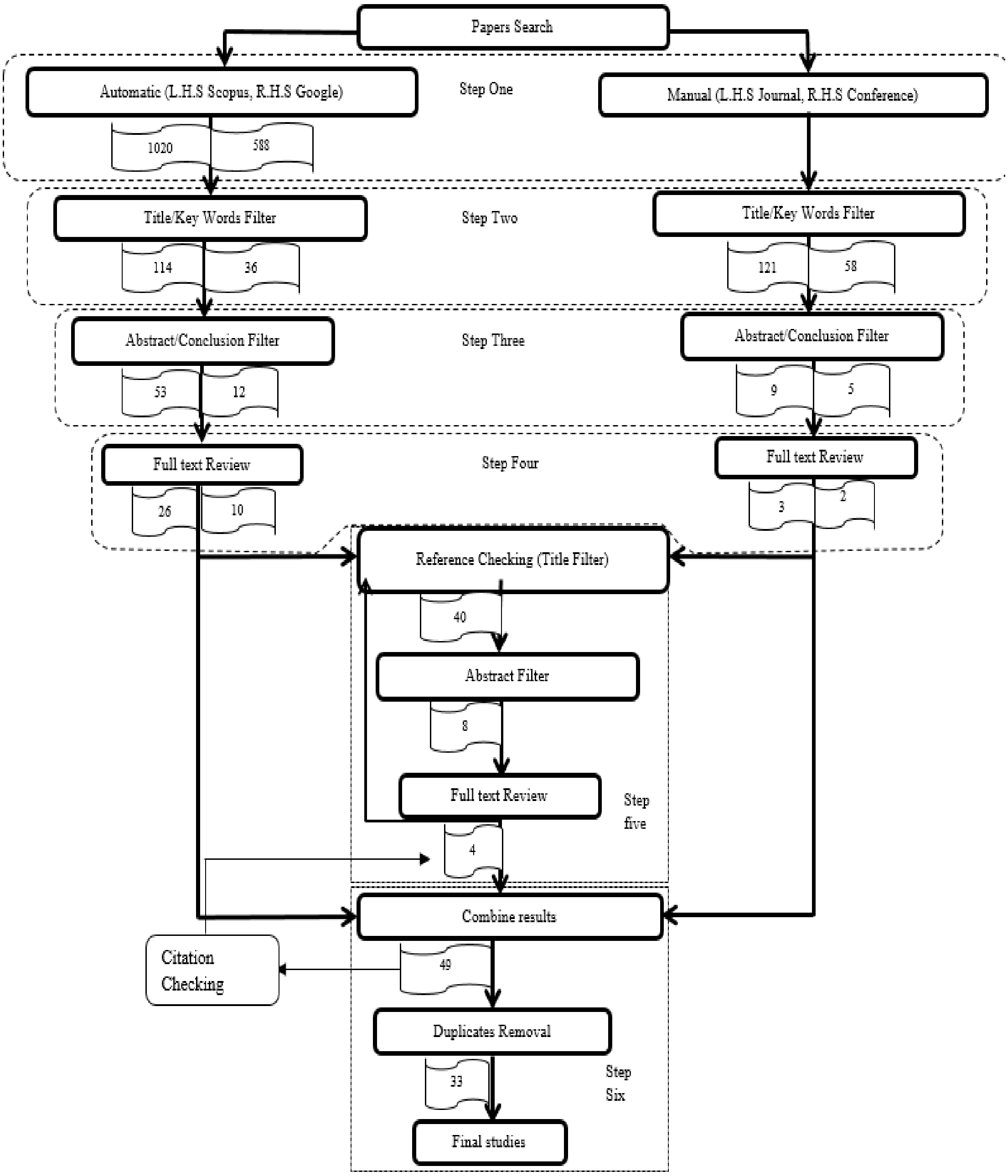

Figure 4-4 Screening Process

To ensure that the results are reported in sufficient detail each main category is divided into sub-categories. These sub-categories convey multiple features that represent different perspectives of analysis.

Table 4.5 Classification Scheme (Jalali & Wohlin, 2010)

Data Item/Category	Values	Additional Notes
1) General Information		
Data Base	SCOPUS, Google	Scopus provides wide access to over 4000 international publishers
Number of Authors	>=1	
Publication year	(1984-2015)	2015 inclusive
Source	journal, conference or workshop	
2) Research Methodology		
Empirical	yes, no, unclear	
Research type	evaluation, validation, solution proposal, philosophical, personal experience, opinion (Wieringa & Heerkens, 2006)	
Research method	qualitative, quantitative, mixed, unclear	
Research sub-method	single case study, multiple case study, experiment, literature review, unclear	
Means of data collection	the survey questionnaire, interview, literature review, case study, unclear	
Means of analysis	comparison, descriptive, measurement, classification	
3) **Artefact (Extract information about proposed (Frameworks/Methods/Tools/Models) for SMPI in SMEs)**		
Introduced	Year, Unclear	
Use in/for	SME, CME, LSE, medium, small, Unclear	CME (Creative Micro Enterprises), LSE (Large Scale Enterprises). The solution developed specifically for small or medium organizations.
Focus	SPI, SM, Measurement Maturity Model (MMM), unclear	
Goal Based	Yes, No	Reported method/solutions is goals based or not.
Perceived/ Reported Performance	Evaluated, Clearly stated, Easy to Understand and Manage (EUM), Effortless (EFL), Complete (COM), Informative (INF), Integration into Process (INTP)(Díaz-Ley et al., 2007) Unclear	Based on reported or perceived performance.
4) Empirical Project/Product Feature		
Size:	small, medium, large, unclear	Small<= 20-person < Medium<= 50-person < Large
Duration:	short, medium, long, unclear	
Participants	industry, academic, unclear	
Domain:	telecom, oil industry, web-based, real-time, embedded, IT industry	
Knowledge area:	RE, design, development, testing, tools, PM, quality, SPI, SM	Requirement Engineering (RE), Project Management (PM)
Perceived/ Reported Successful:	yes, no, unclear	
5) Results		
Contributions:	problem report, recommendations, lessons learned, tools, framework, model, process, method, snapshot, challenges, success factors	

4.1.6.2. Quality Checks

As noted in earlier sections, quality assessment checks were performed on the review protocol design and on the data extraction process. As the review protocol is such a major determinant of the quality of a mapping study's outcomes it was carefully refined through discussions between all those involved in this study. The protocol was first designed by the researcher and primary supervisor and was then discussed with another supervisor to improve its utility, until it reached an acceptance level for all three. The researchers also performed a quality assessment of the data extraction process to minimise any biases in study extraction. According to this process, nine studies were selected randomly from the selected set of studies and shared among the primary supervisor, the thesis researcher and another senior researcher. Each performed a separate data extraction process using the defined classification scheme. Results were aggregated, with final decisions being made based on a 2/3 or 3/3 agreement. Levels of agreement were high (see Appendix 4.2), lending credibility to the data extraction results.

4.2. Core Findings

This section presents and discusses the core findings of the systematic mapping study. As previous studies (Petersen et al., 2008b) have recommended, this research uses graphs and bubble chart analyses to present the results.

4.2.1. General Findings

A close to even split of journal and conference publications were selected (see Table 4.6), and the majority of these were published between 2006 and 2012, as shown in Figure 4-5. According to the findings, the first article to study SMPI in SMEs was published in 1999 (Kautz, 1999). This work reported the personal experiences of those developing and using small-scale metrics programs in SMEs. Following this, Wangenheim et al., (2003) proposed a GQM-based framework called "GQM Lightweight" designed specifically for SMPI in SMEs. Later, a series of research works in SMPI for SMEs was conducted by Diaz-Ley et al., (2008); Díaz-Ley et al., (2007) and Díaz-Ley et al., (2010b). These authors proposed and evaluated a GQM based framework called MIS-PyME.

Table 4.6 Article per Source

Source	No. of Papers
Journal	16
Conference	15
Workshop	2

Based on the retrieved data it was found that the topic of SMPI for SMEs had been discussed by researchers from several different perspectives (such as performance, or quality improvement). Few solutions have been proposed to overcome acknowledged SMPI issues.

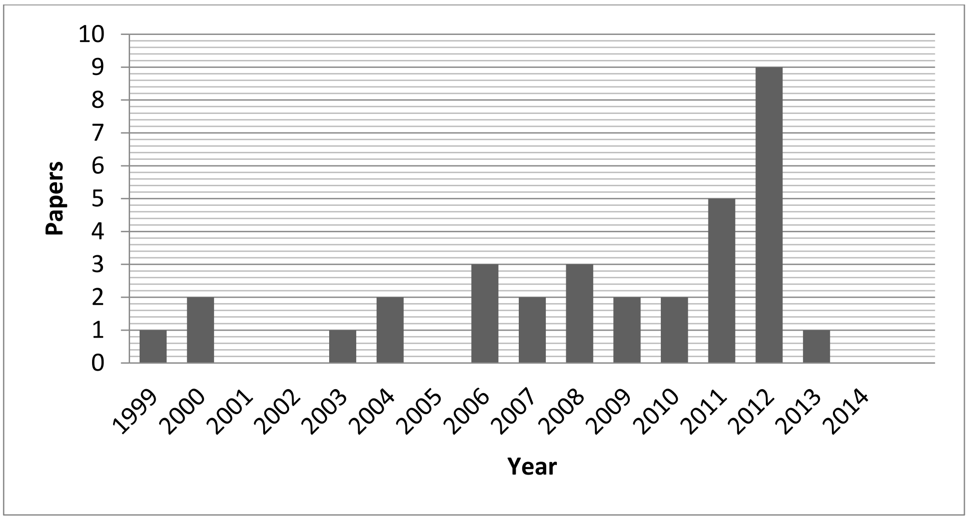

Figure 4-5 Published Articles per Year.

4.2.2. Research Methodology Findings

The results of the research methodology classification are shown in Figure 4-6. Our findings indicate that 'Evaluation' and 'Validation' research publications are more common than other Research Types. These results are positive in the sense that research has proceeded beyond proposals alone, mapping to the increasingly common used of empirical methods in SE generally, and SM in particular (Kitchenham, 2010b), through interviews, case studies and similar. The predominance of such approaches is evident in the results for 'Research Sub-method' and 'Means of Data Collection'.

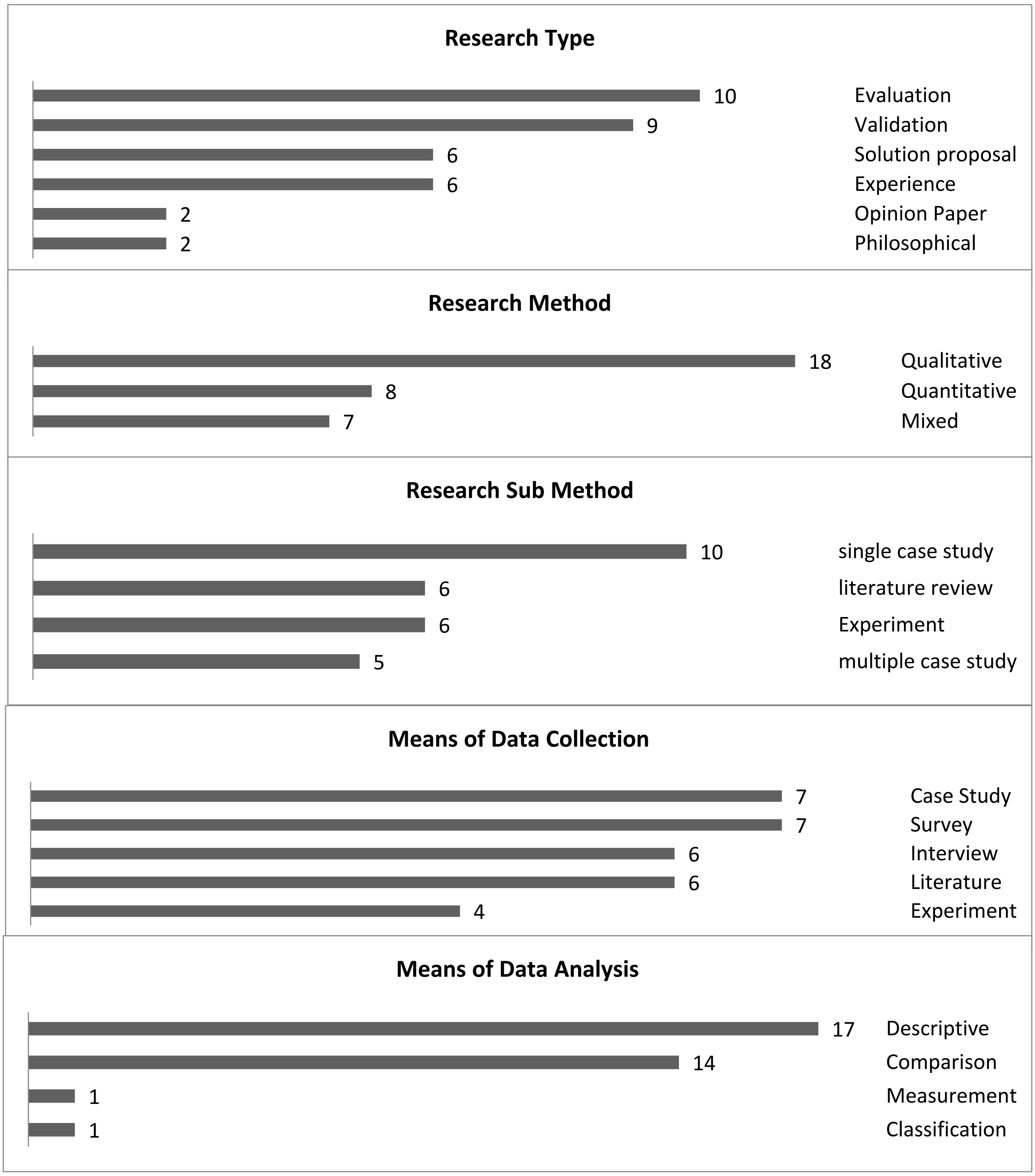

Figure 4-6 Research Methodology Findings

4.2.3. Artefacts Findings

This subsection presents the results regarding the nature of all previously proposed solutions for SMPI in SMEs. In Figure 4.7 the left X-axis shows the number of solutions proposed for organizations in terms of their size, whereas the right X-axis shows in which years these solutions were proposed. The Y-axis depicts the type of each proposed solution. As is evident in Figure 4-7, most of the proposed solutions have been designed for small enterprises or SMEs, and the focus has been on proposing frameworks more than other types of solution. The first relevant publication in the area was published in 2003 (Wangenheim et al., 2003) and there has been a small but steady number of published works on the topic since then. (Figure 4-7 shows the results up to 2013 as no relevant studies published in 2014 and 2015 were retrieved.)

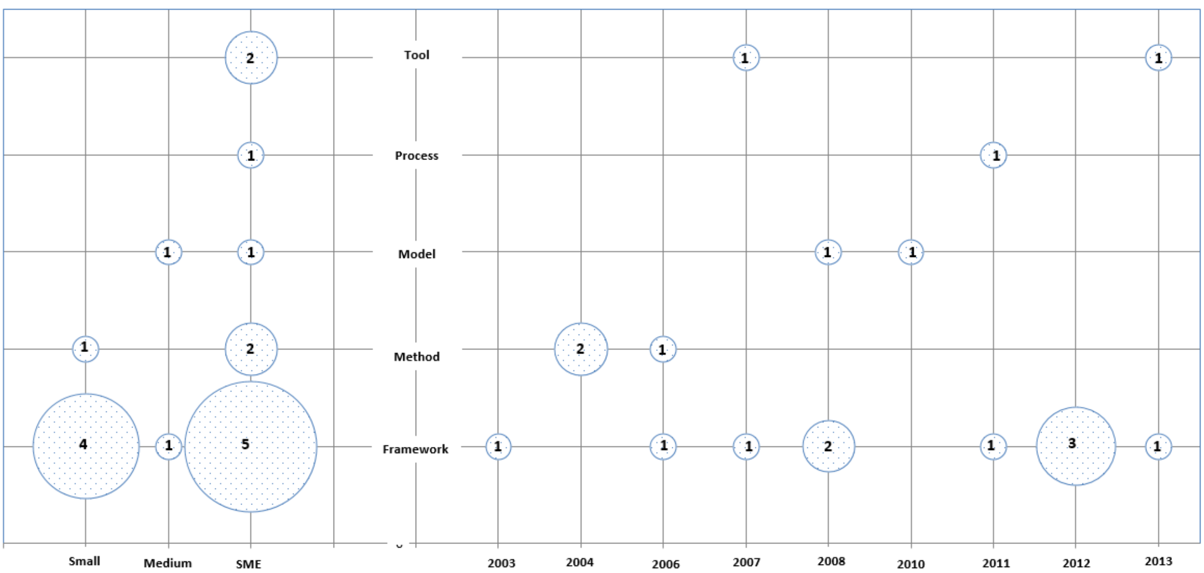

Figure 4-7 Distribution of Existing Solutions

Figure 4-8 depicts different properties of these proposed solutions, where the property "Clearly Stated" is more dominant and Easy to Use and Manage (EUM) is the least dominant aspect. Furthermore, findings relating to the 'Focus' of the proposed solutions show that SM was discussed more often in the studies than other factors, followed by SPI and Measurement Maturity Models (MMM). These findings are somehow expected, given that SM is known to be an essential part of SPI (Morisio, 1999; Wangenheim et al., 2003). This illustrates that most solutions were proposed for SMPI in general, rather than for a specific purpose (for example, quality or productivity measurement). Another relevant finding is the tendency for studies to have used of goal-based approaches to metric definition in the context of SMEs. It has been claimed previously that goal-oriented approaches are more readily accepted for SMPI in software organizations (Petersen et al., 2014), and so this is a positive characteristic of these prior studies.

Figure 4-8 Existing Solutions Findings

4.2.4. Project Features

This section presents the findings related to the project/product features of all selected studies (see **Figure 4-9**). The 'Knowledge area' categorisation was determined based on the research context of each study (i.e., the research focus, either it is general SMPI or it is SMPI for a particular factor (such as SMPI for quality measurement, SMPI for SPI, or SMPI for performance measurement) or from a particular perspective (e.g., Project Managers)). Our findings indicate that most studies have focused on SM in general. Further, the findings indicate that the second most common knowledge area is SPI (given that SM plays a central role in SPI) (Haddad et al., 2012; Kautz, 1999).

The overall context of most of the selected studies was quite clear. However, some of the findings regarding other categories, such as project size or project duration, were not clear due to a lack of information in the studies as reported. The same issue arose in relation to the Domain category findings, hence the predominance of the "Generic IT Industry".

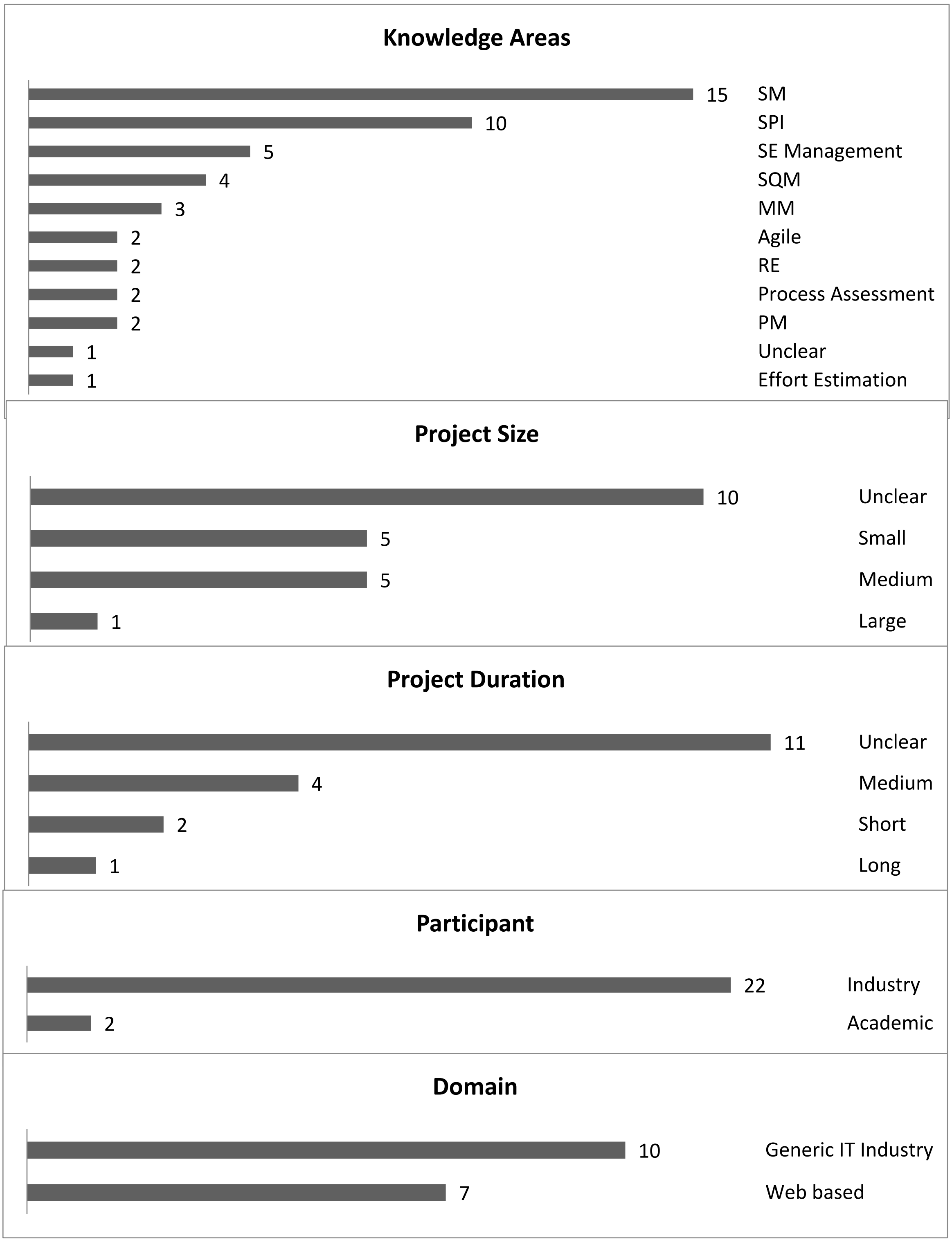

Figure 4-9 Project Features

4.2.5. Contributions

Figure 4-10 depicts a map of the selected studies based on their research contributions. The ‘Research focus’ is shown on the y-axis, ‘Research contribution’ on the right x-axis and ‘Research type’ on the left x-axis. Our findings show that the main focus of these studies was on delivering SPI recommendations or reporting lessons learned regarding software measurement. As noted above, most published works are evaluation or validation studies (e.g., the evaluation of a proposed solution), with few experience and opinion studies.

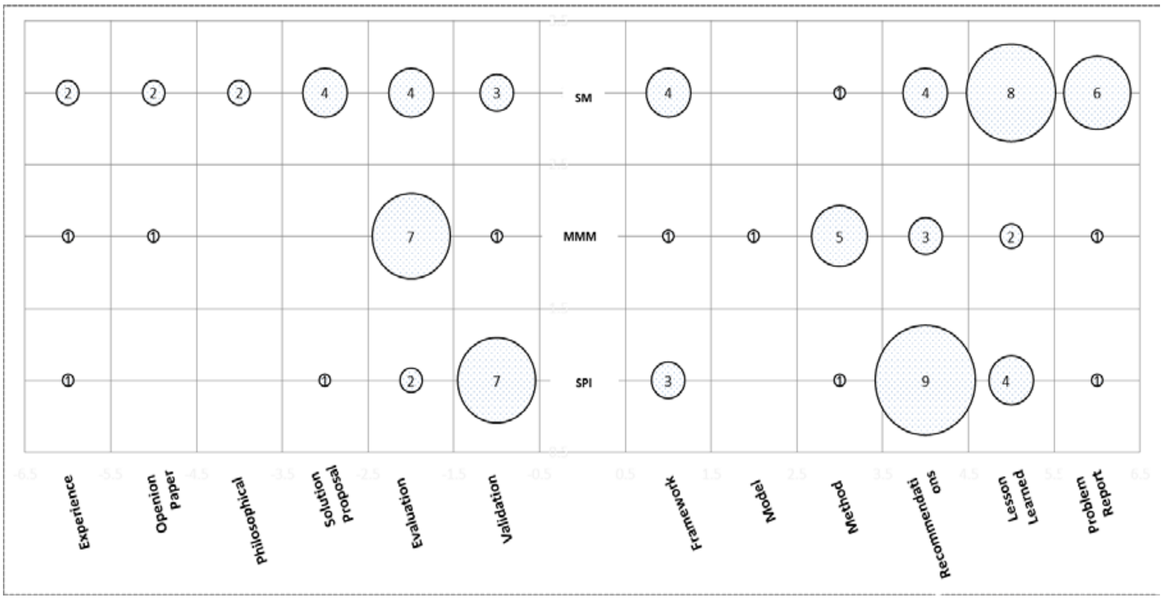

Figure 4-10 Contributions of the selected studies

4.3. Data Analysis

This section reports the analysis of results based on the data extracted from the selected studies. In particular, the research context of the selected studies and the reported challenges and success factors were analysed.

4.3.1. Research Context of the Studies

Our findings reveal that, overall, a limited number of studies have been conducted in the ‘Problem domain’ or research context of SMPI in SMEs. This same conclusion has been found in prior similar studies (Díaz-Ley et al., 2008c; Díaz-Ley, et al., 2008d; Haddad et al., 2012). Most of the research work is conducted, generally, in the context of SMPI - irrespective of organizations’ sizes.

4.3.1.1. Software Process Improvement

The use of SM within SPI has been discussed extensively in the selected studies, almost certainly due to the understanding that measurement plays a central role in SPI (Haddad et al., 2012; Kautz, 1999; Ponisio & Eck, 2012). SPI implementation and management are typically monitored and controlled through the use of software metrics (Ponisio & Eck, 2012) (Diaz-Ley et al., 2008).

4.3.1.2. Agile Software Development

Agile software development has been widely adopted as a software development methodology in SMEs (Caffery et al., 2007; Ruiz et al., 2011). Agile methodologies are said to more effectively ensure the delivery of software projects according to organizational capabilities (Ruiz et al., 2011) and in the last decade have largely replaced conventional development models such as Spiral and Waterfall (Ahmad et al., 2012b). Moreover, specific Agile methodologies such as Extreme Programing (XP) and Scrum (Beck, 2000; Larman, 2004) explicitly direct support to small software teams, projects and firms (Ahmad et al., 2012b; Lindstrom & Jeffries, 2004; Qumer & Henderson-Sellers, 2008). Unfortunately, however, neither XP nor Scrum provides any detailed guidance on using or implementing SMP within those methodologies.

This mapping study identified just one study that has attempted to link SM integration with Agile processes (Ruiz et al., 2011). The goal of the study was to present a hybrid measurement process that supported organisations in switching between software quality models, such as ISO/IEC 15504, ISO/IEC 1207:2008 and CMMI Dev 1.3, while using Agile Scrum practices (Ruiz et al., 2011). Two further studies mentioned this issue but with minimal emphasis (Caballero et al., 2011a; Taylor et al., 2006). In one of these studies (Taylor et al., 2006) risks factors and their assessment in small software organizations that are adopting agile methodology are discussed. In (Caballero et al., 2011a) it was shown how Scrum could improve productivity in very small enterprises, without decreasing product quality. In their study they used metrics that accounted for schedule, effort, and size.

4.3.1.3. International Standards

A small number of studies have addressed the integration or elaboration of SM with international standards and models, such as those designed by ISO and CMMI (Díaz-Ley et al., 2007; Díaz-Ley, et al., 2008d; Pusatli, 2011; Ruiz et al., 2011). The implementation of software measurement programmes through these standards has been seen as a means of increasing the likelihood of successful SMPI (Díaz-Ley et al., 2007). However, at the same time, it has been reported that such quality standards are not completely suitable for SMEs (Díaz-Ley et al., 2007; Haddad et al., 2012) due to their resource expectations.

4.3.1.4. Software Engineering and Management

Jovan and Dragan (2012) studied effort estimation methods in software development. They validated several functional measurements and analysis methods (e.g. IFPUG, NESMA, COSMI and use case points) in small and medium size web-based projects in a CMMI level 2 organization. Haddad et al. (2012) investigated SMP management in SMEs. They discussed a range of application areas and processes including Project Management, Testing, Risk Management, Requirements Gathering, and Change Management. Their study explored challenges related to SMPI in small organizations only, and they proposed a set of metrics that could be used by these organizations to measure cost, size, and quality.

4.3.1.5. Summary of Study Contexts

Most of the reported studies addressed a particular measurement factor relevant to SMEs, such as performance measurement (Laitinen & Chong, 2006; Sharma et al., 2008), effort estimation (Jovan & Dragan, 2012), software quality management (Caballero et al., 2011a; Wangenheim et al., 2003), project management (Kautz, 1999) and metrics-based control in outsourced projects (Kautz, 1999). Some studies discussed the management of SMP itself (Ahmad et al., 2012a; Tihinen & Järvinen, 2006b) rather than its implementation.

4.3.2. Challenges and Obstacles to SMEs in SMPI

Several challenges and obstacles encountered by SMEs when they sought to implement software measurement programmes were reported.

4.3.2.1. Limited resources

One of the major challenges in implementing SMP in SMEs is the limitation of available resources, including time, budget and personnel (i.e., specific team members with specific expertise) (Ahmad et al., 2012b; Caballero et al., 2011a; Caffery et al., 2007; Ross & Haddad, 2010). This particular issue has been highlighted by most of the prior studies (Diaz-Ley et al., 2008; Díaz-Ley et al., 2010b; Gencel et al., 2013; Haddad & Meredith, 2011; Haddad et al., 2012; Pusatli, 2011). There is a belief that such resources are necessarily dedicated to the actual development process, as the added value of SMPI has not been proven (Tihinen & Järvinen, 2006b). Small companies therefore tend not to implement any SMP until they have the financial support, and/or they see the benefits of such programs (Díaz-Ley et al., 2007), as they have restricted financial and human resources (Wangenheim et al., 2003). The use of SM in SMEs is also limited because of short timeframes for product delivery, as SMEs are mostly tied to strict deadlines and at the same time, they have limited resources to meet these deadlines. Due to limited budgets, SMEs cannot hire a consultant to assist with SMPI (Haddad & Meredith, 2011) – or at least they choose not to use their budget for such a purpose.

4.3.2.2. Poor measurement experiences

As just noted, limited resources have a negative impact on the likelihood of implementation of SMP in SMEs. In such situations, SMEs might attempt to use alternative measurement approaches such as expert judgment instead of using quantitative methods. Several studies have shown that cost and effort estimation through expert judgment is widely used in the software industry (Hughes, 1996; Jørgensen, 2004; Loconsole & Borstler, 2007; Tomaszewski et al., 2006), with 60% of companies reportedly relying on work breakdown structures and expert judgments. Only 20% of the companies use measurements and expert judgments together (Birrell & Ould, 1988). However, the use of expert judgments alone can be inaccurate and quite risky. A study by (*CHAOS Report: The Standish Group*, 2008) reported in (Jovan & Dragan, 2012) that between 30% and 35% of projects are completed within the planned timeframe and budget, and this is because of unsuccessful estimation which is based on subjective expert judgments. Therefore, it has been argued that quantitative SM can perform better than, and so should be preferred over, expert judgments (Loconsole & Borstler, 2007).

4.3.2.3. Lack of awareness and measurement expertise

Evidence suggests that most people working in SMEs have insufficient knowledge about SMP (Ahmad et al., 2012b; Caffery et al., 2007), perhaps because the topic itself is too extensive (Díaz-Ley et al., 2007). There are also potential misconceptions about SMPI in SMEs, in that software SME practitioners may perceive that such programs are designed only for large organizations (Haddad et al., 2012; Caffery et al., 2007) or they are more suitable for organizations with high maturity levels. There is evidence that some organizations do not even seek to realize the benefits of SMPI as they only reflect on their implementation cost (Haddad et al., 2012).

Prior research has also noted that difficulties occur when management roles are assigned to non-technical staff (McGuire, 1999), in that such staff might not be able to apply SPI or other software management practices effectively due to their lack of technical expertise. Equally, technically oriented developers (typical coders), normally do not have sufficient knowledge of, or respect for, measurement and management processes (Ahmad et al., 2012b). Another issue related to awareness and expertise is the large number of software metrics and measurement programs that could be implemented. This particular issue was discussed by several researchers includingHaddad et al., (2012) and Ponisio & Eck, (2012). Effective estimation requires the use of different and suitable combinations of measurement methods (Jovan & Dragan, 2012), typically when informed by organisational goals.

4.3.2.4. Workload pressures and cultural reluctance

It has also been reported that some developers might not be very keen to participate in SMPI, for a range of reasons: developers and managers might believe that SMP is unnecessary as it will increase their workload, which affects their ability to deliver on their originally assigned tasks (Allen et al., 2003; Haddad & Meredith, 2011; Haddad et al., 2012; Ross & Haddad, 2010). Similarly, team members could already have multiple roles (Wangenheim et al., 2003) which leads to work fragmentation and overloading. This may make them reluctant to take on what is seen as yet another task in implementing SMP.

In situations where developers are ‘forced’ to implement SMP by their managers, negative attitudes towards SMP inevitably emerge, and this typically results in the generation of poor quality metrics data (Haddad et al., 2012; Ross & Haddad, 2010). In addition, developers might also feel hesitant regarding the collection of specific metrics data, such as the number of defects and bugs found in their code, as such data might be used to assess their personal performance (Haddad & Meredith, 2011; Haddad et al., 2012; Umarji & Seaman, 2008). Therefore, some developers might not participate genuinely in the measurement process (Ross & Haddad, 2010; Umarji & Seaman, 2008). Similar issues have been reported by Haddad et al. (2012), including reluctant cooperation, lack of organizational commitment, fear of individual consequences and dishonesty in reporting metrics.

4.3.2.5. Complexity of measurement models

Successful SMPI is often associated with SPI and software quality models and standards such as CMMI, and ISO/IEC 15504 models. It is known that the implementation of such complex standards requires significant resources, effort, time and cost (Díaz-Ley et al., 2007; Haddad et al., 2012), which SMEs tend to lack. To overcome these issues and yet still keep the process structured, different informal methods have been introduced (Haddad et al., 2012), such as GQM, GQIM, RAPID. However, this research could not find evidence of any widely accepted implementation of these proposed methods in SMEs. One of the reasons could be that these proposed models still require complex analysis in the context of SMEs, and so they are not prioritized relative to other activities. Some other informal methods were proposed to overcome formal methods’ complexities, such as MIS-PyME (Diaz-Ley et al., 2008) and GQM-Lightweight (Wangenheim et al., 2003). However, MIS-PyME integrates SMP with CMMI, which in itself is quite complex to implement in SMEs.

4.3.3. Success factors in SMPI

In response to the range of challenges faced in relation to SMPI in SMEs some solutions have been suggested. This section reports the factors that have been identified in the selected studies as being positively influential when implementing SMP in SMEs.

4.3.3.1. Resource management

Resource limitations issues in SMEs could be partially overcome by providing very lightweight SMPI solutions (Haddad et al., 2012). Time and human resource shortages could also be overcome, or at least minimized, by maximizing the use of automated metrics data collection tools (Iversen & Mathiassen, 2000; Paulish & Carleton, 1994; Pfleeger, 1993). The tools should be reusable, and adapted to the measurement maturity of a company to overcome the challenges related to a mismatch of cultures (Diaz-Ley et al., 2008).

4.3.3.2. More effective management

Poor management, in general, can negatively impact software quality, development cost and project progress (Caballero et al., 2011a; Haddad & Meredith, 2011). As is the case with other management activities and processes, successful SMPI in SMEs requires proper project planning and management, executive commitment, training, staff involvement, teamwork, continuous assessment and evaluation of the new work practices, and their appropriate technical support (Kautz, 1999). (Haddad & Meredith, 2011) reported that most challenges facing SMEs regarding SMPI could be averted by improving areas such as project management practices, testing processes, risk management strategies, requirements gathering, and change management.

Regarding operative management, managers can motivate team members to use and report metrics and data by ensuring that they realize the value of SM to the organization's success (Díaz-Ley et al., 2007; Haddad et al., 2012; Umarji & Seaman, 2008). It is equally important to develop the trust of individuals to report true metrics data, which can help to ensure the success of SMPI in SMEs (Druffel et al., 1983).

4.3.3.3. Informed standard metric selection and use

SMEs should select software metrics that are easy to understand, collect, analyse and validate over time (Diaz-Ley et al., 2008; Haddad et al., 2012). In fact there is likely to be a 'standard' set of metrics for small organizations which are easy to collect within a specific time and budget allocation (Ross & Haddad, 2010), that can be used to assess size, schedule, cost and defect detection related metrics. Some of these metrics do not necessarily require an additional upfront cost. Haddad et al. (2012) go on to suggest that factors that can be 'easily' measured in the context of SMEs include cost and effort, productivity, size, scheduling and software quality. Their reported results show that metrics dashboards, capturing and reporting the standard set of metrics, can assist SMEs in SMPI.

4.3.3.4. Clear definition of roles and responsibilities

Goals regarding the implementation of SMP-in-SMEs are in fact similar to those of larger organizations interested in measurements programs, but only a few SMEs will take a charge to make it happen. Essentially, the roles and responsibilities for SMP in all previously proposed solutions are not sufficiently or properly defined. In regard to organizational roles and responsibilities in implementing SMI, it has been recommended that decisions in small organizations should not be made by so-called experts (Loconsole & Borstler, 2007); instead, managers should use simple structural measures. At a minimum those managers should also revisit and analyse the results to achieve the organizational goals (Pressman, 2010), as they should be familiar with the organization's high-level goals (Haddad et al., 2012). On the other hand, software product quality should be assessed mainly by team leads, QA teams or through software review meetings (Díaz-Ley et al., 2007). Such recommendations indicate there should be explicit role and responsibility definitions for the performance of each step of SMPI.

4.4. Discussion

This section discusses the findings of the mapping study in relation to the previously defined research questions. As a general observation, the topic of SMPI in SMEs has not been widely explored in the past. There are certainly many open challenges in the topic that need to be investigated. It is also important to note that most of the studies in the area to date have focused on investigating the challenges that are faced by SMEs when they are seeking to implement SMP, rather than proposing practical solutions to overcome these challenges. In fact, there are only a few studies that have attempted to propose solution frameworks to overcome some of the challenges. The first major contribution in the area was published in 2003 (Wangenheim et al., 2003), while the majority of works in the area appeared between 2006 and 2012. After 2012, very few studies addressing SMPI in SMEs have been published.

RQ 1.1: What software measurement tools, techniques, frameworks, and methods have been developed specifically for SMEs?

Our findings show that very few solutions have been proposed to date for SMPI in SMEs (see Section 4.2.5). Furthermore, it is also evident that most of those proposed solutions are based on the GQM framework. By looking at the identified challenges and their proposed solutions, it seems that those solutions are more suitable for medium-sized organizations working at a relatively high maturity level. Most of the suggested solutions are claimed to be suitable for SMEs; however, none of these solutions are tested in the context of both small- and medium-sized organizations. In general, the researcher could not find any clear evidence in the literature of SMP acceptance in SMEs.

One of the major contributions in the area is the body of work of Díaz-Ley et al. (Díaz-Ley et al., 2007, 2008, 2010b), which introduced and evaluated the MIS-PyME framework. MIS-PyME consists of two parts: an SMP definition methodology and a measurement capability maturity model (Díaz-Ley et al., 2010b), the latter of which emphasises a company's measurement maturity. There are some commonly discussed challenges related to the implementation of SMPI in SMEs (Haddad et al., 2012; Díaz-Ley et al., 2009; Wangenheim et al., 2003). To overcome these particular challenges, the MIS-PyME framework added a reusability concept, incorporating a data base of predefined goals and indicators. Furthermore, MIS-PyME provides a goal-oriented definition template to improve personnel awareness and appreciation of the intent and value of measurement. This framework was developed and tested only in a medium-size organization which already had measurement practices in place. Its utility in a small organization new to measurement was not demonstrated.

The proposed solution at the core of the work of Díaz-Ley et al. (Díaz-Ley et al., 2007, 2008, 2010b) integrates CMMI Dev 1.2 and ISO/IEC 15504 with Agile. As discussed above in the section on challenges (Section 4.3.2), the use of such complex standards is one of the reasons that people in SMEs are reluctant to undertake SMPI. One of the solutions proposed to overcome this issue is the GQM-Decision Support Framework for Metrics Selection (GQM-DSFMS) (Gencel et al., 2013). The GQM-DSFMS framework was developed primarily to support organizations in selecting an optimum number of metrics that would fulfil their information needs under the constraints of available budget and time. This proposed framework includes goal and question definition templates, as provided by MIS-PyME, and a reusability feature, as GQM Lightweight and MIS-PyME also provide. GQM-DSFMS was developed and implemented in a medium-level maturity organization (at CMMI level 3), but its intention was metrics optimization instead of coping with SMEs challenges. It could potentially be useful and remain suitable for medium-sized organizations.

Some of the proposed solutions, including GQM Lightweight (Wangenheim et al., 2003), GQ(I)M (Park et al., 1996) and ISO/IEC 15939, do not provide clear guidelines on the selection and adoption processes of relevant measurements, which could vary from one environment or organizational context to another. Some solutions were proposed to address specific measurement factors such as performance measurement, SPI and quality improvements. The work of Laitinen & Chong (2006) discussed performance measurement for specific organization sizes. Similarly, Haddad et al. (Haddad et al., 2012) introduced a measurement framework for instituting metrics in small organizations or a specific measurement data management program (Tihinen & Järvinen, 2006b). Table 4.7 reports a summary of existing solutions and their properties.

RQ 1.1.1: What software measurement tools, techniques, frameworks, and methods are being used by SMEs?

Based on the findings and analysis reported in Sections 4.2 and 4.3 respectively, a number of proposed solutions were identified. However, the analysis also revealed that there are no commonly accepted or used SMPI solutions. The reasons could be either they are newly developed or not followed up by their inventors – GQM Lightweight has seen no follow-up studies or further development, and MIS-PyME is to some extent still newly developed.

RQ 1.2: What are the main areas of focus in software measurement programs in SMEs?

It is evident that in general there is very little work that has been done in this area. However, in those works that have been published the goal has been to elaborate the challenges associated with SMPI and in some cases to provide solutions. For example, some of these works have focused on providing a set of metrics that are easy to use in the context of SMEs, as in (Haddad et al., 2012). Other works have focused on the quality aspects of software, or on how to manage the collected measurement data. Tihinen & Järvinen (2006b) proposed a framework called Measurement Data Management (MDM), where the main purpose was to build and sustain a measurement data management environment in SMEs. Overall our results (in the subsections of 4.2.1) show that most of the studies in this area have focused on the SPI aspects of SM.

The findings also show that SMPI in SMEs has not been discussed in relation to software development methodologies. It is widely acknowledged that Agile development methodologies are being commonly used in SMEs, but there is only one study that has considered the integration of SMP with Agile (Martinez et al., 2011) in the context of SMEs.

Other studies discussed some potential challenges that could be faced by SMEs when trying to implement SMP while using standards such as ISO/IEC 15504 and CMMI (Diaz-Ley et al., 2008; Haddad et al., 2012). There are some one-off attempts by several researchers to investigate the use of SM for specific measurement aspects (including Knowledge Transfer in SM by Soini, (2007) performance (Laitinen & Chong, 2006) and effort (Jovan & Dragan, 2012)). It was also found that there are some unique issues that could be faced by SMEs implementing SMP in the context of ‘outsourcing’ development.

RQ 1.3: What are the reported success factors in implementing software measurement programs in SMEs that have been identified in previous research?

Our findings show that research studies to date have focused on SMPI for particular aspects of measurement data management (MDM), performance, effort measurement, or the integration of measurement models. There are also some solutions proposed for SMPI in general. To the best of our knowledge, none of these studies discusses implementation success or failure factors explicitly and only one of these studies discusses the challenges faced by small enterprises only (Haddad et al., 2012). Overall, there is greater focus on the challenges than on providing solutions to existing issues. Resource limitations faced by SMEs, and their negative impact on SMPI, is a widely discussed challenge. To overcome these challenges several recommendations has been made, such as proposing simple and easy-to-use solutions and maximizing the use of automation in metrics data collection. A further challenge to the success of SMPI is limited awareness – managers and developers in SMES reportedly have limited knowledge about the importance of SMP to their goals. This can be overcome by adding features in any developed solutions, such as predefined metric data sets and goal determination templates. Similarly, other works have provided a core set of software metrics that can be easily collected by small organizations (Haddad & Meredith, 2011). Other efforts have focused on defining a set of steps for SMPI to enable better understanding (Wangenheim et al., 2003) for the SMPI participants. All of this said, the complexity of many proposed solutions remains an unexplored challenge in terms of impeding likely SMPI success.

Table 4.7 Existing Solutions

Author(s)	Year of Publication	Artefacts/ Solutions	Based on	Type	Description	Used For
(Wangenheim et al., 2003)	2003	GQM Light Weight	GQM	Framework	This framework provides a set of guidelines to adopt GQM for SMEs. It integrates the reuse of context-specific quality and resource models into GQM methods.	SMEs
(Boyd, 2004)	2004	Goal Driven Process (GDP)	GQ(I)M	Method	A framework that outlines ten steps for the evaluation and documentation of business process re-engineering. A theoretical process designed and examined within a small software firm.	Not specific. However, the framework was examined in a small enterprise.
(R. Anacleto et al., 2004)	2004	15504MPE	ISO/IEC 15504	Method	An assessment model based on the exemplary model of part 5 of ISO/IEC 15504, including process reference model and measurement framework, as well, as a context process relationship model and a process risk relationship model.”	Small
(Tihinen & Järvinen, 2006b)	2006	Measurement Data Management (MDM) Framework		Framework	“The main goal of MDM is to integrate both project and organization level measurement activities for producing an environment of comprehensive measurement utilization.”	SMEs
(Beitz et al., 2001a)	2006	FAME: The Fraunhofer Assessment Method		Method	“Used to define measurement goals. It allows applying either SPICE or BOOTSTRAP Assessment, and uses the standard assessment model of the upcoming standard for software process assessment (ISO/IEC TR 15504)”.	Small to large organizations
(Soini, 2007)	2007	Information System		Method & Tool	“A web-based information system for measurement knowledge transition. The generated system offers information about different metrics and their applicability to measuring different processes. The system is only to serve the issues related to the software process and product measurement; other subjects are excluded”.	Nine out of ten participating enterprises were SMEs.
(Díaz-Ley et al., 2007, 2008, 2008c, 2008d, 2009, 2010b)	2007 - 2010	MIS-PyME	GQ(I)M	Framework	“The MIS-PyME framework is composed of three main modules: the MIS-PyME methodology, the work products that support this methodology (MIS-PyME measurement	In SMEs for measurement

					goals table, MIS-PyME indicator template and MIS-PyME database) and the measurement maturity model (MIS-PyME measurement maturity model)."	activities related to SPI tasks
(Ruiz et al., 2011)	2011	Hybrid Measurement Process	ISO/IEC 15504-ISO/IEC 12207:2008 and CMMI Dev 1.3	Process	"Definition of Hybrid Measurement Process for the models ISO/IEC 15504-ISO/IEC 12207:2008 and CMMI Dev 1.3 in SMEs."	In SMEs for measurement.
(Haddad & Meredith, 2011; Haddad et al., 2012)	2011-2012		GQM	Framework	A theoretical method that discusses SMPI and management.	Small enterprises.
(Beland & Abran, 2012)	2012		GQM	Framework	"A measurement framework to support continuous improvement in software intensive organizations."	Not specified, but examined in two small software enterprise.
(Ponisio & van Eck, 2012)	2012			Framework	"A framework that consists of two parts: a set of organizational effectiveness measurements and a set of information infrastructure principles."	Implemented in a large organization but claims comparable with MIS-PyME and can be used for SMEs.
(Gencel et al., 2013)	2013	GQM-DSFMS	GQM	Framework & Tool	"A decision support framework for metrics selection in goals based measurement programs."	Not specified, but *could be* suitable for medium organizations.

4.5. Summary

This chapter has presented a mapping study on SMPI in SMEs. It has mainly explored SMPI challenges, success factors and existing solutions for SMPI in SMEs. In total 33 primary studies were identified and analysed. The results showed that most of these studies were empirical in nature. Overall, this small collection of studies addresses a diverse range of topics related to software measurement in SMEs. More importantly, almost all are one-off in nature, with no follow-up studies reported, those addressing the MIS-PyME solution excepted. Only a couple of studies propose or evaluate solutions specifically designed for SMPI in SMEs; GQM-Lightweight and MIS-PyME. Even then, however, there is no evidence in the literature to suggest that these solutions are indeed successful, or have been adopted beyond their initial studies. Even though numerous challenges to SMPI in SMEs remain, none of the selected studies discuss or describe the SMPI challenges and success factors explicitly, meaning that the suitability of solutions is open to question – perhaps negatively affecting their adoption.

In order to better understand practitioner attitudes to the challenges and success factors associated with SMPI in SMEs it seemed appropriate to seek the views of those actually working in such a context in industry. This is the focus of the chapter that follows.

Chapter 5 Industrial Review

Drawing on the findings of the mapping study presented in the previous chapter, the researcher sought to further investigate the challenges and success factors of SMPI in SMEs by performing practitioner interviews. This industrial review was conducted as part of the first phase of the Design Science Research (DSR) methodology; that is, problem identification. In this part of the overall research programme the main research question was **RQ2:** *What is the state-of-practice (in industry) of SMPI in SMEs?* And the core objective was **Obj2:** *To study the current state-of-practice through an in-depth industrial review in software SMEs*.

In total, 22 semi-structured interviews were conducted in 17 different software development SMEs in Pakistan and the UAE. The participants were selected as an ideal purposive sample (Easterbrook et al., 2008). In qualitative research, purposive samples are selected so that participants have particular characteristics that reflect their relevance to the research objectives. Although not all of the participants (the interviewees) were experienced in the specific area under investigation due to a general lack of adoption of SMPI in SMEs, they still had a sufficient level of knowledge and experience in software processes improvement, management and development, to ensure that they could answer in an informed manner in respect to the data needed for this thesis.

The research reported in this chapter adds to the body of knowledge in terms of practitioners' views regarding the challenges, obstacles, benefits and success factors of SMPI in SMEs, complementing the knowledge gained from the previous analysis of the research literature. As noted in Chapter 3 this research phase uses Grounded Theory-based qualitative data analysis methods to establish this knowledge, with each step described in more detail in upcoming sections. Section 5.1 presents the research design as it applies to this phase, Section 5.2 presents the findings relating to participants and companies, Section 5.3 presents the data synthesis and discuss the overall findings and Section 5.4 provide a summary of the chapter.

5.1. Research Design

The aim of industrial review was to identify the challenges and success factors of SMPI in practice and to compare the findings to those reported in the systematic mapping study. The specific objectives of this review are:

- Identification of deficient and unexplored areas of SMPI in SMEs.

- Identification of SMPI challenges, and any approaches to overcome them.
- Identification of success factors specific to SMPI in SMEs.

Practitioner interviews were used for data collection as a research method. For data analysis this research phase uses methods from Grounded Theory (GT) as described by Glaser and Strauss (2009) and Hoda et al. (2012). GT is a moderate form of inductive research that is commonly used where existing knowledge is fragmented (Elo & Kyngäs, 2008; Hoda et al., 2012). In inductive research, data is used to build theory, create relations and finally engage evolving theory with existing theory (Coleman & O'Connor, 2007; Elo & Kyngäs, 2008; Pace, 2004; Urquhart, 1997, 2000, 2001). It is more appropriate to use when there is no (or limited) existing knowledge about the domain under investigation (Elo & Kyngäs, 2008; Orlikowski, 1993). As such an inductive approach is appropriate for this study. Figure 5-1 depicts the flow of this research.

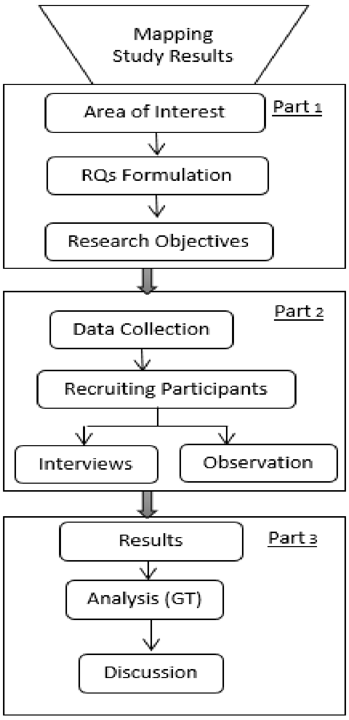

Figure 5-1 Research Methodology

5.1.1. Area of Interest

Under a GT approach researchers are recommended not to formulate the research problem themselves (Glaser, 1978; Hoda et al., 2012). Rather, they should seek to understand the participants' core problem so as to understand the research phenomenon from their perspective – this is one of the key reasons this research phase uses GT. The predetermined research problem concept can influence the researcher to simply produce theory based on the existing research literature (Glaser, 1978; Hoda et al., 2012). Although it is recommended not to formulate a research problem it is recommended that the researcher choose a general area of interest (Hoda et al., 2012). In the case of this research, the area of interest chosen was 'Software Measurement Program Implementation in SMEs'. The researcher had formed a degree of prior knowledge of the area of interest in broad terms, based on the initial mapping study (Chapter 4). The more specific substantive topics to be investigated here are the challenges and success factors for SMPI in SMEs according to practitioners, which reflects the research objectives of this phase.

5.1.2. Research Objectives

After declaring the area of interest, the next step was to define the research questions. These are important in that they help to explicitly demarcate and demonstrate the study's scope, enabling the researcher and the reader to ensure that answering them will indeed accomplish the aims and objectives of the research. The following research objectives were defined to investigate the problem domain.

Table 5.1 Research Objectives

S.No.	Research Objectives
1	Identification of deficient and unexplored areas of SMPI in SMEs.
2	Identification of SMPI challenges and approaches to overcome them.
3	Identification of success factors of SMPI in SMEs particularly.

5.1.3. Data Collection

Having established a level of core knowledge about the area of interest and the current trends in the problem domain as reported in the literature via the mapping study mainly, the next step was to design the data collection procedures for this phase of the research. The subsequent sections describe how and why particular participants were recruited and provides a summary of their characteristics.

5.1.3.1. Selection of Practitioners

To identify perceptions of and practices in industry in relation to software measurement, 22 face-to-face interviews were conducted with professionals from 13 Pakistani and four Dubai-based small and medium-sized software development companies. There were several reasons for choosing to seek interviewees from this particular region. Due to rapidly increasing levels of outsourcing capability in this part of the world, and the associated drive for western companies to find lower-cost global partners under a follow-the-sun business model, there are now many software development SMEs operating in Pakistan and the UAE. Moreover, these companies are typically developing products and services for the international market, especially in the USA and Europe – as such these SMEs need to be pursuing excellence in their processes to improve the quality of their offerings, and so gain more business. The researcher had also been working for nine years in the selected region, which reduced obstacles to engaging potentially relevant SMEs.

For company selection, no constraints (as, project/product duration, domain, or team size) were considered beyond that they were software development SMEs. The intent was to select individual participants with a prominent organizational profile, working in management, quality assurance, or other roles relevant to software development processes, with good experience and having been 'hands-on' in development. In the following sections, participants and companies are represented by P and C respectively. These notations are used to maintain participant confidentiality, as per the approval of the Human Ethics Committee of the University (see Appendix 5.8). Table 5.2 reports a summary of various characteristics of the interviewees and their companies. The interviews were semi-structured, open-ended and conducted in English (see Appendix 5.4). In Table 5.2 the Position column represents the interviewee's current role, Experience (Exp) reports their years of individual experience, Expertise details their particular areas of strength, Processes describes in which process(es) each was involved, Applications (Apps) note their typical application domains, and Global Development (GD) indicates whether or not they were involved in global software development. (Further detailed descriptions of other notations used are given following Table 5.2.)

Finding relevant participants was challenging, a not unusual experience in seeking industry engagement in qualitative research (Hoda et al., 2012). In addition, in order to meet the research objectives the targeted organizations were small or medium-sized, but this meant that most were not mature in terms of their processes. Only a couple of the organizations were found to be using or implementing SMPs. Most either did not have an SMP or simply followed ad-hoc approaches to achieve their various objectives, such as scheduling and quality assurance. Therefore, the researcher simply sought to find companies that were developing software and that may have implemented, or could implement, SM in some form, irrespective of whether they followed formal or ad-hoc methods.

Table 5.2 Interviewees and Companies Characteristics

P#	Country	Position	Degree	Exp	Staff#	Expertise	Processes	Apps	GD
P1	Pakistan	ITM	Master	10	39	PM, SA.	All	WA	No
P2	UAE	Project Lead	Bachelor	6	10	Warehousing, PM	Anly, Plng, ETL	BI	No
P3	UAE	PSE	Master	11	17	PM, SD, ESI.	Mgt, Anly, Dsgn	WA, MA	Yes
P4	Pakistan	Software Architect	Bachelor	12	88	Java, CMS, Web Tech	Anly, Plng, Impl	CMS, BPM, VDP	Yes
P5	Pakistan	Team Lead	Bachelor	7	48	VB SE, LSRE, VB SM	All	WA	Yes
P6	Pakistan	SQAE	Bachelor	13	89	ST, QA, PS, TAuto	QA, Tst	WA	Yes
P7	Pakistan	Team Manager	Master	6	16	PM, ORM DB	SAD	MS CRM	Yes
P8	Pakistan	Team Lead	Bachelor	7.6	95	SAD, SA	Plng, Dsgn	CB	Yes
P9	Pakistan	SSE	Bachelor	10.7	19	Sys A, SA, SD	Anly, Plng, Dsgn	WA, DA, MA	Yes
P10	Pakistan	Project Manager	Bachelor	13	87	WS, TM	Impl, Int	WA	Yes
P11	Pakistan	Team Lead	Bachelor	9	55	TMgt	Mgt, Impl, Int	WA, MA, GA	Yes
P12	UAE	Software Engineer	Master	2	68	SAD	Impl	WA, WS	Yes
P13	Pakistan	QAE	Bachelor	10	8	MT, RT, LT	Plng, Anly, QA	Web	Yes
P14	Pakistan	SSE	Master	6	49	SA, BPM, BI	QA, Dsgn, Plng, RE	WA, DA	Yes
P15	UAE	Team Lead	Master	11	25	DM	All	PI	No
P16	UAE	Director	Master	20	32	Mgt	RE, MA, Plng	WA, MA	Yes
P17	UAE	Technical Architect	Master	15.3	41	RE, Sys A, CTS,	RE	CSA, GUI, WA, MA	No
P18	Pakistan	Project Manager	Bachelor	13	22	SD, DBM, QA	Plng	Web	Yes
P19	Pakistan	SSE	Bachelor	10.5	37	SA, SD, DB	Plng, Dsgn, Impl	DA, WA	Yes
P20	UAE	CTO	Master	11	120	MS, LLO	All	WA, MA	Yes
P21	Pakistan	CTO	Master	12.4	113	B2B/B2C, SA, Sys A	All	DA	Yes
P22	Pakistan	Team Lead	Bachelor	6	34	DBMS, SD.	Plng, Dsgn, Impl	RIA, ETL, SOA, MA	Yes

Description about notations used in Table 5.2.

UAE = United Arab Emirates, ITM = IT manager, PSE = Principal Software Engineer, SQAE = Senior Quality Assurance Engineer, SSE = Senior Software Engineer, QAE = Quality Assurance Engineer, CTO = Chief Technical Officer, SD = Software Development, CMS = content management System, VB = value-based, LSRE = Large scale requirements engineering, SM= Software Measurement, ST = Software testing, PS = Professional Services, TAuto = Technical Automation, MT= manual testing, RT= Regression testing, LT = load testing, DB = Data base, BPM = Business Process Management, BI = Business integration, DM = Development management, Mgt = Management, RE = Requirement engineering, Sys A = system analyst, CTS Communication technical skills, DBM = data base management, MS = Management Scalability, LLO = Language Level Optimization, ESI = enterprise software integration, web services, TMgt= team management, SAD = System analysis and design, Dsgn = design, Plng = Planning, Anly = Analysis, Impl = Implementation, Int = integration, Tst = testing, MA = measurement analysis

Domain: WA= web applications, BI= Business Intelligence, MA= mobile Apps, VDP = Variable Data Printing, MS= Microsoft, CRM= customer relationship management, CB = client Base, DA= desktop, GA = games application, PI= print industry, GUI= graphical user interface, CSA= Core Server end applications, DF= defence application, RIA= rich internet application, GD = Global development

5.1.3.2. Practitioners’ Interviews

The primary researcher conducted face-to-face interviews with all of the participants. The interviews were semi-structured, open-ended and conducted in English. The duration of each interview was approximately 30 minutes, tending longer or shorter depending on the nature of the discussion and the availability of the interviewee. The main aim was to build knowledge based on the participants’ perceptions of and experiences in SMPI, either with or without a context of Software Process Improvement (SPI). As noted above, SMPI was not common in the selected SMEs, but even so, the emphasis during the interviews was on perceptions, expectations and experiences in the problem domain, and to better understand the challenges practitioners face in SMPI or in performing measurement in general. Where possible the interviewer also sought to observe companies’ processes and practices, as an informal check on the explanations provided during the interviews.

The interviews were recorded electronically and then transcribed by the researcher. The recordings supported post-interview information elicitation, supplemented by informal observations of the interviewees’ actions and expression as noted at the time.

5.1.4. Data Analysis using GT Methods

The detailed motivation behind the selection of GT was presented in the Methodology Chapter 3; this section reports the application of GT to the interview data. The results of this application are presented in Section 5-2 and the findings are reported in Section 5.3. Three core steps of GT were followed in conducting the data analysis, as shown in Figure 5-2. Each step was performed to complete open, selective and theoretical coding, respectively. On each coding step, memoing and constant comparison were performed. The memoing process helps the researcher to identify the key properties and categories for relation formulation. Although the coding steps are shown separately, as if they occur one after the other, in practice there was some reflexivity and iteration among them. During selective coding, emergent codes were identified and derived from open coding, and new codes were further considered. Similarly, during the theoretical coding process, where relationships between categories were identified, the categories’ names (drawn from the open and selective codes) were also reconsidered. Further details of each step are provided in the following subsections. The whole coding process was supported by the use of NVivo 10.

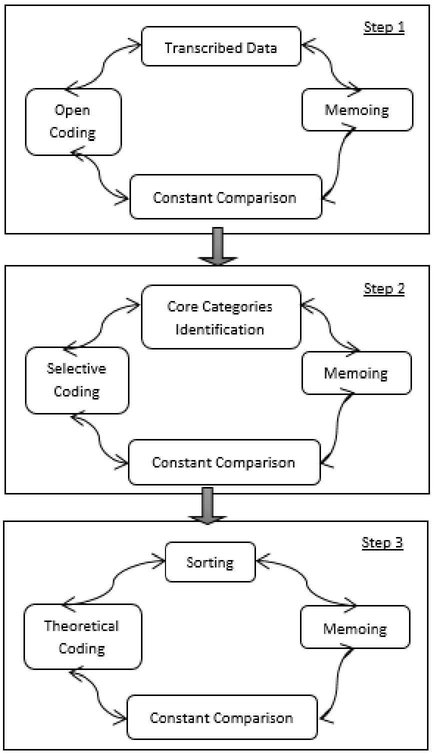

Figure 5-2 GT Implementation Steps

5.1.4.1. Step 1 – Open coding

As the first step of GT, open coding was performed to identify the categories, subcategories and their properties from the transcribed interview data. The interviews were coded line by line to achieve the open coding purpose, as discussed by Glaser, (1998); Glaser & Strauss, (2009) and Urquhart et al., (2010). The process was initiated by collating and assigning codes to key points in each interview. A code was assigned to a key point to summarize it, where each code normally comprises 2 to 3 words, as suggested by Georgieva and Allan (Georgieva & Allan, 2008).

Figure 5-3 (of a screenshot taken from NVivo) shows some of the identified keywords and categories in a tree structure. In Figure 5-3 one of the keywords refers to resource limitations as a challenge. Upon selecting this entry, a noting interview comments regarding resource limitations is opened. The tab contains key points extracted from each interview and following its source path. Figure 5-3 is showing only one key point of interview 8, but by clicking on the link (in Figure 5-3 case <<Internals\\Interviews\\8>>) shown above the key point, a new section will open. This newly opened section is the source/document, from which the key points were extracted. It also highlights the excerpted portion. The use of NVivo 10 made it easy to highlight the key points and assign codes using a drag-and-drop approach. At the backend, NVivo can support the generation of relations among sources, memos, and respective codes.

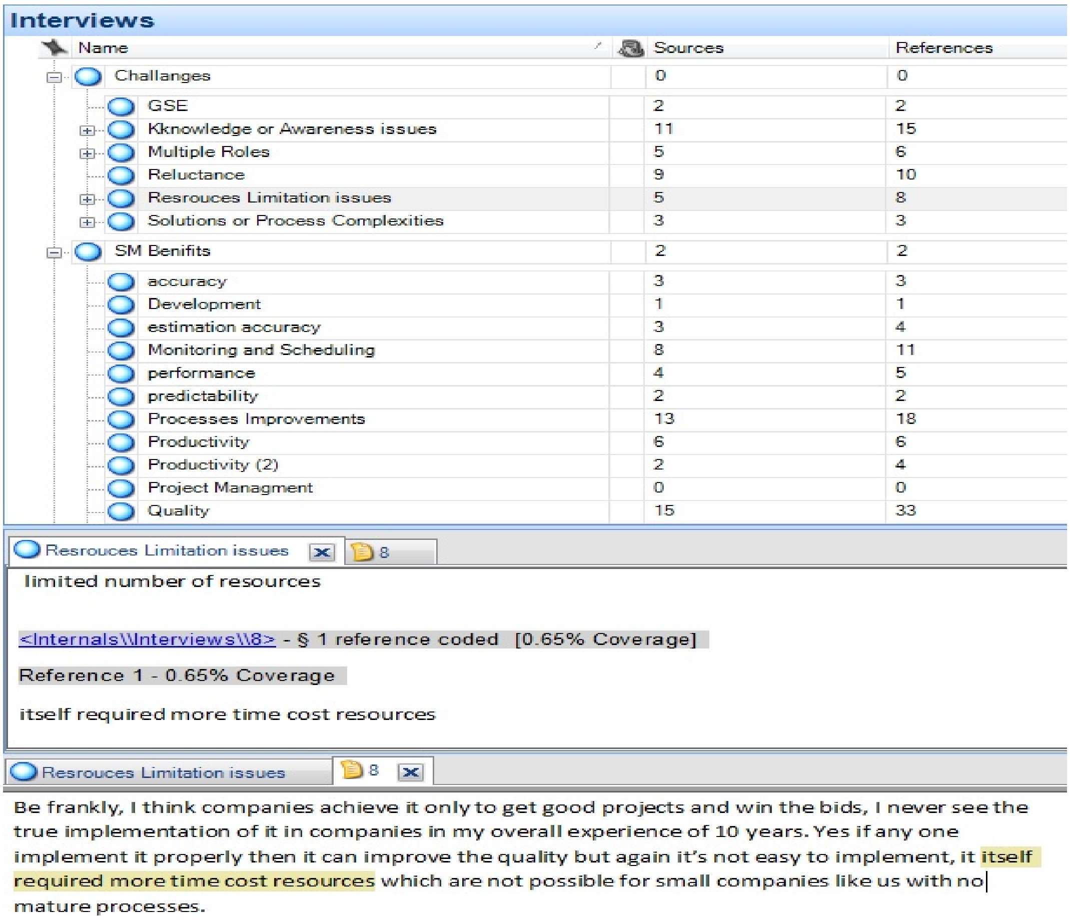

Figure 5-3 Open Coding Extract

5.1.4.2. Step 2 – Selective coding

The second step was to perform the selective coding, which, according to Glaser, GT should be followed by open coding but coding around core categories. Core category identification was not objective. Instead, planning was to group and organize open codes for core categories. These core categories were already identified during the literature review and mentioned in research questions as SM challenges and success factors. The selective coding step was comparatively easier than the open coding. It was just because of familiarization with data and the constant comparison method which could be time-consuming. Also, it was easier to choose and define a selective code for relevant core categories through open codes rather than re-coding for all categories. The coding was not stopped for any category until the process reached the point of diminishing returns. This situation is called “reach to Theoretical Saturation” (Glaser, 1992). During the selective coding process, some open codes were converted in main categories, sub categories and others were converted to their properties.

In reality a combined approach was used – open codes were organized and grouped around both existing and new core categories to avoid loss of any variables, as suggested by Glaser & Strauss, (2009). Grouping is important at this point in order to achieve a suitable abstraction level, given that open coding was performed at the sentence level and so was too fine-grained to support synthesis. Here, the decision was made to follow a focused coding process as defined by Charmaz (Sage Publications Ltd/2006), in which the most significant codes found in open coding are considered in relation to the predefined core categories.

The predefined core categories were:

1. SM Challenges: under this core category, six subcategories were identified. Each subcategory may have further subcategories, and their properties were incorporated as shown in Figure 5-16.
2. SM Success Factors: under this core category, 22 subcategories were identified, and their properties are shown in Figure 5-18.

In the process of grouping under the selective coding process, two other core categories were identified as:

3. SM Obstacles: Under this core category, seven subcategories were identified where some of them have further subcategories, as shown in Figure 5-17.
4. SM Benefits: under this core category, 14 subcategories were identified along with their properties, as shown in Figure 5-19. Table 5.3 shows an example of one of the selective codes “In-house training” and the corresponding open codes/concepts.

Table 5.3 In-house training category (success factor) and relevant open codes/concepts

Selective code	Open Codes/Concepts
In house training	Train each new resource, Quality team train resources, personal grooming sessions, train resources accordingly

5.1.4.3. Step 3 – Theoretical coding

The third step was to perform the theoretical coding. Theoretical Coding is defined by Glaser (Glaser, 1992) as the step “…that yields the conceptual relationship between categories and their properties as they emerge”. The memos created during the open coding process especially, and others created during the selective coding process, were very helpful in informing relationships between the identified categories. While there are some coding families suggested by Glaser (Glaser, 1992, 2005), to define relations among categories, in this research it was preferred to identify and define relations among categories based only on the interviewees’ explanations.

Theoretical coding helps the researcher to create relationships between the identified categories, which leads to the design of theoretical models for each core category. Table 5.4 represents a sample of a theoretical code where "improvement" is a key relationship between *benefits of SM implementation* and its subcategory *Quality*.

Table 5.4 Benefit (core category) Relation with Quality

Excerpt	*"Yes, it is. The results of measurement can help in project monitor and scheduling which assure the **quality improvement** as well. I think it's one of the major **benefits** of **SM implementation**."* **[Interviewee 17]**
Categories	Benefit, Quality
Relationship	Improvement

In this theoretical coding step, the theory (whether emerging or existing) is compared with data which helps with the identification of new categories, subcategories, and their relations. It also confirms the categories already identified. As with open and selective coding, theoretical coding continues until saturation is reached.

The Constant Comparison Method (CCM) is an important component of GT. This method needs to be enacted continually during each coding process to ensure that the emerging categories are, and continue to be, appropriate and workable (Glaser, 1992). CCM helps the researcher to compare different data slices (Glaser & Strauss, 2009) which lead to the understanding of a problem space and relates data to the categories' conceptualization (Sulayman et al., 2012). CCM is conducted in each coding process, with each code compared to other emerging codes within and across interviews and the important codes are labelled and re-labelled accordingly. Although constant comparison is a time-consuming and challenging activity due to need to consider often substantial amounts of rich data, it should enable the researcher to develop a fuller understanding of the data and help to maximise the credibility of the results.

In parallel, the memoing process was also conducted which is another core element of GT (Glaser, 1998). Memos are "theoretical notes about the data and the conceptual connections between categories written down as they strike the researcher" (Glaser, 1978), recorded during the process of open, selective and theoretical coding. Memos are intended to help the researcher to clarify the codes and in the creation of relations between them.

5.2. Results

This section presents the analysis of the interviews' results. An important point to keep in mind during the reading of this section is that the interviewees belonged to organizations that did not use SMP, nor did they follow any formal method for SMPI. Very few interviewees had prior knowledge or were involved in SMPI during their careers at any stage. It was observed that most interviewees were performing SM-related activities without having knowledge or intention of SMPI; as such, ad hoc methods for performing measurement related-tasks for scheduling, estimation and quality assurance were common. As a result, when this situation was identified by the researcher during interviews emphasis was placed on obtaining knowledge of how they were implementing and tackling measurement problems and opportunities, even if these were approached using ad hoc methods. The material that follows is presented in two sections. The first section presents demographic information while the second section presents the results analysis.

5.2.1. Demographic Information

As stated in the preceding section, the data used in this interview study were collected from 22 professionals from 17 different SMEs located in the UAE and Pakistan. Table 5.5 reports a summary of the demographic properties of the participants and their companies.

Table 5.5 Interviewees' and Companies' Demographic Information

Interviewees	Frequency
Experience (Years)	
1 – 5	1
6 – 9	7
10 – 15	12
16 or more	2
Highest Educations	
Bachelor	12
Master	10
Position (Level)	
CTO	3
Managerial	5
Architect/Analyst	7
Team lead	5
QA professional	2
Companies:	
Age (Years)	
1 – 5	3
6 – 9	7
10 – 15	4
16 or more	3
Staff #	
1 – 20	2
21 – 50	8
51 – 100	5
101 – 200	2
Global Development	
Yes	14
No	3
Using Measurement as Tool	

Yes	1
Yes Ad-hoc	5
No	11
Have Measurement Experts	
Yes	4
No	13
Following QA Guidelines	
Yes	12
No	5

5.2.2. Participants' & Companies' Practices

This section presents results representing the participants' expertise and awareness, visualized primarily using graphs and charts because of their quantitative nature.

5.2.2.1. Participants' awareness, experience and expertise

This section presents the participants' expertise and awareness. The comparisons are made based on retrieved data and visualized using graph and charts because of their quantitative nature.

5.2.2.2. Key Process Areas

This section presents the frequency to which participants were or had been actively involved in each key process area. It was important to establish the interviewees' experiences at the start of the interview, in terms of subsequent questioning as well as supporting the researcher's understanding of their particular perspectives. Figure 5-4 depicts the key process areas that the participants had reported to have been involved in within their current role. As mentioned above, frequencies are out of 22; and many participants were involved in more than one process area, with 7 interviewees reporting involvement across all process areas.

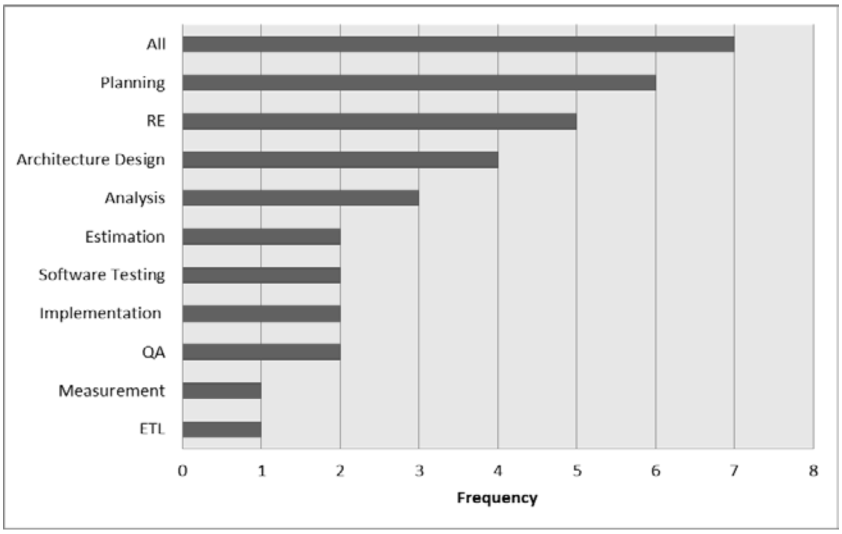

Figure 5-4 Key Process Areas

5.2.2.3. SPI Tools Awareness

During discussion about SPI tools, we found that many of the interviewees knew that there were tools that could be used to improve the software processes. However, the researcher did not find many participants actually practicing SPI, with or without tools. The discussion suggested that they have at least had some exposure to SPI. This point was used to contextualise later discussion around SMPI particularly. Figure 5-5 depicts the number of participants who were aware of SPI tools.

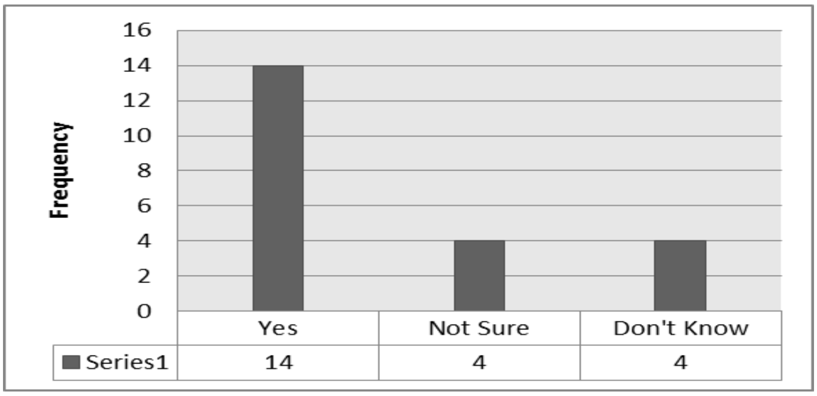

Figure 5-5 SPI Tools Awareness

5.2.2.4. Measurement vs. Quality

Furthermore, discussion concerning whether "measurement helps in quality improvement" returned positive feedback; even though its practice was not common in participants' companies. Figure 5-6 depicts the results obtained for the question: does measurement improve quality? The frequency of positive answers suggests that most participants had some understanding of the positive basis for SMPs.

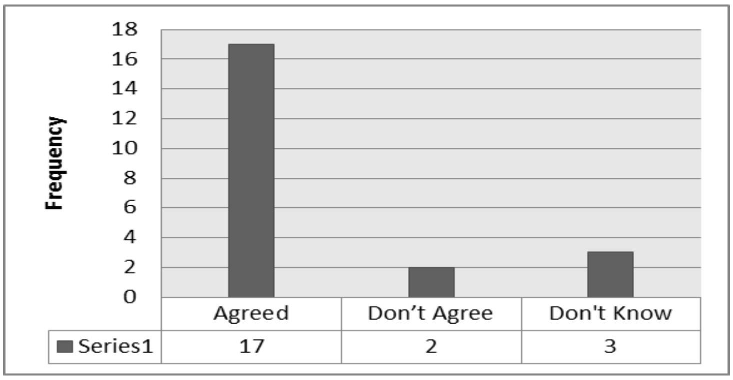

Figure 5-6 Measurement Improves Quality?

5.2.2.5. SME Challenges

Interviewees willingly described the challenges they faced as an SME in regard to software processes improvements. The researcher did not find evidence of challenges regarding SMPI, although this was likely due to the fact that SMPI was not in practice in most of the companies. However, it was found that most of the SMEs were performing SM-related activities on an ad hoc basis. Thus, discussion was focused on the context of SMPI as represented by their ad hoc approaches. Participants were not forced to stay with the SMPI discussion, but the interviewer attempted to keep the discussion within the general measurement context, to ensure discussions related to the problem domain of interest. The interviewer had some prior knowledge of SMPI challenges and success factors as they were explored in the mapping study (Chapter 4). So, at certain stages, hints were provided, such as using prompts: do you ever face this issue? The intent was not to lead but just to investigate as thoroughly as possible so as to get the most detailed knowledge from the interviews. Figure 5-7 depicts the major concerns of our participants, which were described during the interviews and identified during the analysis. These challenges could impact SMPI directly or indirectly.

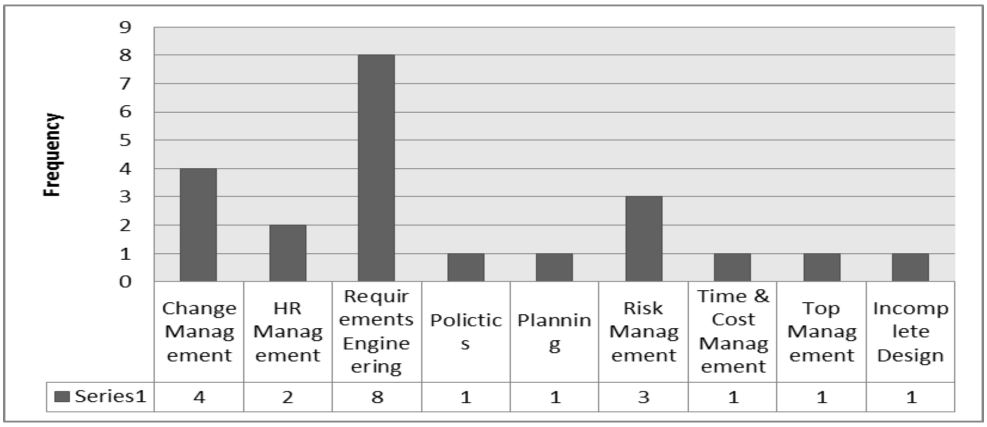

Figure 5-8 SMEs Challenges

5.2.2.6. Companies

This section presents the companies' properties and practices. As discussed earlier, the interviews conducted in two different countries, Pakistan and UAE (Dubai & Abu Dhabi). Figure 5-8 depicts frequency of companies and participants from each country.

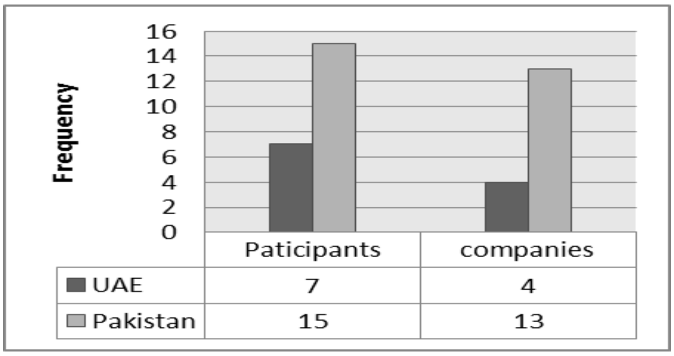

Figure 5-9 Participants and Companies

5.2.2.7. Development Methodologies

This section presents the results regarding companies' reported use of development methodologies. Most of the companies were using Agile-based methodologies, while others had their own internally defined process. Interviewees from two companies replied that methodology use totally depends on the nature of the project, involving consideration of domain, duration, and budget. Interviewee responses suggested that those who were following Agile-based methodologies were rather 'going with the tide.' It was not always evident that they understood know how or why it was important or suited their current project or product. They just adopted it because it was being used commonly in other companies and industries, and gave the impression of leanness which was perceived as positive. That said, interviewees indicated that they were satisfied with the use of Agile-based methodologies. Figure 5-9 depicts the frequency of each methodology being used, where 'depends on' means they did not stick to any one specific approach but decided based on domain requirements.

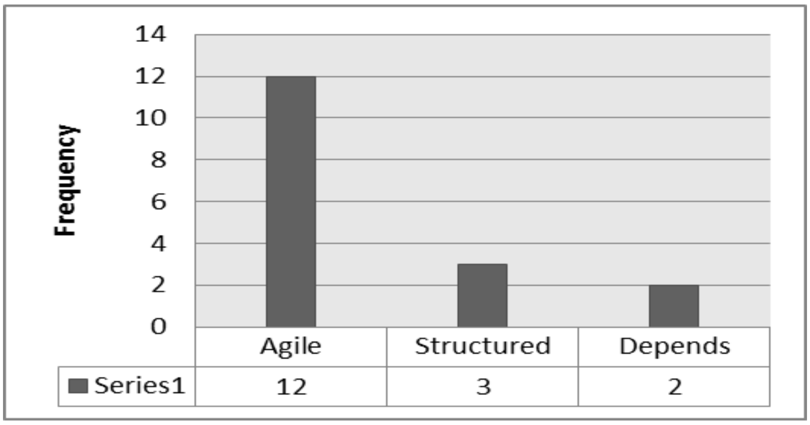

Figure 5-10 SME's Methodologies

5.2.2.8. Quality Engineers' Availability

The availability of quality engineers was a common characteristic in the participating organizations, an encouraging sign in terms of the implementation of SMPs. Quality Assurance (QA) activities were mainly software testing (though these are not exactly or exclusively QA practices) performed by QA engineers. Personnel who were performing testing activities were typically named QA engineers. Within these activities, measurement tended to be performed on an ad hoc basis where testing reports were mainly used. For example, practitioners measured quality through numbers of reported bugs and their severity level. Figure 5-10 depicts QA engineers' availability in the participating companies.

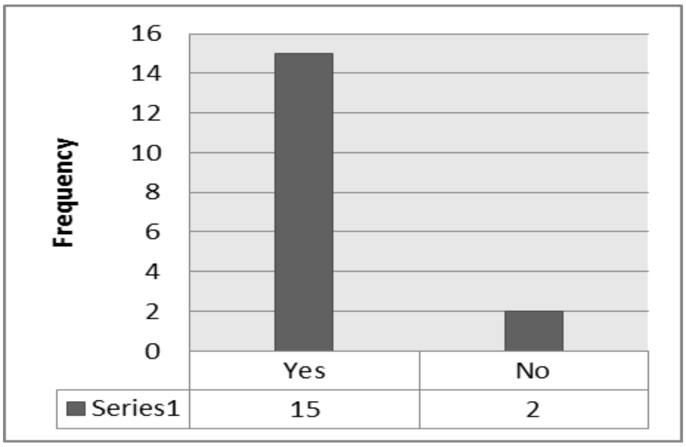

Figure 5-11 QA Engineers' availability

5.2.2.9. Quality Assessment

As noted we found that most organization had quality engineers available and they were performing testing activities. The next step was to investigate whether or not they used testing/inspection for quality assessment. It can be observed in Figure 5.11 that most of them were indeed performing testing/inspection, but very few used it specifically for quality assessment. For the most part they were using testing for finding bugs and defects and fixing them before release.

Figure 5-12 Inspection vs. Testing, for Assessment

5.2.2.10. Software Measurement Program Implementation (SMPI)

This section presents information about the interviewee's reported usage of measurement-related activities during the Software Development Life Cycle (SDLC). As mentioned above, most organizations were not implementing SMPs, so this information was elicited based on their ad hoc approaches (e.g., experts' judgment) or unintentional implementations (e.g., using bug reports for release decisions). Most of the SMEs were found to use measurement activities during the implementation phase, as shown in Figure 5-12. These measures are thus applied mostly at the time of development, and were typically focused on project quality based on experts' judgments and testing reports. Also a few companies were implementing SMP on an as needed basis, but not systematically for all projects.

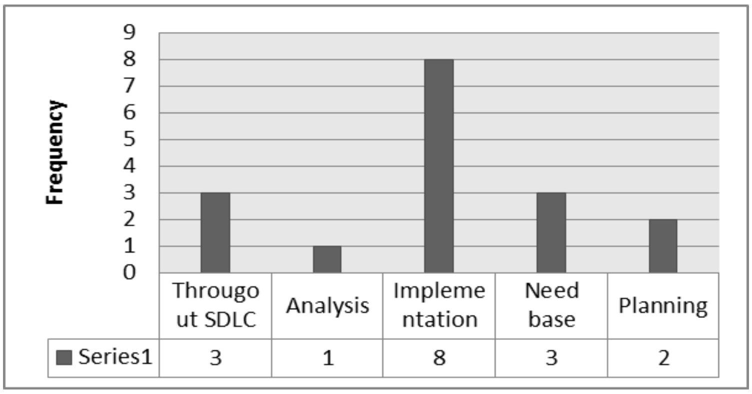

Figure 5-13 SM Implementation

5.2.2.11. Measurement Sources

Based on the previous finding the researcher probed further in the interviews to ascertain the sources that participants were using to perform measurement activities; for instance, how they do scheduling or make a decision about releases. Again it was found that QA reports were mainly used to perform measurement. Moreover, companies were using experts' judgment based on these QA reports. The QA reports were mainly number of bugs reported with different severity levels. Figure 5-13 depicts frequencies of commonly used SM sources.

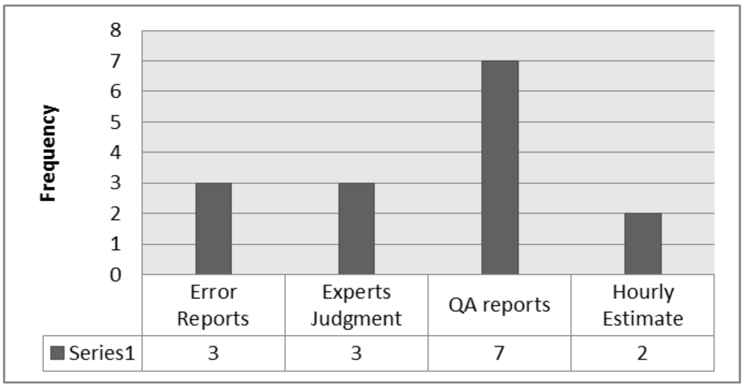

Figure 5-14 SM Sources

5.2.2.12. Who Should Implement SMP?

A thought-provoking discussion with interviewees occurred regarding implementation responsibilities i.e., who should implement a SMP? Most interviewees expressed that it should be carried out by Project Managers (PMs). To investigate further, answers were sought regarding "who was performing such activities currently in their organization?" It was found that, in general, PMs were leading such activities either directly or through Team Leads (TLs). The overall finding was that the senior resources (PMs, TLs) were involved in measurement-related activities but using ad hoc approaches. Figure 5-14 depicts the frequencies of each role currently involved in SMPI.

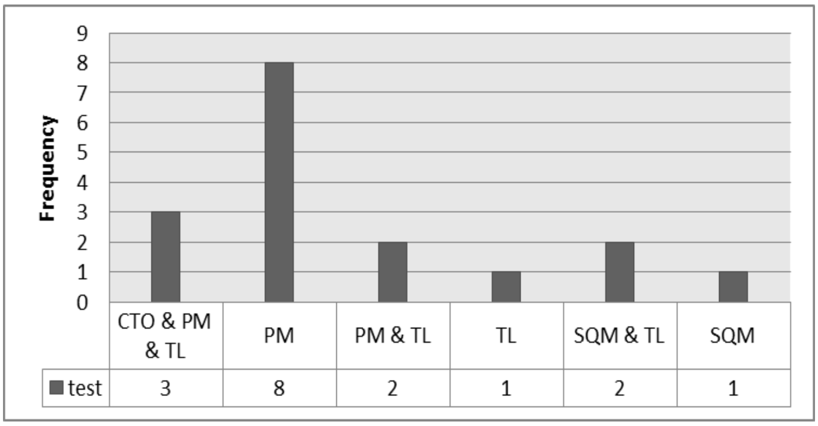

Figure 5-15 Roles Involved in SMPI

5.3. Interview Data Synthesis

This section presents a synthesis of the data collected for this component of the research. This takes the form of four preliminary exploratory frameworks of SMPI; challenges, obstacles, benefits and success factors. These frameworks have been created drawing on the GT results.

Figure 5-15 depicts the four identified core categories that comprise the frameworks of SMPI. *Challenges* are shown in a pile-up (multi-document) shape, which could be reduced or increased depending on the degree of attention paid to them. *Obstacles*, which correspond to challenges, are shown in a quad arrow shape, as they could occur from any direction and at any level – they can arise through any process, or be encountered by technical or management personnel when addressing challenges. *Success factors* are shown as being added into a database for future use and for reference. The *Benefits* should always be increasing, with increasing process maturity, so these are represented by a plus shape.

As noted, Challenges and Obstacles are closely linked, though they are distinct (Moffat, 2011): obstacles are hurdles or blocks that impede the addressing of challenges. The line between challenges and obstacles is drawn based on the researcher's interpretation during the analysis. Challenges tended to arise where interviewees expressed interest in seeking to achieve certain outcomes or milestones. Obstacles were noted where interviewees discussed factors that were slowing that achievement.

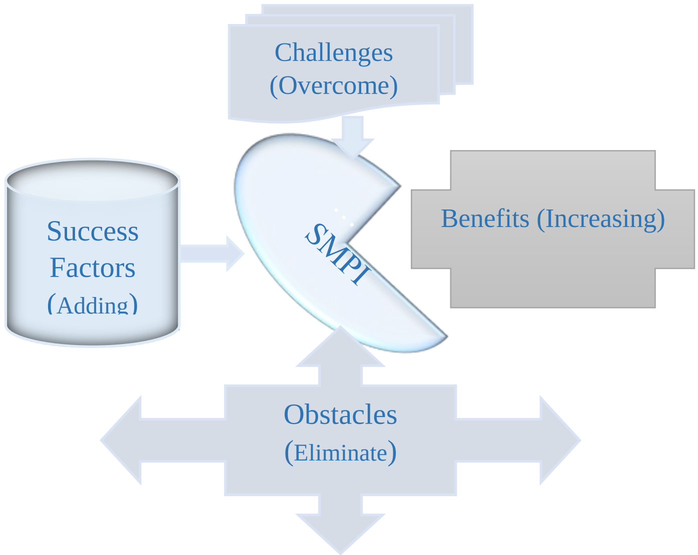

Figure 5-16 Core categories of SMPI

Furthermore, it is important to note that some subcategories of each core category (challenges, obstacle, benefits and success factors) overlap. One such example is top management. This was perceived as an obstacle in that when top management were not interested in SMPI there is no implementation. On the other hand, the same top management could be a success factor, if they show interest in and support for SMPI. This example shows that the context of a code matters in terms of categorisation. Details of each category and their subcategories are given in upcoming sections. A detailed chart of each core category and the subcategories relations is presented in Appendix 5.3. Furthermore, an indication of the importance of each category is shown in Appendix 5.1, represented by the number of interviewees who commented against each category. It is readily acknowledged, however, that this is only a 'blunt' indicator of importance. There are some categories, for example, that were not discussed by the majority of interviewees but are still seen to be important in terms of extent of influence.

Each category is arrived at based on transcribed interview data, so each represents the reported perspective of one or more participants based on their experience working in SMEs. Each interviewee's perspective toward the respective category is provided, either as discussed, quoted or excerpted from interviews, presented under each section. Additionally, in each section, a box is included to define the particular category based on the researcher's analysis.

5.3.1. SMPI Challenges

These sections describe in detail the categories of SMPI challenges. The identified categories and the resulting preliminary exploratory SMPI challenges framework are among the primary contributions of this research. This section also presents the subcategories of each main category, their properties, and the relations with categories in upcoming sections. To covey as faithfully as possible the true perspectives of the interviewees and their evidence, each subsection contains a number of quotes taken from the interviews. Figure 5-16 is a pictorial summary of the identified categories (challenges) and their relations.

5.3.1.1. Multiple Roles

Interviewees portrayed SMPI as a burdensome overhead because individuals already had multiple roles to perform. For example, sometimes the Team Lead was performing some of the Project Manager tasks. It was observed that they felt uncomfortable with holding multiple roles, which also made them annoyed, so they did not want to own yet another responsibility. An interviewee (*senior resource*), instead of owning or accepting the importance of SM, expressed his frustration towards SMPI as:

"*I think it is just overhead and can delay our work. It is just adding another job in my responsibilities where I am already overloaded, like some time performing management roles, sometimes DBA role and even sometimes working with QA team*." **[Interviewee 6].**

We found that interviewees believed that multiple roles resulted in performance reduction which led in turn to timeline delays and eventually client displeasure. Indicative interviewees' statements were as follow:

"*Our developer performs a quality check by themselves currently. As we are limited numbers of the team working on this project. So these different roles reduce developer performance and create a delay in delivering their tasks. In this case adding another responsibility is not possible*" [**Interviewee 10]**.

"I think the problem is this, we developers already overloaded most of the time, like we need to perform most of the process from requirements engineering to development and release. So, in this case, it's not possible to tackle with this another process." **[Interviewee 13]**

Box. 1:
Based on our data analysis and observation, SMPI Challenge, "**Multiple Roles**" is defined as '**Where the shortage of human resources in SMEs results in individuals performing more than one role, creating reluctance to take on SMPI responsibilities.**'

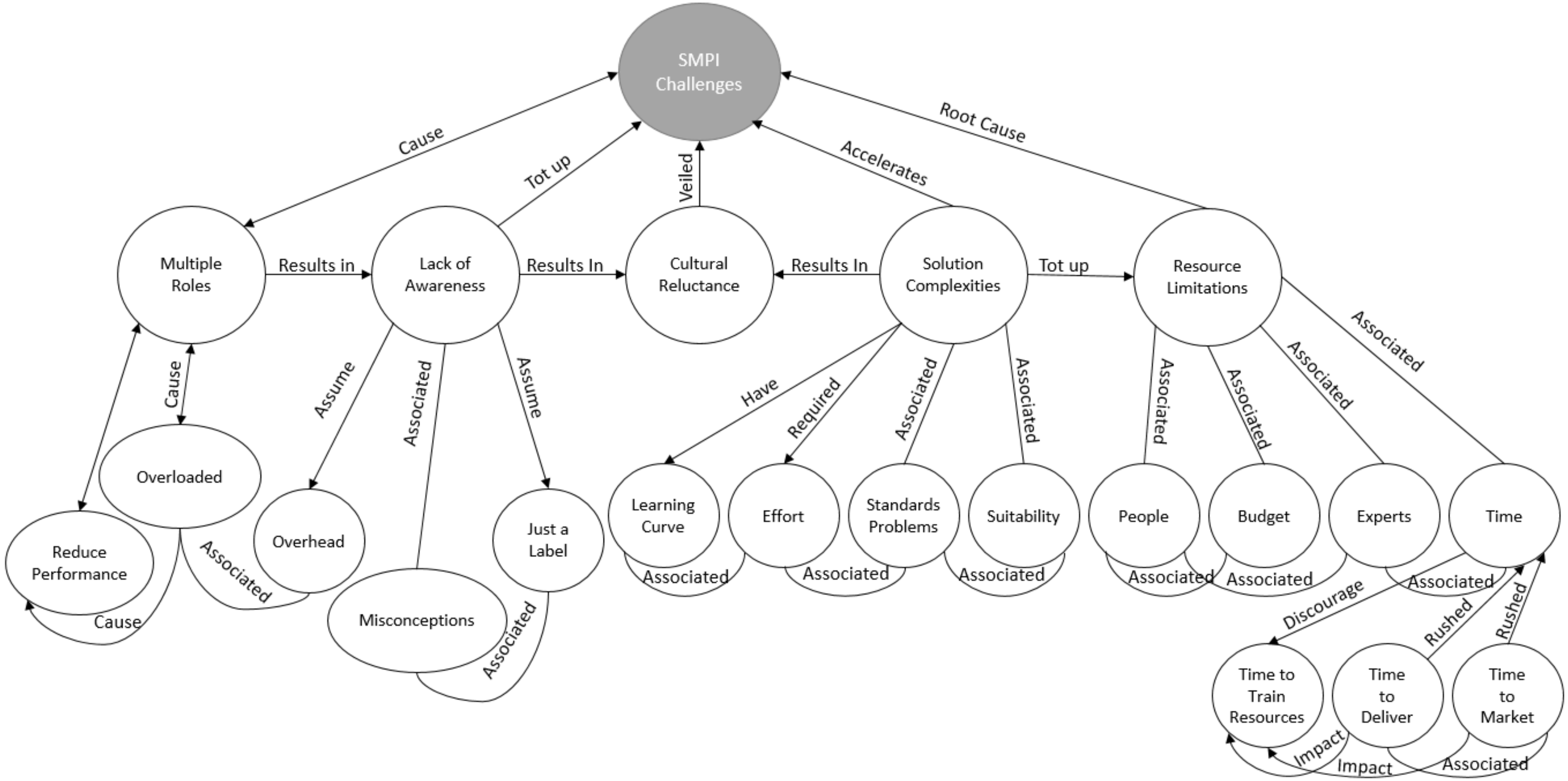

Figure 5-17 SMPI Challenges and their Relations

5.3.1.2. Lack of Knowledge/Awareness

A lack of awareness of SM has traditionally been considered to be one of the critical issues impeding SMPI, although it was not acknowledged that much during discussions with interviewees. However, on further probing, the researcher observed that most of the interviewees had limited knowledge of SMP. Many indicated that they did not know what to do or how to start with respect to SMPI. So in some cases, the interviewer observed that interviewees perhaps hid their lack of knowledge, did not accept the importance of SMPs, and instead asserted that it was irrelevant or not required. As an interviewee stated:

"But problem I told it looks like just waste of time, and I never see any expert of it or never heard too much about it in our professional discussions" **[Interviewee 14]**

Interviewee 10 was not sure whether SMPI was helpful or not, regarding achieving quality objectives. He was working as a Project Lead, which shows that sometimes even people working at a managerial level have limited knowledge about measurement. He stated:

"*Might be measurement can improve, but I am not sure. I think if I am the one who ask to implement this process. I need too much research first to understand it and then how to implement it.* "**[Interviewee 10]**

There are also many misconceptions about software measurement: "*only large organizations can implement it*" **[Interviewee 10 & 19]**, "s*uitable for large organizations like Microsoft, Google, etc*" **[Interviewee 15]**, "*I think it's just overhead and can delay our work*" **[Interviewee 14]**, "*it's just headache, and overload my work*" **[Interviewee 9]**. It is not surprising that practitioners would not want to adopt another process, without first knowing about it to a sufficient degree to be confident that it would be beneficial.

An interviewee stated that lack of awareness could impact on scheduling as: "*Quite often, the risks identified during the project planning are those involving tools and technologies, which the team is relatively inexperienced with. This causes a lot of teething issues which can have great impacts on project schedule*" **[Interviewee 20]**.

During the discussion of interviewees' awareness of formal processes, most agreed that formal processes can help. At the same time, however, some saw it differently, and spoke of formal process adoption rather cynically: "*it just looks like a show piece*" **[Interviewee 3]**, "*I think companies achieve it only to get good projects and win the bids*" **[Interviewee 8]**, "*I know such* *companies who achieve such standards to improve their profile but never apply them properly*” **[Interviewee 9]**.

Box. 2:

SMPI Challenge, “Lack of **Knowledge/Awareness**” defined as ‘**Where SMEs have insufficient knowledge of the mechanisms and benefits of SMPI**”.

5.3.1.3. Cultural Reluctance

Interviews revealed a general sense that people in SMEs implement new processes when they are forced to do so. Thus they may use SMPI even when they do not see any financial benefits as their top management wish them to do it. The challenges of resource limitations, solution complexities and lack of awareness add up to this challenge ‘reluctance’. Several interviewees stated the reasons for reluctance to implement SMP as:

“*Normally organization feel burden adopt the software process improvement activities...*” **[Interviewee 17]**

“*We think the software measurement is not important for quality improvements, especially, our top management believes that this is a waste of time.*” **[Interviewee 21]**

It was observed that different interviewees give different reasons for not following formal processes: “*we just focus on the required output and workflow irrespective of following formalities*” **[Interviewee 10]**, “*it’s just overhead, we don’t use it instead we are learning by mistakes and seniors’ experience*” **[Interviewee 2]**

Box. 3:

SMPI Challenge, “**Reluctance**” defined as ‘**Where industrial people have no motivation to implement such processes or they have fear of being judged through measurement results.’**

5.3.1.4. Solution/Process Complexities

Even in cases where interviewees agreed that SMPI could be beneficial, other challenges were relevant. In particular, there was concern over the complexity of the existing SMPI solutions:

“*The software measurement process, the one you are investigating about, I think is too much controversial. Once I try just to investigate about. There are many methods and tools; it’s not easy to choose one for a particular situation and if somehow manage it then not easy to use.*” **[Interviewee 5]**

The interviewees who had some knowledge of either SMPs or software process improvement methods expressed concern that existing SM solutions are not suitable for SMEs. They were seen to require much effort to understand and time to implement, so they had 'learning curve' and 'suitability' issues. As some interviewees stated:

"*Be frankly due to time limitations it's not easy for us to follow all these processes/standards*" **[Interviewee 3]**, "*in fact don't have enough time to learn and then implement processes to support our development*" **[Interviewee 5]**, "*there is a learning curve and then implementation overhead…*" **[Interviewee 12]**, "*required enough time to understand and implement them*" **[Interviewee 6]**.

Some interviewees, while acknowledging these issues, talked about processes and their complexities in a positive way:

"*I personally fell it help to increase productivity in the long run but in the start, it looks like a hassle. I think once we have a well-defined process using any standard, will be beneficial in the long run and more productive*" **[Interviewee 11]**.

"It helps to improve the quality but definitely slow the development which is not affordable where we are already working with tight timelines." **[Interviewee 17]**

Box. 4: SMPI Challenge, "**Solution/Process Complexities**" defined as '**Where SMEs perceive solutions to be complex, requiring extra effort to understand and implement.**'

5.3.1.5. Resource Limitations

Resource limitations relate to manpower, budget, and expertise. It was found that resource limitations were perceived to be one of the major challenges to SMPI, and a root-cause of many other challenges. Our SME-based interviewees maintained a stance that SMPI is possible only when the company has enough resources. Some of their responses were as follows:

"*Yes, it is not easy to implement. It, by itself, requires more time cost resources, which are not possible for small companies like us with no mature processes.*" **[Interviewee 8]**

"Yes it is, but not for our company, (as we got a limited number of resources with heavy workload) to implement such processes." **[Interviewee 22]**

"Software measurement can definitely help but in the case of very small teams and small level projects, sometimes it is not affordable to implement all the processes. As the company and team grow then, software measurement becomes really helpful." **[Interviewee 1]**

Within the general challenge of needing to work under resource limitations, limited time was one of the major challenges discussed by most of the interviewees. **Figure 5-16** depicts the time-related challenges and their relations to time. Interviewees commented on SMPI with respect to time as follows:

"No, we are not using, because there is a learning curve and then implementation overhead and we don't have enough time for both." **[Interviewee 12]**

"It's quite hard to implement for organizations with limited time and budget" **[Interviewee 6]**

Other references to the time and cost of SM implementation were: "*don't have enough time to implement…"* **[Interviewee 15]**, *"itself required more time and cost…"* **[Interviewee 8]**. Some other terms commonly used by interviewees regarding SM implementation were "*time shortage, time limitations, running out of time and cost"*. Such terms became subcategories of the resource limitations category.

Another listed challenge subcategory of resource limitations is referred to as "*Experts*," reflecting that some interviewees believed that SM implementations failed because of experts' absence.

"*Yes SM can improve a lot in the organization. To improve the quality, we need to implement the process, and it required professional to do this job. Unfortunately, we don't have such professional.*" **[Interviewee 13]**.

"*Yes, it could beneficial to monitoring and planning projects and producing a quality product. Currently, we are not following any standards process due to limited people, with not sufficient knowledge and time.*" **[Interviewee 20]**

Other terms used relating to Experts in SMPI were "*lack of skill set…", "lack of competent resources…" and "they are not measurement expert…*"

Box. 5:

SMPI Challenge, "**Resource Limitations**" defined as '**Where SMEs (believe that they) have insufficient time, budget and experts because of their size. This resource shortage can result in SMPI failure, or the non-initiation of SMPI.**'

5.3.2. SMPI Obstacles

Multiple obstacles were identified in relation to SMPI in SMEs. This section discusses the identified Obstacles (as categories), their subcategories and their relations, as represented in Figure 5-17.

5.3.2.1. Reliance on Expert Judgment

It was found that most SMEs have been relying on experts' judgments for decision making even though this approach does not always meet their desired results. Most interviewees appeared to reluctantly prefer experts' judgment over formal SMPI approaches because of the challenges noted above, in spite of their acknowledging that SMPI through formal approaches could be more successful than experts' judgments for decisions making.

"*We don't use any typical measurement, mostly based on experts' judgments for the time of development especially. I think anyone will apply measurement until it's critical to use or have some financial advantage.*" **[Interviewee 14]**

Other interviewees expressed their reliance on experts' judgments as: "*We mostly base on our experience, not any defined process*" **[interviewee 15]**, "*We measure the time cost and others base on our extensive previous experience in the area.*" **[Interviewee 17]**, "*we use our seniors' experience to estimate time to develop and deliver.*" **[Interviewee 3]**, "*predict the project quality and reliability through our experience or base on QA reports.*" **[Interviewee 6]**

Box. 6: SMPI Obstacle, "**Reliance on Experts' Judgment**" defined as '**SMEs make decisions based on experts' judgment, in spite of their acknowledging that the use of formal approaches could be more effective'.**

5.3.2.2. Top Management

Top management was perceived by some interviewees to be a major obstacle in slowing or stopping the implementation of better processes. There are a range of reasons that lead to top management being an obstacle, for example, either they are not experts in their field or they do not want to invest in SMPI. An example can be seen in the response of an interviewee who expressed his recent experience, where the top managerial roles were given to family members

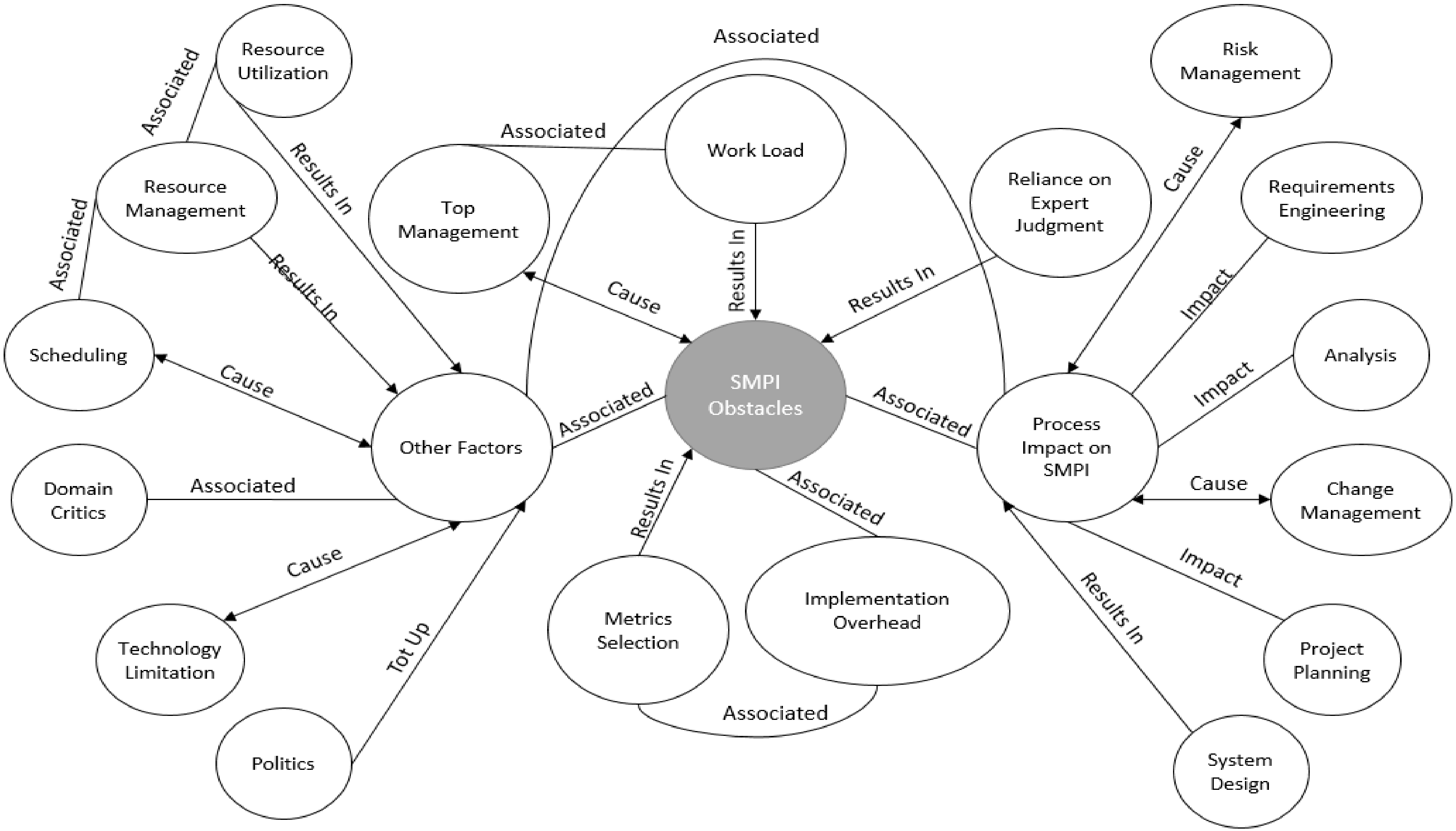

Figure 5-18 SMPI Obstacles and their Relations

just to please them; he stated: “I think the top management matters too much; my last organization was my worst experience in my IT career of 10 years approx. Because there the management role was given to non-professional people who even don’t know the ABC of the IT. The role was given only because they were the brother of the owner who outsourced the project. In short, I will say that immature/nonprofessional top management is one of the main obstacles to the successful completion of any project.” **[Interviewee 14]**

“I sometimes see just to please someone they higher as a project manager, in fact, he/she is not illegible for a particular role. In this case, they mostly rely on the other seniors in their team working under them. So I think the good management is the guarantee of successful completion of project/product.” **[Interviewee 3]**

Box. 7:
SMPI Obstacle, “**Top Management**” defined as ‘**In SMEs the people who are in top managerial posts, either as owners or managers, can be barriers to successful SM implementation due to negative attitudes to change or to investment.**’

5.3.2.3. Implementation Overhead

As discussed in the previous section ‘Solution complexities’, where existing SM solutions were perceived as requiring extra costs for learning and implementation, there is an associated obstacle of perceived implementation overhead. It was noted during the interviews that practitioners in the industry were said to require light-weight solutions. Interviewees commented on implementation overhead as follows:

“*There is a learning curve, and then implementation overhead and we don’t have enough time for both*” **[Interviewee 12]**, “*it’s not easy to manage and implement it continually in our projects, due to tight time schedules*” **[Interviewee 16]**, “*it’s not easy for us to follow all those processes/standards…*” **[Interviewee 3]**, “*it’s not easy to implement*” **[Interviewee 8]**

Box. 8:
SMPI Obstacle, “**Implementation Overhead**” defined as ‘**Employees in SMEs, who are already overloaded due to multiple roles and tight time schedules, consider SMPI as and the adoption of complex solutions as an overhead.**’

5.3.2.4. Process Impact on SMPI

This section presents the interviewees' views regarding how software development processes may impact directly or indirectly on SMPI results. During a discussion an interviewee said:

"*We estimate deadlines and others based on analysis, and if the analysis does not perform properly, it could impact on subsequent processes for sure.*" **[Interviewee 11]**. This statement shows that how the analysis process can impact, positively or negatively, on deadline estimations.

Another interviewee commented on the impact of the design process as: "*Unavailability of proper design is the main problem for me, being a developer. It's hard for me to estimate the completion or delivery time/date until I have proper and complete design, what they want me to develop actually.*" **[Interviewee 12].**

Interviewee 16 described two main issues he faced in the context of processes. The first process was hiring the relevant resources for a particular job and the second related to making estimates beforehand. For example, initially, they may have decided to do a task in 6 months based on their experience. Later, they took more time, because either the requirements changed or they made improper estimations about time and resources. Other statements about processes which may impact MPs were as follows: "*Poor planning & incomplete requirements gathering*" **[Interviewee 8]**, "*Requirements Understanding,*" "*Absence of professional risk management.*"

> Box. 9:
> SMPI Obstacle, "**Process Impact**" defined as '**SMEs typically have non-mature development processes, which may impact the efficacy of SMPI.'**

5.3.2.5. Other Factors

During data analysis a number of other factors which may impact SMPI directly or indirectly were identified – project domain, organization culture and organization's maturity. The significance of the impact of these factors could vary based on other corresponding factors. During a discussion with an interviewee about the significance of such factors on SMPI, he stated that:

"*I think it varies in current organization, design; architecture is given more importance. But I also have a couple of other experiences. Like, when I was working in an organization which was developing defence relevant software; those guys were too much critical in the context of* *software development processes. They focused too much on quality, reliability, and maintainability. So I think it varies from domain to domain and company to company. Also, that was a large organization, so it was easy for them to handle such processes.*" **[Interviewee 12]**

Such statements show that domain critics and company maturity can create a difference. Another interviewee stated that: "*Each process is effective, just depends on what kind of project product is under development and what are the requirements*" [**Interviewee 13**], another interviewee's main concern was with the impact of politics within organizations, as he stated that: "*politics in companies play very important role in success or failure of any process*" [**Interviewee 2**]. Some other factors also discussed to a certain extent were: "*Human Resources Management,*" "*Time Dedication,*" "*Effective Financial Management,*" "*Scheduling*" and "*Resources Utilization*."

Box. 10:
SMPI Obstacle, "**Other Factors**" defined as '**There are some factors which are not considered universally significant but that may have either a direct or indirect impact on SMPI depending on specific circumstances.**'

5.3.3. SMPI Success Factors

There are multiple factors that are perceived to contribute to SMEs' successful SMPI. These are identified as success factors, and their relations represent a preliminary exploratory framework of successful SMPI. The framework is shown in Figure 5-18. It is a second major contribution of this research.

5.3.3.1. Tool Automation

In prior sections it was observed that, due to workload pressures and multiple roles, most of the interviewees were not enthusiastic about adopting another process, irrespective of whether it would ultimately be beneficial to them. It seemed no-one was ready to put in the effort, either employee or employer. So when either the interviewee suggested or the researcher proposed solution automation, they expressed interest as if someone had found a lost treasure. They believed that automated tools can accelerate the SMPI and so require less effort and time. One interviewee went so far as to say: "*automated tool with reusability features can guarantee the successful SM implementation*" **[Interviewee 9]**

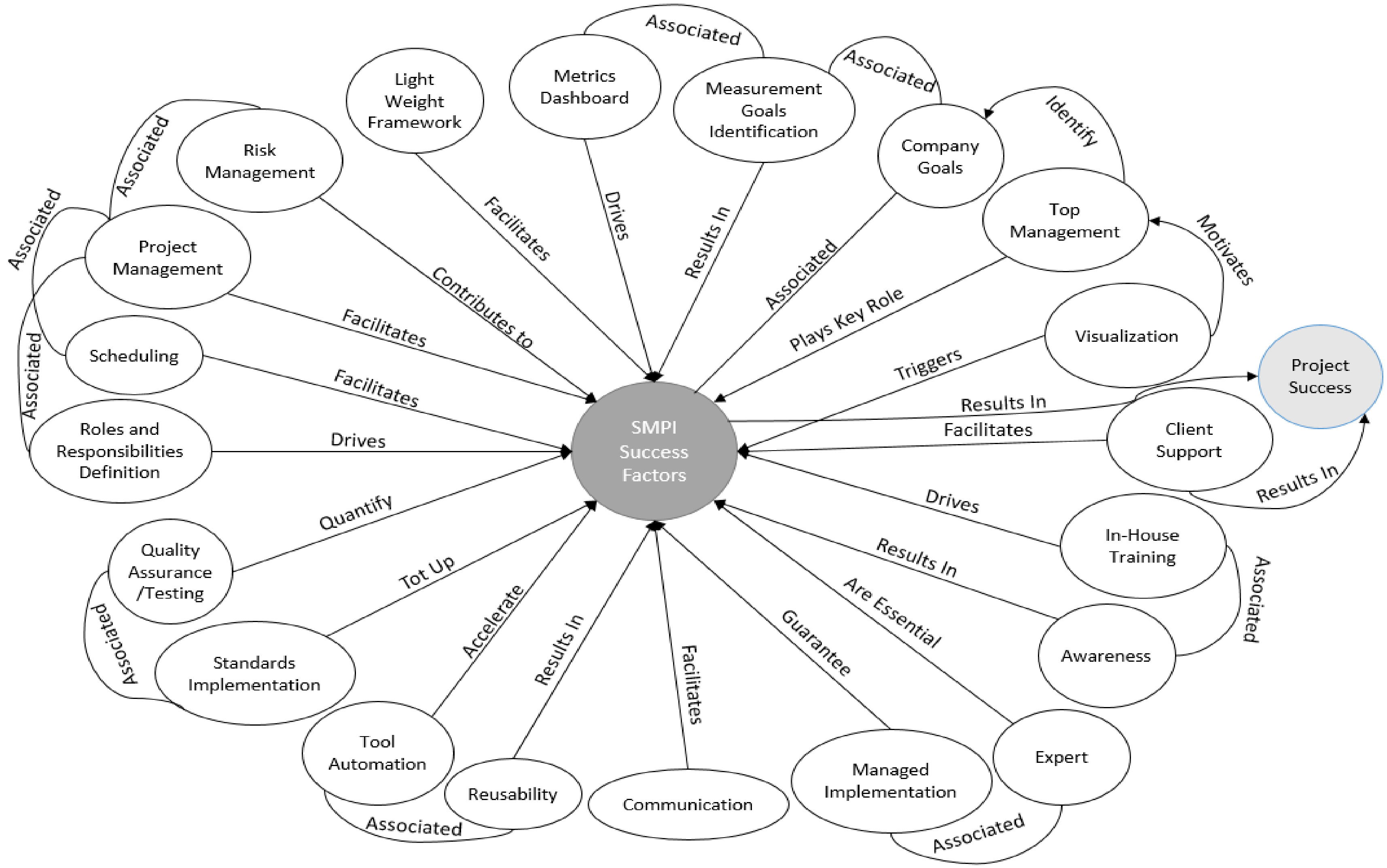

Figure 5-19 SMPI Success Factors

Automated tool requirements were highlighted, mainly, in the context of resolving the challenge of resource limitations. Most of the research participants recommended and wanted only automated and lightweight solutions. As an interviewee said "*like agile, there should be lightweight solution based on divide and conquer rule*" **[Interviewee 19]**. "*We prefer the solution which is easy to use in the context of flexibility feature that we can mould according to our needs.*" **[Interviewee 16]**

Another interviewee who was working in machine learning systems suggested that "*the tool should be a learning agent which learn the company decision and can suggest a better solution for future. Like in future, it should tell in the case of particular situation XYZ the best decision was ABC*" **[Interviewee 2]**.

> Box. 11:
> SM Success factor, "**Tools Automation**" defined as '**A light-weight solution, with reusability features, helpful in making decisions according to the situation, is ideal.**'

5.3.3.2. Measurement Goals Identification

Some interviewees were of the opinion that successful software measurement programme implementation is subject to appropriate measurement goals definition. As an interviewee stated:

"*Also, I would like to add about software measurement; the proper goals identification is important like what objective you want to achieve by measurement. This can give you direction and scope what to measure and which metric should use.*" **[Interviewee 1]**

It was suggested that successful measurement implementation could assist in monitoring and scheduling, and so help in achieving overall success for the company. During the discussion of measurement goal determination, a couple of interviewees prolonged the discussion about who should undertake the measurement goal identification. One said "*The measurement goals should define the senior resources, like working on management level, with a discussion of business owners under the light of company goals. Because the manager and the owner on top level knows, what they actually need in the result and what they are struggling with. But afterward definition should be discussed with people who are going to implement them*" **[Interviewee 15]**. Another interviewee highlighted goal definition as "*I will recommend that the goals should be structured, defined and reusable. The ideal is that as the company has* *certain goals to achieve a particular purpose. The measurement goals should define based on them."* **[Interviewee 20]**

Box. 12:
SM Success factor, "**Measurement Goals Identification**" defined as '**To achieve measurement objectives goals should be determined and synchronized with organization goals. Moreover, top management should be involved at this stage.**'

5.3.3.3. Managed Implementation

A couple of interviewees highlighted that proper implementation of any process through experts is the key to success. The right person meant, to them, the person who has knowledge of the process, its implementation, and objectives. The key person should be the one who defines the process and presents it to employees, who are stakeholders in implementation. As an interviewee stated:

"… Also, the implementation is the key point of any process. The person, who is responsible for implementation, should have complete knowledge of software measurement as well as of framework going to use" **[Interviewee 1]**.

Managed implementation encompasses accountability, and the role is challenging. Another interviewee expressed it with a definitive example stating: "*if it's implemented properly otherwise it's same like garbage in garbage out*" **[Interviewee 21]**, meaning that if users are not following the process properly the result will be a failure. A couple of other interviewees highlighted similar sentiments: "*yes it can help if applied properly*" **[Interviewee 16]**, "*yes if anyone implements it properly then it can improve the quality …*" **[Interviewee 8]**.

According to some interviewees, before implementation, "c*hoosing the right solution is of seminal importance*" **[Interviewee 13]**. An in-depth discussion with one interviewee showed his main concern was choosing the right solution and then modifying it according to the company's needs. He stated:

"One should choose an appropriate solution based on business needs, which is flexible to modify according to one's needs. As an agile org, we are following an iterative and incremental development method; we plan and focus for short iterations, typically three weeks, and we do measure the progress and quality of that small time box, using burn-down charts (SCRUM Model)"

Box. 13:

SM Success factor, "**Managed Implementation**" defined as '**A person with good knowledge of SM is required to choose and implement it properly.**'

5.3.3.4. Top Management

Top management was discussed above as an obstacle, but the management of any company can also play a key role in successful SMPI. This was stressed by most of the interviewees directly or indirectly. The interviewees considered owners, CEOs, CTOs, directors, PMOs and other senior managers (or others on the same level) as part of top management, and they believed that these individuals should be convinced of the need for SMPI. As an interviewee stated:

"*Being a CTO of the company, I am directly in communication with owners and my technical staff, like managers and team leads. I think I could be the ideal initiator of the SMPI with influence of owners*" **[Interviewee 21]**

Top management should ask and encourage all employees to define and design software processes for improvement. As with SM, all interviewees believed that top management could ensure the creation of an SMPI culture within organizations. As an interviewee stated: "*The owner can make sure the successful implementation of any process in the organization in case he/she is following it directly*" **[Interviewee 11]**. As per the researcher's discussion with a couple of managers, they expressed an "*Unveiled Secret*": that while they were on a managerial level they were sometimes working 'as robots' with less decision power and high expectations from owners. One of them stated "*it all depends on our business owners if they want they can improve processes, where eventually we will be doing that but only with their wish. It's not like that they don't want to improve, but they think these are only cosmetics and time consuming*" **[Interviewee 2]**.

As stated above, most of the interviewees were of the opinion that successful SM implementation is dependent on top management. They presented it as a two-way exchange. First, top management should be committed to the implementation and take initiative with the help of immediate subordinate managers and team leads. On the other hand, the technical people who will implement the process should be taken into their confidence and be convinced too. As an interviewee stated "*it is team work, where the managers and team lead plays the key role. They convince the owners about SM implementation and then take the responsibility of to do* *so. The manager and team lead know the company goals, so they are ideal candidate for its implementation by defining a process*” **[Interviewee 3].**

Box. 14:

SM Success factor, “**Top Management**” defined as ‘**Owners, CEOs, CTOs and other senior managers are top management who can play a key role in successful SMPI.**’

5.3.3.5. Client Support

The client’s support was not a great concern for most interviewees, but yet some of them expressed it as one of their major concerns. It seems to be generally perceived as an indirect impact factor but in some organisational contexts it could be a direct impact factor, given that client feedback and their satisfaction can indicate how and where to improve. It was found that some companies have a fear of having their weaknesses exposed in front of clients by their involvement in the measurement process. However, some saw advantages in the client’s involvement in terms of motivating improvement:

“*Although most of the time we don’t give much importance to client feedback and improve our processes. In fact, the client is the main stakeholder of the project whom satisfaction is important and feedback matters. Based on the client feedback we can improve quality and other related*” **[Interviewee 14]**

“*We generally open up our scrum management and task ticketing tools to clients. We believe in 100% transparency*” **[Interviewee 16]**

Client interactions could vary according to the nature of a project; most of the interviewees were working on outsourced offshore projects, so it depends on what kind or level of client involvement is important in any process. An interviewee stated their concern while working on a project where a US-based organization outsourced their core development on an hourly basis. The interviewee was in favour of client involvement in this context to avoid the misunderstanding of any measured time to delivery. He stated that “*client satisfaction and interaction is most important. If the client knows the daily progress of each employee, then he feels more satisfied and knows in advance any shortfall or delay in deliverable*” **[Interviewee 11]**. By keeping clients in the loop, you build their confidence.

Box. 15:

SM Success factor, “**Client Support**” defined as ‘**The client should be in loop, which may help to improve the processes by their feedback. It can develop client trust and increase their satisfaction levels via results transparency.’**

5.3.3.6. Communication

Communication is one of the key success factors as highlighted by most of the interviewees. They pointed out that the communication between employees on department and managerial levels is important for successful implementation of any process. Communication should increase collective and individual understanding of company processes. As an interviewee stated:

"*Communication is the key factor of understanding any new process and its worth. The different department and their head should communicate and discuss any newly added process for its better understanding and improvement. As you are suggesting for SM process so it should properly document and communicate with all stakeholders, get their feedback improve and then implement*" **[Interviewee 12]**

"*Talented people are the most important; however, having a framework helps communication flowing smoothly inside and outside the company*" **[Interviewee 12]**

Some of the interviewees also highlighted that the reasons for communication fear are rooted in the behaviour of both top management and lower-level management. Top management may create a communication gap between them and the employees. This may be due to differences in culture and also sometimes the employees do not have the confidence to communicate, which increases the communication gap. Such reasons discourage employees from putting forward their ideas in meetings. Such hidden issues require the intention to increase employees' confidence, so they can add valuable input during discussions. This input could be helpful in the successful implementation of any process including SMPI:

"*Successful implementation of processes involves proper communication. I will say no communication no success in long run. Poor communication causes the failure and demise of any process*" **[Interviewee 6]**.

"*Communication increases the understanding of the processes and built trust on either end. There should be a well-defined process of communication and points should be documented as meeting minutes. It could be helpful for future decisions and input for process improvements*" **[Interviewee 18]**.

Box. 16:

SM Success factor, "**Communication**" defined as '**Communication can play a key role to overcome process deficiencies. There should be well defined communication processes at and between all levels.**'

5.3.3.7. Awareness

As a main observation of the interviews, awareness is clearly fundamental to the successful implementation of SMP. It was found that most interviewees did not know about SMPI, although it was also found that some of them were performing measurement-related activities intentionally or unintentionally. Most of the interviewees mentioned that awareness is the first step of successful implementation. The implementer should be aware of processes as well as their objectives and expected outcomes. An interviewee stated:

"*Throughout my career, I found a majority of SMEs lack awareness about proper software development processes even. This includes many good developers, analysts, and architects. They either do not know about the formal processes or terminologies, but still, they implement them on ad hoc basis. So the organizations should have the awareness sessions to improve their processes. We have our own well-defined process for quality assessment where we train each new hired resource accordingly.*" **[Interviewee 16]**

Most interviewees suggested different ways to create awareness about SMP in order to make it successful, where the most common way was in-house training. A couple of interviewees commented about training for awareness, saying that:

"*There should be a properly defined process to train resources about company processes*" **[Interviewee 8]**.

"*We have in-house training and personal grooming sessions for juniors and seniors to improve*" **[Interviewee 9]**.

"*I think companies should have the training sessions for newly hired employees specifically, to make them understand about company processes their goals. Before implementing any new process, as we are talking about the SM process the employees should properly train for that to achieve the purpose. The company should hire some experts of such processes at least for training if can't hire permanently.*" **[Interviewee 22]**

Box. 17:

Based on our data analysis and observation, SM Success factor, "**Awareness**" defined as '**The successful implementation of each process depends fundamentally on awareness and awareness comes through training.**'

5.3.3.8. Experts

Almost all interviewees emphasized expert involvement as a requirement to implement the SMP. They mentioned that an expert could make the difference which leads to successful SMPI. Experts can define the process effectively as they have the ability to interpret and work with company processes, based on their extensive experience. As an interviewee stated:

"*The companies should have a measurement expert or hire a consultant to implement it successfully. An expert has extensive experience of implementation in different domains and organizations*" **[Interviewee 4]**.

Although SMEs have resource limitation issues, interviewees suggested that companies should either hire or train resources to get good results from SMP implementations. The interviewees also stressed that experts could only analyse a process based on project domain and company structure and define processes accordingly. An interviewee suggested consultant hiring as: "*The hired consultant should be familiar with the company goals, project domain, and company structure to get the better results*" **[Interviewee 17]**. A couple of interviewees further described the need for expertise in this way:

"*Talented people are most important; however, having a framework helps communication flowing smoothly inside and outside the company*" **[Interviewee 12]**

"*Finding the right talent is of seminal importance*" **[Interviewee 13]**

> Box. 18:
> SM Success factor, "**Experts**" defined as '**For a successful SMPI, SMEs should either train their resources or hire experts who have previous experience. Experts can be crucial in defining and implementing the process.**'

5.3.3.9. Roles and Responsibilities Definition

Although the importance of clear "roles and responsibilities" was highlighted in lesser detail by most interviewees, some of them presented it as a major factor. According to those participants clarity around roles and responsibilities can result in more mature processes and reduced SMPI failure rates, which can in turn lead to project success. It could also help in more effective management with proper planning and monitoring. An interviewee said:

"I suggest there should be clear roles and responsibilities definition, such processes should be either implement by project manager or at least he handles that which part will be done by developer, QA, Designer, DBA, etc." **[Interviewee 13]**

It was observed that industry practitioners appeared to be looking for role and responsibility definition as part of solution implementation guidelines. As an interviewee stated:

"*The measurement process should explicitly define which role will perform by which type of the employee (for example QA, Developer, and Analyst). As I will suggest the process should initiate by the managers or team leads. There should be an explanation of the jobs to do by a developer, QA person or others. It will make its implementation crystal clear and efficient*" **[Interviewee 5]**

Another interviewee stated:

"*It's not being implementing as a proper process, but senior guys know how to tackle and perform*" **[Interviewee 19]**. This means that SM was not just performed formally, but that the relevant activities were handled by senior resources. Some other interviewees stated about roles as follows: "*QA team should know about SM process as they are mostly working with quality assurance*" **[Interviewee 13],** "*… Who are in QA department and some might say who closely work with QA guys*" **[Interviewee 20]**

Some interviewees suggested adding the roles and responsibilities definition task to the Project Manager's duties. "*It should be a part of their plan where they have proper risk management, and scheduling of process implementation*," as stated by one of the interviewees. In short, it is observed that practitioners want SMP as a proper part of the project manager's responsibilities instead of leaving it open.

"*I am technical lead performing project management activities as well. I think this is the driving seat which can lead to success or failure of any product. So I think I should be actively involved in measurement process*" **[Interviewee 5]**.

"*Measurement results can assist me, mainly, to schedule and monitor my project properly. It eventually increases the chances of successful completion of the project. So I would like to implement this process with the help of QA and development team leads properly. As I already have met with them to predict the quality and time to deliver*" **[Interviewee 18]**

Box. 19:
SM Success factor, "**Roles and Responsibilities**" defined as '**Roles and responsibilities need to be clearly defined in order to implement SMP successfully. This should include who is going to initiate the process and who will be responsible to lead throughout the process.**'

5.3.4. SMPI Benefits

Successful implementation of SMP can contribute to company success. It is essential to highlight such benefits to convince the stakeholders of the importance of SM implementation. This section discusses the benefits that SMEs can earn through SMPI. The categories were identified during the determination of SM success factors and the benefits associated with SM success. Figure 5-19 depicts the identified SM benefits and their relations.

5.3.4.1. Top Management

Top management is one of the commonly identified factors across the core categories (obstacles, success factors, and benefits). If the top management is non-cooperative, then it is an obstacle in itself. If the top management is supportive, then this helps to ensure successful implementation. This will in turn benefit the top management by increasing their project success rate and would ultimately be a benefit to the company owners. As two interviewees stated:

"*I think the successful implementation of SM is going to benefit the owners eventually.*" **[Interviewee 11]**
"*Actually duration, quality and cost measurements are the basic need of our company which gives more control to top management to make decisions*" **[Interviewee 21]**

Another factor associated with top management elaborated by one of the interviewees, which seems to be explored rarely in the SM context but has its own worth, is the issue of trust. He stated that:

"*I feel that most employees don't report the number of errors correctly, as they have a fear of judging their performance. So, first of all, we need to develop this trust on both ends employee and employer. SM results give a clearer picture to owners to make decisions, and the employee will be more confident to report them correctly for business success*" **[Interviewee 3]**.

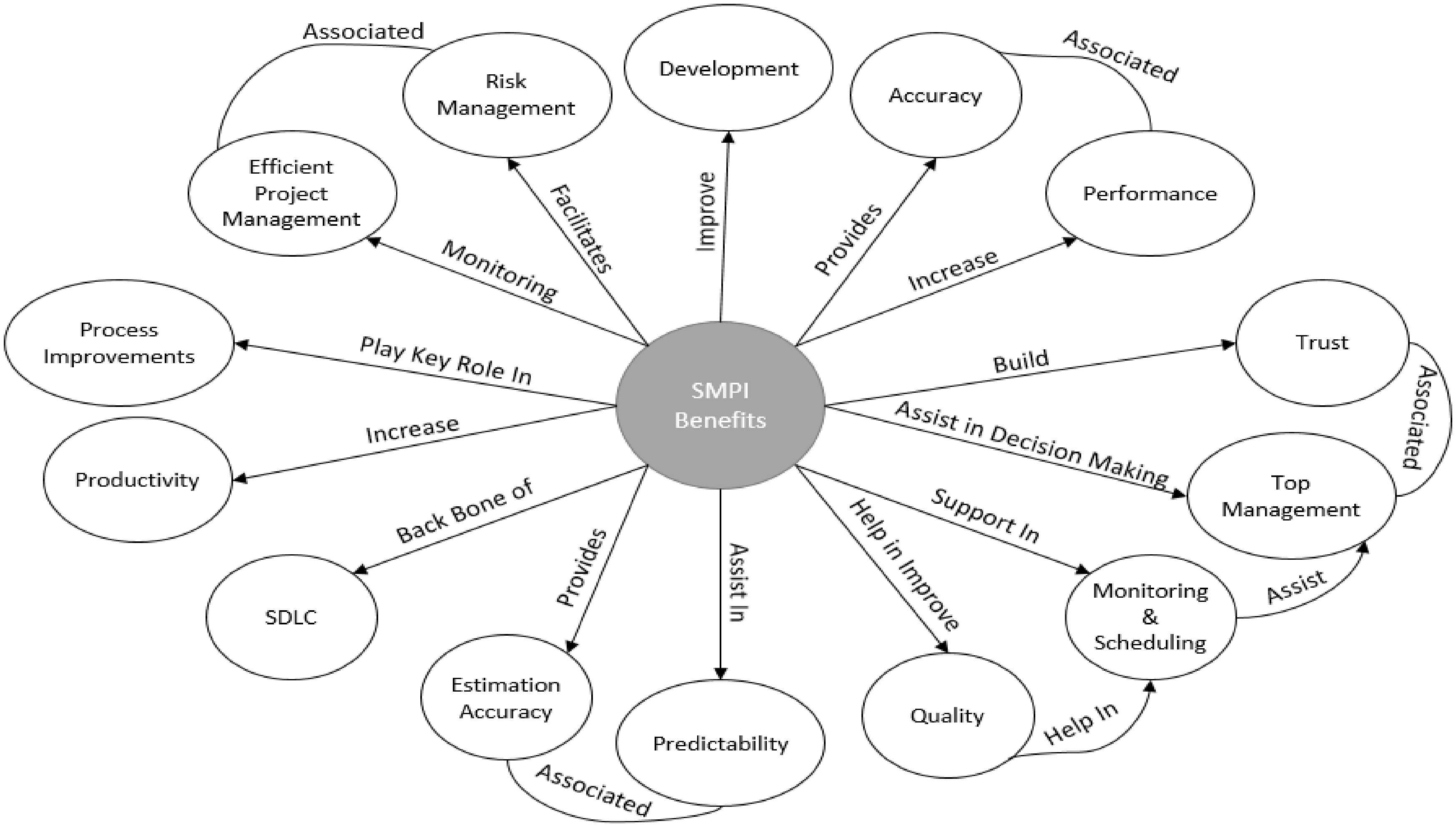

Figure 5-20 SMPI Implementation Benefits

Box. 20:

SM Benefit, “**Top Management**” defined as ‘**Top management can benefit from SMPI results, by making better decisions that can lead to project success.**’

5.3.4.2. Development/Performance/Productivity

A range of interviewees highlighted different SMPI benefits that can accrue through the effective implementation of SMP. The analysis from the interviews suggested that SMPI helps to improve the development process which results in increased performance and productivity. An interviewee stated:

“*Software measurement helps to improve software development, but it’s not the only thing required*” **[Interviewee 1]**.

SMP helps senior management to improve project/product performance and to increase team productivity. Moreover, SMP results give a truer picture to top management about the project/product, team progress, and all other aspects. The managers can then make predictive decisions more easily. Interviewees noted the following in regard to the utility of good measurement data: “*we get a feel for how the project is performing on a daily basis*” **[Interviewee 10],** “*… helps in the reputation of company*” **[Interviewee 7],** “*very good criterion to assess quality and reputation of any organization*” **[Interviewee 14],** “*I personally feel it help to increase productivity in long run*” **[Interviewee 11],** and “*increase productivity*” **[Interviewee 18]**.

Box. 21:

SM Benefit, “**Development/Performance/Productivity**” defined as ‘**Successful implementation of SMP in SMEs improves the predictability of development, which helps to increase the performance and productivity as a result.**’

5.3.4.3. Efficient Project Management

Project management is another commonly identified factor in SM success and benefits. If project management is performed accurately, it will increase the chances of successful implementation of SM in SMEs. This, in turn, results in the facilitation of monitoring and scheduling. Interviewees thus believed that measurement benefits the PM, as per following statements:

- "*Tasks are estimated and monitored on time*" **[Interviewee 10].**
- "*The results of measurement can help in project monitor and scheduling*" **[Interviewee 17].**
- "*It could beneficial like monitoring and planning*" **[Interviewee 20].**
- "*It gives clear idea of your software development and current status of your product, Timeline*" **[Interviewee 8].**

Good measurement results facilitate managers to manage any associated risk:

"*It helps people understand and manage risks better. When risks are managed better and fewer things are done whilst firefighting, quality automatically improves*" **[Interviewee 12].**
"*It can be very useful in risk management phase*" **[Interviewee 9].**

Box. 22: SM Benefit, "**Project Management**" defined as '**SM results can be used as input to PM especially for monitoring, scheduling and future risk management.**'

5.3.4.4. Process Improvements

One of the key SMPI benefits is the range of software processes improvements (SPI) that it can support. As per our analysis, measurement plays a key role in SPI and is considered the backbone of the system development life cycle (SDLC). This all contributes to successful software product development and successful projects. As interviewees stated in regard to SM:

"*It helps to implement processes efficiently, proper documentation becomes an essential*" **[Interviewee 1].**
"*Being a small organization, it helps us to manage our project and team in a lean and efficient fashion*" **[Interviewee 20].**
"*It should cover all aspects, from initiation, planning, execution, monitoring & control and closing*" **[Interviewee 21].**

A couple of interviewees discussed the broad role of measurement across the SDLC: "*We do it on all stages as per our requirements*" **[Interviewee 20]**. "*In all aspects, it helps from analysis till implementation*" **[Interviewee 3]**.

Box. 23: SM Benefit, "**Process Improvement**" defined as '**Successful SMPI in SMEs will increase the process' maturity which helps in producing better results.**'

5.3.4.5. Quality Improvements

Some of the interviewees expressed that the SM process and quality are linked to each other as 'body and soul'. Some even deemed measurement as a guarantee of better quality. Some of the excerpts from the interviewees that relate SM to quality are as follows:

"*improve the companies quality", "criterion to assess quality and reputation of any organization", "We have errors report on daily bases which help us to predict quality of our product", "It increases the products quality", "impact on both the quality and costing of your project", "It will enable to deliver quality products with fewer issues in it" and "it can improve the quality*".

Some interviewees further described measurement benefits relating to higher quality management as follows:

"*It gives predictability too,*" "*software measurement can provide an accurate timeline for deliverable*", and "*all tasks are estimated.*"

Box. 24: SM Benefit, "**Quality**" defined as '**Measurement helps to improve software quality. It also supports improved predictability, accuracy and estimation.**'

5.3.5. Additional Information

This section presents other general statements about software measurement that were made by the interviewees, irrespective of any core category.

Interviewee 10: explained how they used software measurement and how it was helpful:
"*All tasks are estimated and monitored on time. We get a feel for how the project is performing on a daily basis via scrum meetings. We can look at burn down charts for looking at project status.*"

Interviewee 3: said that they had a separate quality assurance department, but they did not follow any measurement process specifically:

"*Yes, we have a department of Quality Assurance. This department has quality assurance engineers. Based on their results we measure the productivity and quality*".

Interviewee 12: advised that although they did not follow any proper measurement process during development, they did collect some metrics data:

"*We deploy measurement packages along with software for monitoring the software performance after deployment.*"

Interviewee 8: described their current process base on agile, where he was satisfied that this was fulfilling their measurement requirements somehow:

"*Agile only, because following this methodology we almost nicely manage all the software engineering processes. As we receive tasks in small chunks where we can analyse requirements properly, develop them and do the quality check through testing and send to QA department. This also not builds much pressure on us which results in the nasty or code smells. Yes, I am not sure about the managerial level how they tackle over there, being a senior developer I am only receiving tasks in chunks and then prioritize them and assign to suitable resource accordingly*". Further, he stated about SM process: "*it clear idea of your software development, and current status of your product, Timeline, quality assurance*."

Most of the interviewees stated that they were following agile development methodologies, and so either they did not feel the need for measurement specifically, or that their particular methodology automatically fulfilled SM requirements somehow. There follows a brief listing of some companies' development methodologies, methods or tools.

Interviewee 1: "*JIRA Agile, Atlassian Confluence*."
Interviewee 10: "*Complete SQM Process, Continuous Integration, and Custom Quality Tools*."
Interviewee 19: "*We are using Agile, JIRA and integration testing.*"
Interviewee 13: "*We use our defined process which involves testing on a regular basis, e.g. unit testing, integration testing.*"
Interviewee 14: "*In-house developed processes.*"
Interviewee 16: "*Problem definition. Cause identification and analysis. Optimal solution based on the cause(s). Finalize how the corrective action will be implemented. Implement the plan. Track the effectiveness of the implementation and verify that the desired results are met.*"
Interviewee 17: "*Code Coverage, PMD, Find Bugs, Hudson Code Analysis Plugin.*"
Interviewee 18: "*On time, Scrum.*"
Interviewee 22: "*Different built-in utilities of IDEs (MyEclipse) and QA tools.*"
Interviewee 20:"*We follow agile practices (SCRUM, XP, TDD).*"
Interviewee 12: "*We are using JIRA so you can say it's being used to judge the productivity and quality.*"

For the reader's interest, a number of word trees (of keywords such as limited, expert, resources, measurement, and measures) representing participants' views are given in Appendix 5.7.

5.4. Summary

This research phase investigated the key SMPI challenges, obstacles, benefits and success factors that are specifically relevant to software SMEs. A qualitative research approach following GT guidelines was adopted to analyse data collected from 22 different professionals working in 17 different SMEs in Pakistan and the UAE. Open-ended interviews were conducted in English and then transcribed prior to analysis. SMPI challenges, obstacles, benefits and success factors were identified as a result of performing open, selective and theoretical coding. The major contribution of this component of the research are preliminary exploratory frameworks of each core category.

Chapter 6 The Current State of SMPI in SMEs

This chapter summarises and discusses the current state of the research regarding Software Measurement Program Implementation in Small and Medium Enterprises (SMPI in SMEs) as excerpted from the literature and industrial reviews. It presents an analysis of known existing solutions and notes their capabilities and limitations according to the SMPI requirements of SMEs. This analysis also forms a basis on which to identify any existing gaps and to motivate the researcher to bridge these gaps through the research reported subsequently in this thesis.

Findings of this baseline research in previous chapters show that software measurement is widely recognized as a fundamental part of controlling, evaluating, understanding, predicting, and maintaining software development projects. Despite this, there are still questions raised about SM process design, initiation, and implementation, specifically for SMEs. The reasons are a lack of involvement of top management, no alignment with business goals and strategies, a perceived lack of suitable improvement initiatives, and significantly limited resources.

In this part of the thesis the main research question to be addressed is **RQ3:** *What are the differences in the challenges and success factors for SMPI implementation as identified in the literature and industrial reviews?* and the core objective is **Obj3:** *To analyse comparatively the state-of-the-art and state-of-practice: to identify the main challenges in the context of SMPI in SMEs*. In the rest of this chapter, Section 6.1 discusses the current state of SMPI in SMEs, and the motivation for the research that follows is given in Section 6.2.

6.1. Software Measurement in SMEs

This section describes the previously proposed solutions for SMPI in SMEs. While the body of research addressing SMPI in general is quite extensive, very few researchers have investigated the specific context of SMPI in SMEs. This is followed by a synthesised summary of the findings of the two previous chapters and then recommendations for SMPI-in- SMEs.

6.1.1. SMPI in SMEs: A Summary of Factors

This section summarises the challenges, obstacles, benefits and success factors as identified during the literature and industrial reviews. These factors have not been highlighted/listed categorically in the literature to date with respect to SMEs.

Table 6.1 Literature vs. Industrial review (Challenges, Obstacles, Benefits and Success Factors)

Industrial review	Literature (mapping study)
Challenges	
Resource limitations	Resources limitation mainly includes time, budget and experts (Ahmad et al., 2012b; Caballero et al., 2011b; Haddad & Meredith, 2011; Caffery et al., 2007; Ross & Haddad, 2010; Tihinen & Järvinen; Wangenheim et al., 2003)
Lack of knowledge/awareness	Mostly people in SMEs not aware of SM process (Ahmad et al., 2012b; Haddad, Ross, & Meredith, 2012; Caffery et al., 2007; McGuire, 1999)
Multiple Roles	Already overloaded due to multiple roles (Haddad et al., 2012; Wangenheim et al., 2003)
High learning curve	SM process has learning curve (Haddad et al., 2012)
Misconceptions	SM is not designed for SMEs (Haddad et al., 2012; Caffery et al., 2007)
Expert required	SMEs cannot be higher expert for implementation (Haddad & Meredith, 2011)
Time consuming	SMEs mostly tied to strict time frames (Díaz-Ley et al., 2007; Díaz-Ley et al., 2008a; Haddad et al., 2012)
Solution/process complexities	SM topic itself too extensive to understand (Díaz-Ley et al., 2007; Haddad et al., 2012)
Reluctance to adopt	Practitioner not adopting SM process (Ahmad et al., 2012a; Allen et al., 2003; Haddad et al., 2012; Ross & Haddad, 2010; Umarji & Seaman, 2008)
Obstacles	
Expert Judgments	As alternate, they mostly make decision based on experts judgments (Hughes, 1996; Jørgensen, 2004; Loconsole & Borstler, 2007; Tomaszewski et al., 2006)
Implementation overhead	
Metrics selection	Effective measurement required appropriate metrics selection (Haddad et al., 2012; Ponisio & Eck, 2012; Popović & Bojić, 2012)
Top management	Owners perception of need (Haddad & Meredith, 2011; Laitinen & Chong, 2006)
Workload	Workload decrease efficiency of employees (Haddad et al., 2012)
Politics	Key barrier identified politics (Cater-Steel, 2001; Goldenson & Herbsleb, 1995)
Success Factors	
Lightweight solution	Small scale solutions required to overcome resources limitation issue (Haddad et al., 2012)
Roles and responsibilities definition	Roles and responsibilities should be clearly defined(Díaz-Ley et al., 2007; Loconsole & Borstler, 2007; Roger, 2005)
Tool automation	Tool automation mainly helps in successful implementation (Iversen & Lars Mathiassen, 2000; Paulish, 1993; Pfleeger, 1993)
In house training	In-house training is mandatory to implement processes successfully (Dangle et al., 2005; Haddad et al., 2012; Hamann et al., 2001b; Trudel & Tardif, 2006)
Measurement goals determination	Goals must be determined (Díaz-Ley, et al., 2008b; Haddad & Meredith, 2011; Pino et al., 2009; Pusatli, 2011; Tihinen & Järvinen, 2006a; Wangenheim et al., 2003)
Metrics dashboard	Right metrics selection (Anacleto et al., 2004; Beland & Abran, 2012; Díaz-Ley, et al., 2008a; Ross & Haddad, 2010)
Reusability	The developed tool should have reusability property (Díaz-Ley, et al., 2008a)

More effective management	Successful SM implementation required operative management (Druffel, et al., 1983; Haddad & Meredith, 2011; Kautz, 1999)
Benefits	
Monitoring and scheduling	Monitoring of process (Díaz-Ley et al., 2007; Caffery et al., 2007; Tihinen & Järvinen, 2006a) Could be utilized for scheduling (Pusatli, 2011)
Quality improvements	Contribute to the software quality improvement (Anacleto et al., 2004; Haddad et al., 2012; Hamann et al., 2001b; Popović & Bojić, 2012; Ross & Haddad, 2010; Trudel & Tardif, 2006)
Increase productivity	Evaluate productivity (Anacleto et al., 2004; Haddad et al., 2012; Hamann et al., 2001b; Popović & Bojić, 2012; Ross & Haddad, 2010; Trudel & Tardif, 2006)
Process improvement	Metrics for process improvement (Beland & Abran, 2012; Diaz-Ley et al., 2008; Díaz-Ley, et al., 2008a; Díaz-Ley et al., 2010a; Haddad et al., 2012; Hamann et al., 2001b; Kautz, 1999; Ross & Haddad, 2010; Taylor et al., 2006)
Risk management	Help in risk management (Gómez et al., 2008b; Pusatli, 2011)
Efficient project management	Assist in project management (Ahmad et al., 2012a; Beland & Abran, 2012; Diaz-Ley et al., 2008; Haddad & Meredith, 2011; Niazi & Babar, 2009; Ruiz et al., 2011; Tihinen & Järvinen, 2006a)

6.1.2. Recommendations for Successful SMPI

This section presents sets of recommendations suggested by different researchers, which have been adopted or referred to during the development of SMPI solutions. The first four lists present recommendations that are said to lead to successful SMPI irrespective of organizations' size; whereas the fifth list, reported by Diaz-Ley et al. (2008), is drawn from the only major work found in our research domain of SMPI in SMEs. The sixth list then presents the success factors identified via the literature and industrial reviews undertaken during this research. These lists show that, irrespective of organizations' sizes, there are some common success factors for SMPI, but that SMEs comparatively require simplicity and flexibility in SMPI processes, due mainly to inherent resource limitations.

1. The Recommendations for Successful SMPI, by Rifkin and Cox (1991b).

Measure:

- Start small
- Use a rigorously defined set
- Automate collection and reporting

People:

- Motivate managers
- Set expectations
- Involve all stakeholders
- Educate and train
- Earn trust

Program:

- Take an evolutionary approach
- Plan to throw one away

- Get the right information to the right people
- Strive for an initial success

Implementation:

- Add value
- Empower developers to use measurement information
- Take a “whole process” view
- Understand that adoption takes time

2. The Secrets of Highly Successful Measurement Programs, by Dekkers (1999)

- Set solid objectives and plans for measurement
- Make the measurement program as part of the process, not a management “pet project.”
- Gain a thorough understanding of what measurement is all about – including benefits and limitations
- Focus on cultural issues
- Create a safe environment for reporting true data
- A predisposition to change
- A complementary suite of measures

3. The Principles for SMPI on Knowledge Areas, by Iversena and Kautzb (2000)

Knowledge:

- Use improvement knowledge
- Use organizational knowledge

Organization:

- Establish a project
- Establish incentive structures

Design:

- Start by determining goals
- Start Simple

Communication:

- Publish Objectives and collected Data Widely
- Facilitate debate

Usage:

- Use the Data

4. SMPI Success Factors, by Hall & Fenton (1997)

Implementation Factors

- Consensus recommendations
- Incremental implementation
- Well-planned metrics framework
- Use of existing metrics materials
- Involvement of developers during implementation
- Measurement process transparent to developers
- Usefulness of the metrics data

- Feedback to developers
- Ensure that the data is seen to have integrity
- Measurement data is used and seen to be used
- Commitment from project managers secured
- Use an automated data collection tools
- Constantly improving the measurement program
- Internal metrics champions used to manage the program
- Use of the external metrics gurus
- Provision of training for practitioner

Other Recommendations

- Implement at a level local with the developers
- Implement a central metrics function
- Metrics responsibility devolved to the development teams
- Incremental determination of the metrics set
- Collecting data that is easy to collect

5. Challenges versus Recommendations, by Diaz-Ley et al. (2008)

Limited Resources:

- Few People involved in process (FPP)
- Reuse Measurement Model (RUSE)
- Few but effective and complete steps (FSTEP)

Poor SM Knowledge:

- Specific guidelines to support basic process improvement needs. (GPIN)
- Specific guidelines to integrate measurement into software processes. (GINT)
- Specific guidelines to adapt measurement definition to the measurement maturity of the company. (GMM)
- Specific guidelines to understand the benefits & potential for management (GB&P)
- Measurement examples (EXMP)

6. Success Factors for SMPI in SMEs identified during literature and industrial reviews

Literature review (Chapter 4)

- Resource management
- More effective management
- Informed and standard metrics selection and use
- Clear identification of roles and responsibilities

Industrial review (Chapter 5)

- Measurement goals identification
- Tool automation
- Managed implementation
- Top management
- Client support
- Communication
- Awareness

- Experts
- Roles and responsibilities definition

6.2. Summary of Findings from the Literature and Industrial Reviews

This section is divided into three further sub-sections. The first sub-section 6.2.1 summarizes the existing related work for SMPI in the context of SMEs. The second sub-section 6.2.2 presents the identified challenges and obstacles. The associated literature references and commonalities are provided in the previous section in Table 6.1. The third sub-section 6.2.3 presents the differences between the existing methodologies.

6.2.1. Challenges and obstacles

6.2.1.1. Reluctance to adopt

Reluctance to adopt SMPI in SMEs is one of the commonly identified problems in literature and industry. It appears that many practitioners do not even consider implementing SMP in their practice, while the main observed reason is that they do not have any knowledge about SMP. If they arrive at an intent to implement an SMP, even then they may find it hard to initiate the process. Moreover, it is found that the variety and complexity of existing solutions make it hard for them to select a suitable solution. This issue could be resolved by raising the general level of awareness regarding the SMPI process.

6.2.1.2. Time Consuming

The time-consuming nature is another possible factor that leads to reluctance in the adoption of SMP. People complain about such hurdles in adopting SMP in SMEs where schedules are already tightly bound with deadlines.

6.2.1.3. Resource Limitations

Resource limitations relating particularly to budget and personnel are perceived to be high-priority genuine issues for SMEs. Evidence gathered in this research suggests that most of the challenges/obstacles occur because of resource limitations. Thus, solutions need to be designed so that SMEs can implement them with limited resources, as these limitations will remain in place.

6.2.1.4. High Learning Curve

Another issue contributing to practitioners' reluctance is a perception of a high learning curve for existing solutions. Even those who, somehow manage to initiate SMPI, sometimes give up due to the higher learning curve of existing solutions. This issue could be resolved by providing simple and straightforward solutions.

6.2.1.5. Expert Requirements

Most solutions, due to their complexities, require experts and trained resources for SMPI. This is not feasible for SMEs who are working with limited resources. To overcome this issue, most SMEs use experts' judgments for some basic metrics. For the most part SMEs cannot hire SMPI experts due to a limited budget so again it is important to keep the solution simple and automate it as much as possible.

6.2.1.6. Measurement Goals Determination

Measurement goals determination is one of the major challenges found, and one of the key reasons practitioners are reluctant to SMPI in SMEs. It can be difficult to define measurement goals and align them with organizational and project objectives. It also requires the immediate attention of top management, and of measurement experts. Top management could be convinced to participate in this process if a positive value proposition can be formed, but the "need for experts' skills" requirement will remain a challenge. This issue could be resolved by providing a standard set of measurement goals that could fulfil the basics measurement needs of (most) SMEs.

6.2.1.7. Lack of Knowledge/Awareness

This issue was mainly identified during the industrial review in which the researcher found that some of the interviewees in SMEs were not aware of SMPI at all. In such a situation, the worst thing was their concerns about process complexity and SMPI benefits were just based on their weak background knowledge. So, awareness sessions should be mandatory for all employees. It could be more efficient if it becomes part of the training for newly hired employees.

6.2.1.8. Lack of Communication between Different Levels of the Organization

Communication can be a strength of SMEs, with small numbers of employees spread across few organisational layers. However, there is evidence that some SMEs were found to lack sound communication processes and channels, which could be a cultural issue if they are working with other parts of organisations. Adding an appropriate communication model to an SMPI solution can resolve several issues, including helping with the transparency of the programme and the use of the data that are collected.

6.2.2. A review of existing solutions

This section reviews the essence of the existing solutions for SMPI in SMEs, with respect to the required characteristics of a solution. An assessment is made as to whether or not they are fulfilling the particular challenge of SMPI. So this section is divided into two sub-sections: the first sub-section addresses recommendations and the second relates to the addressing of the various challenges.

This research found that all three existing solutions are 'complete' in that they provide mandatory steps from goal definition to measurement data analysis, but the problem is the guidance and definition itself, especially for non-mature SMEs. However, before going into further details the summary of existing solutions for SMPI in SMEs is first presented.

6.2.2.1. GQM-Lightweight

GQM-lightweight mainly reduces the extent to which GQM tasks are undertaken and adds more support for the implementation of the measurement process. GQM-lightweight specifies the reuse of the measurement models. It defines steps to store the measurement data and maintains the measurement process improvement. On the other hand, it has not been assessed in any follow-up studies, and further, GQM-lightweight was required to be validated empirically by its author, to make general statements about its impacts upon SMPI in SMEs.

6.2.2.2. MIS-PyME

As described earlier, one of the major contributions in this area is the work of Díaz-Ley et al., who introduced and evaluated the MIS-PyME framework. MIS-PyME consists of two parts: 1) the SMP definition methodology and 2) the measurement capability maturity model. The first part mainly follows GQ(I)M steps to provide a set of goals and a detailed template for indicator definition which describes data such as how, who and when the indicator should be created; as well as information regarding results analysis and interpretation. The second part emphasizes a company's measurement maturity.

Overall MIS-PyME focuses on software process improvement needs with respect to SMP, wherein it guides the integration of the measurement program into the software process. Moreover, the MIS-PyME goals are clearly focused on SPI. The MIS-PyME framework added a reusability concept that is similar to the one in the GQM-lightweight. Furthermore, MIS-PyME provides indicator and goal-oriented definition templates to reduce users' lack of awareness. That said, the indicator template requires the completion of quite an amount of technical information, which could cause reluctance as per the findings of this research.

Its major contribution is the measurement goal definition and indicator templates in the first part, whereas the second part is a totally new introduction in SMP, which does not comply with SMEs' requirements as it instead adds further overhead. As such, it may be more suitable for large organizations or more mature SMEs. Moreover, in looking at SMPI solutions particularly for small organizations, MIS-PyME, does not seem to comply with small organizations at all. Overall this MCMM looks like an unnecessary overhead for SMEs. Comparative to GQM-lightweight, which was introduced by reducing the GQM tasks, MIS-PyME added the job of indicators, which is no doubt appealing for the measurement process but does not comply with SMEs requirements.

6.2.2.3. Hybrid Measurement Process (HMP)

The HMP contains generic activities which could be implemented by making minimal variations. HMP takes into account the reuse and improvement of measurement programs, and the defined process is iterative by nature. HMP deals with how and with what frequency data should be collected and reported. HMP guides about storing the measurement plan, collected data and analysis sheets and other related data. HMP was mainly proposed to enable organisations to attain higher maturity levels where both CMMI Dev 1.3 and ISO are used. HMP ties up with the standards/models usage which may not be suitable for SMEs as per the findings of this research (though it could be suitable for SMEs with higher maturity levels).

6.2.2.4. Challenges fulfilled by existing solutions?

The identified challenges are used to analyse whether the three existing solutions considered, GQM-Lightweight, MIS-PyME, and HMP, are suitable for SMPI in SMEs. Table 6.2 presents three scales. 'Yes' and 'No' means either solution does or does not address the corresponding challenge. The third scale is 'Partially', which indicates that the solution copes with that the challenge to some extent. These scales are given based on the claims by the solution providers and literature review results especially discussed in Díaz-Ley et al., (2008).

Table 6.2 Challenges vs. existing solutions

Challenges	GQM-Lightweight	MIS-PyME	HMP
Resource Limitations	Partially	Partially	No
Lack of Awareness	No	No	No
Solution Complexities	Yes	Partially	Partially
Time Consuming	Partially	Partially	Partially
High Learning Curve	Partially	No	Partially
High Implementation Cost	Partially	No	No
Measurement Goals Determination	No	Yes	No

6.2.2.5. Requirements and Characteristics for Successful SMPI

The existing solutions are further analysed in the light of the recommended success factors (as presented in the previous section). Suitability was assessed based on the literature and industrial reviews of SMPI in SMEs. In the following Table 6.3 the scale 'Yes' is given if a solution complies with the requirement and 'No' is recorded if it does not comply with the requirement. The 'Partially' scale is chosen if a solution complies with an SME's success factor requirements up to some extent.

Table 6.3 SMEs requirements vs. existing solutions

Factors	GQM-Lightweight	MIS-PyME	HMP
Process Initiation	No	No	No
Easy to Use	Yes	Partially	No
Communication Model	No	No	No
Roles & Responsibilities Definition	No	Partially	No
Metrics Dashboard	No	No	No
Measurement Data Reusability	Yes	Yes	Partially
Motivation & Communication of Top Management	No	Partially	No
Solution Automation	No	Yes	No
Cost Effective	Yes	Partially	Partially
Involve all Stakeholders	No	No	No

6.3. Summary

The assessments above show that none of the analysed solutions completely comply with the requirements of light-weight SMPI in SMEs. Though MIS-PyME is the most recent and most regularly studied methodology for SMPI in SMEs, in fact the solution that is closest to fulfilling SMEs' requirements is GQM-lightweight. Overall, the requirements of SMPI in SMEs show that the solution should also contain a strong communication model for creating and sustaining shared awareness and understanding. It should also keep the process transparent and implement it successfully, whereas the above analysis suggests that all three of the existing analysed solutions are lacking in these respects.

The analysis of existing solutions in this research was conducted mainly with respect to non-mature SMEs i.e., SMEs that would not be expected to achieve an ISO or CMMI Level. The requirements were selected to analyse whether the existing solutions complied with the simple and straight-forward SMPI in SMEs. It was found that the major challenge is that of resource limitations, which are the underlying cause of many other challenges. In SMEs there is no magic solution to maximize resources; instead, the solution should be made to maximize and simplify the support provided. Also, none of the existing solutions explicitly address the SMPI challenges. It is thus found that the existing solutions are fulfilling the core SMPI requirements but are lacking in overall measurement initiation and implementation management processes. All of this discussion leads to the requirement for a new light-weight solution.

The intent is captured as follows:

- "Can a small software organization overcome these challenges? How can they come up with an efficient process that will produce valid, actionable information while at the same time getting all of the "regular" work done, and convince management that this is a long-term win for everyone? Why should they even bother?"(Haddad & Meredith, 2011).
- SMPI in SMEs is subjective, open to discussion and controversial - not only challenging (Díaz-Ley et al., 2007).

This discussion can be concluded by reiterating that, to date, just a few attempts have been made to provide solutions for SMPI in SMEs. The major focus of most researchers regarding SMPI solution development is still large organizations, meaning the solutions may not comply with the SMEs' requirements. The research reported in this thesis focuses on SMPI in SMEs; how to initiate a measurement process, how to cope with challenges in each phase, how to manage the process and how to make sure of its applicability for the long term.

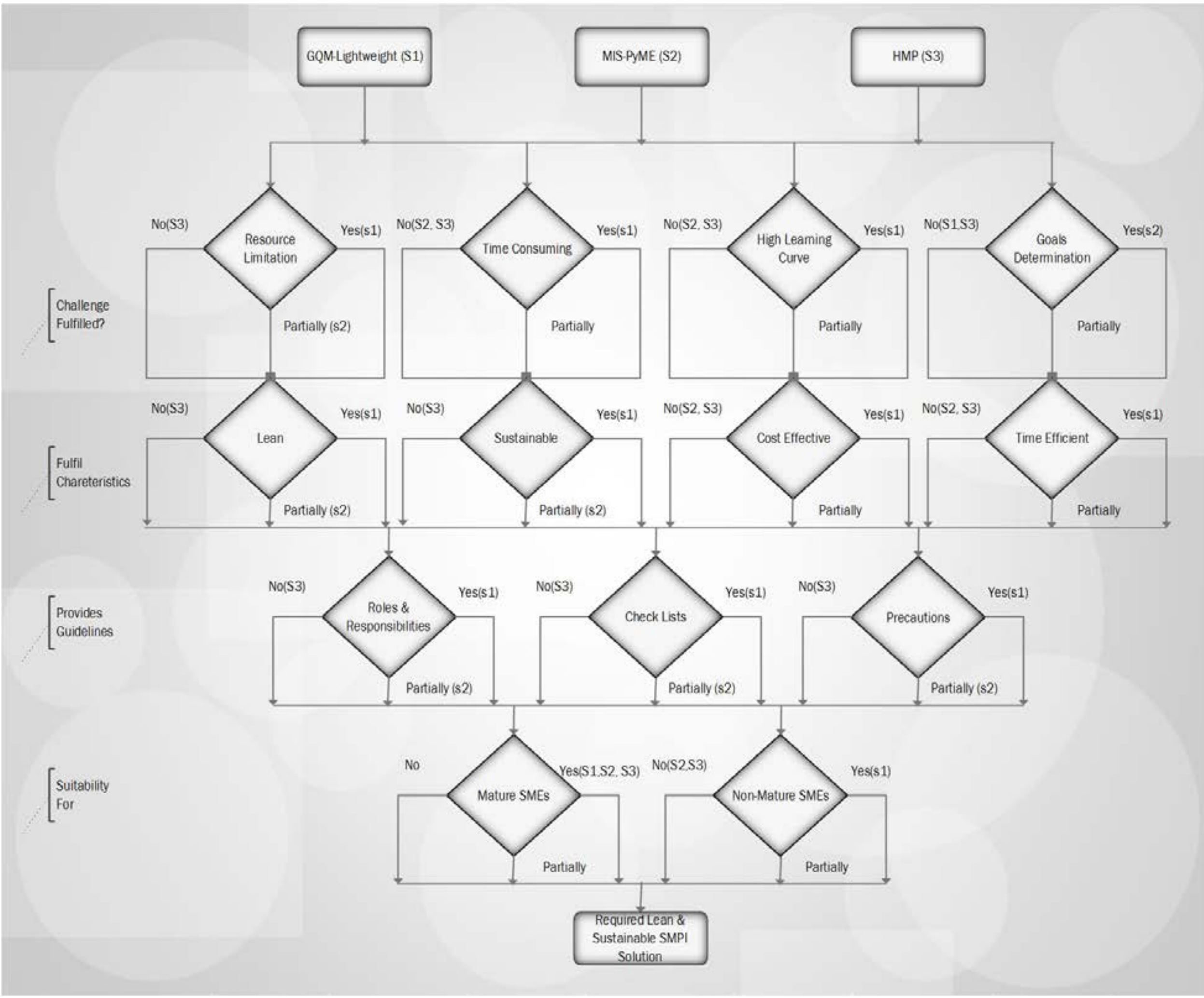

Figure 6-1 Comparative analysis of existing solutions w.r.t SMEs' needs.

Based on the literature and industrial reviews, this research has identified the following core aspects that should be considered when initiating a plan to implement SMP successfully in SMEs. Any proposed solution should be:

- Simple and straight-forward to learn.
- Light-weight in use.
- Cost and time efficient.
- Suitable even for non-mature organizations.
- Populated with built-in functionality.
- Supported by SMP initiation and implementation guidelines.

Based on the above discussions, a conclusion can be drawn that in successful SMPI in SMEs proper planning is important, where the first step should be giving awareness to the process stakeholders. Moreover, an ongoing follow-up process through communication is mandatory. The SM process should be transparent to all stakeholders, and the solution should be equipped with implementation guidelines and maximum supportive material, where the stakeholders are required to put in the minimum effort possible when identifying and defining the material. Only then will SMEs move from the scenario depicted in Figure 6.6.

Figure 6-2 A common scenario for SME's (Forss, 2014)

Part 3: Contribution

This part of the thesis represents the solution design/development phase of DSR; it thus presents the process of development for the proposed software measurement framework (SMF). It has also been established in the previous chapters that there are several challenges that would need to be addressed by a successful software measurement framework (SMF) in terms of complying with SMEs’ software measurement program implementation (SMPI) requirements. These are addressed in the validation of the framework.

Chapter 7 A Novel Software Measurement Framework for SMEs

In spite of its benefits in other fields, measurement in, and of, software engineering is perceived as a complex undertaking, and is seen as especially challenging in Small and Medium Enterprises (SMEs). Over many years there has been a record of measurement failure in this field: Rubin (1991) suggested that around 70% of measurement programs did not continue beyond their second year; close to a decade later Pfleeger stated that two out of three such programs failed during implementation (Pfleeger, 1999). Wangenheim et al. (2003) reported that this type of failure trend was very common specifically in SMEs. Yet on average, SMEs make up 60% to 80% of companies contributing to the economy of a country (Pfleeger, 1999), a figure that is higher again in nations including Ireland, New Zealand and the Scandinavian nations. In this era of burgeoning technology, these results are not encouraging.

It has been established in the previous chapters that there are several challenges that would need to be addressed by a successful software measurement framework (SMF) in terms of complying with SMEs' software measurement program implementation (SMPI) requirements. Prominent among these challenges are the limited resources and limited knowledge that are common in SMEs, and these in fact underpin other challenges. For example, SMEs are highly constrained in terms of staff, budget and expertise, meaning that finding the time and the capabilities to implement SMPs is extremely difficult. Moreover, due to their limited budget, SMEs are highly conscious of cost vs. benefits. So even when SMEs' seek to attempt SM, either they avoid formal approaches to SMPI or they use alternative channels and mechanisms that rely on resources already to hand, e.g., judgements by in-house 'experts', standard QA reporting and the like.

Having identified the various challenges and success factors of SMPI in SMEs, through a comprehensive systematic mapping study complemented by interviews with 22 practitioners working in SMEs, this research sought to propose, evaluate and refine a new solution by working in real-time with relevant employees to overcome challenges as they emerged. In this component of the research programme the primary research question is **RQ4:** *Can SMP be* *implemented effectively and efficiently in SMEs?* and the core objective is **Obj4:** *To develop a framework to enable SMEs to implement simple, sufficient and straight-forward SMPs*.

The remainder of this chapter is organized as follow: Section 7.1 defines the problem, Section 7.2 provides an overview of the field studies conducted and the methods applied, Section 7.3 presents the design and implementation of the field studies in detail along with the results obtained, Section 7.4 reports the findings of the field studies and details the proposed framework, namely SMF4SMEs, Section 7.5 discusses the findings, and this is followed by a summary in Section 7.6.

7.1. Problem Definition

Successful SMP implementation has tended to rely on the use of standards, such as CMMI, SPICE, and ISO, instantiated as formal frameworks. This requires extra trained staff, as well as effort, time, cost and patience (Díaz-Ley et al., 2007; Haddad et al., 2012), all of which SMEs typically lack. To overcome these problems and yet keep the process somewhat structured, a variety of methods have been introduced (Haddad et al., 2012) such as GQM, GQIM, GQM Lightweight, TSP, RAPID, TSP, MIS PyME. Uptake of these methods has been limited, however, as SMEs continue to encounter challenges when implementing SMPs. One of the reasons could be that these solutions themselves remain complex and so require resources that do not typically exist in most SMEs.

After analysing the relevant literature, seeking industry views regarding SMPI challenges, and evaluating the solutions previously proposed for SMEs, two key statements stood out as they showed that several challenges remained unresolved and that there remained a need for an efficient process for successful SMPI:

1. "Can the small software organization overcome these challenges? How can they come up with an efficient process that will produce valid, actionable information while at the same time getting all of the "regular" work done, and convince management that this is a long-term win for everyone? Why should they even bother?" (Haddad & Meredith, 2011).
2. "We can deduce that software measurement and metrics are not only challenging, but they also can be controversial, subjective and open to discussion." (Pusatli & Misra 2011)

Based on the findings drawn from the literature review (Chapter 4) and industrial interviews (Chapter 5) a new framework was to be developed. The Software Measurement Framework for SMEs (SMF4SME) was intended to better support SMEs in their implementation of SMPs. To this end field studies were carried out in one medium-sized and one small-sized organization.

7.2. Field Studies and Methods

This section presents an overview of the field studies and the methods employed in conducting them to answer RQ4 and to achieve the corresponding research objective.

7.2.1. Field Studies Context

The field studies were performed in two software development companies; one company was a medium-sized organization (referred to here as ABC Company) and the other one was a small organization (known as XYZ Company). The aim of the field studies was to develop the SMF4SMEs in an iterative, real-time manner by getting input and feedback from the practitioners in those companies. Figure 7-1 shows an overview of the three cases as conducted through field studies. Case 1 was conducted in ABC with coordination provided by PM1 and assistance from the SQM. The outcome of Case 1, the SMF1, was utilized in parallel in Cases 2 and 3, to further enhance the SMF1. In Case 2 the Co-PM was main point of coordination where PM1 assisted continually and the Onshore PM was kept in the loop via posting him update of the process. In Case 3 the point of contact was the CEO, assisted by the TL of the selected team. Further details are given in proceeding sections.

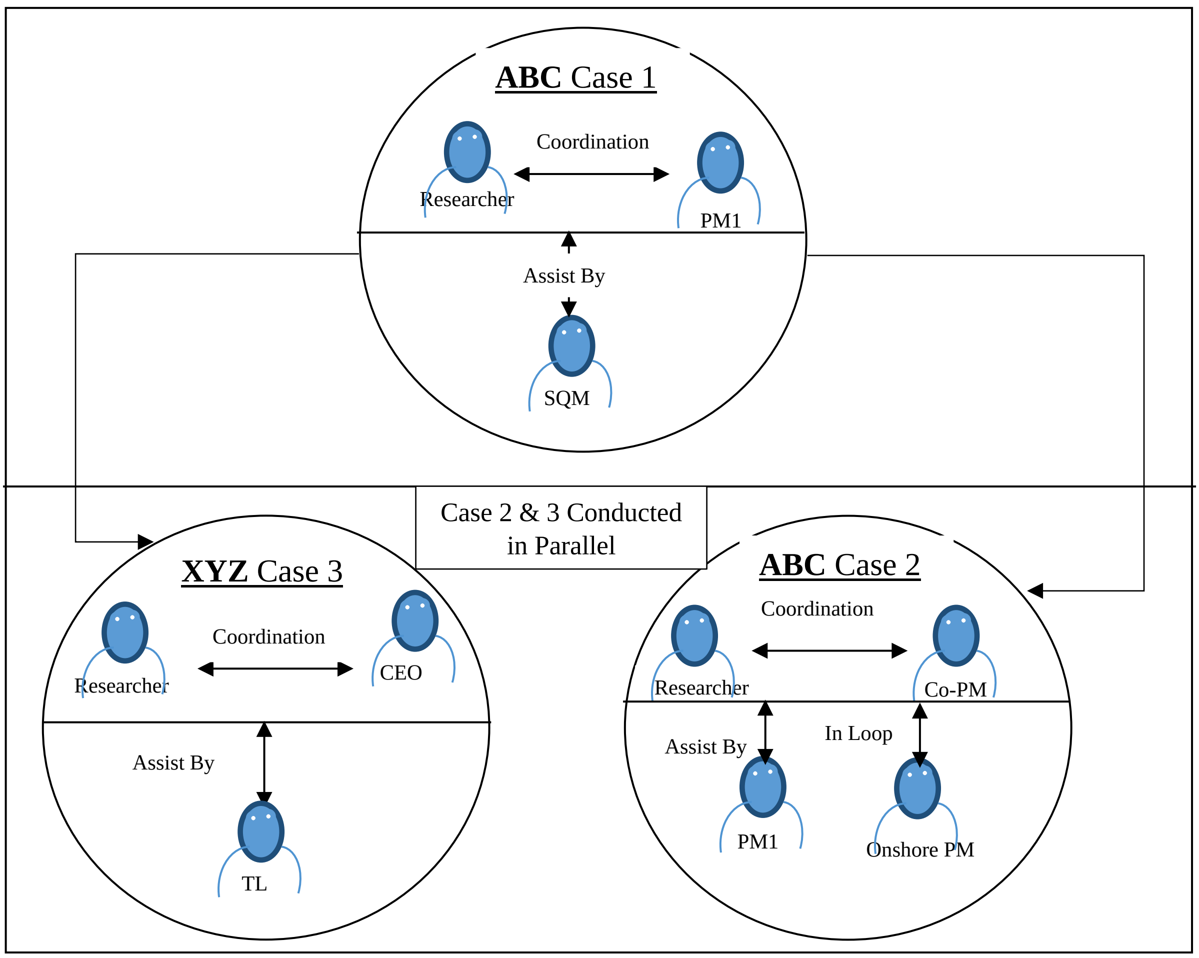

Figure 7-1 Field Study Contexts

7.2.1.1. Company ABC

Two of the three cases were conducted in ABC, which was working on an American outsourced project. The American company, which had outsourced its IT development work to ABC, is B2B and B2C oriented. It has multiple stores in the United States of America. The American onshore company was set up in 1971 whereas ABC was seven years old, having been founded in 2008.

In ABC, the SM initiative was encouraged by the researcher with the coordination of a Project Manager (PM1), although initially there was no agreement or acceptance by ABC's top management to implement SMP. Offshore, ABC had around 79 employees who were divided into different teams by project modules (subprojects). The American onshore company had around 25 employees in the IT department who were interacting directly with the offshore teams in ABC. Also, the American onshore company had more IT personnel who were involved in the non-technical activities of the American company and so did not have any direct interaction with ABC.

ABC had some informal, internally-defined processes for development. They were using measurement on an as-needs basis, but did not consider themselves to be performing software measurement. For example, they were using their bug reports and seniors' experiences in decision making, for quality management, schedule release deployment, and productivity management. Also, for one project, it was found that they were considering a code coverage report which they were generating via an IDE. The existence of such informal measurement activities was sufficiently encouraging for both the researcher and the practitioners. These activities made it a little easier for the researcher to explain the concept of SM to the company and to help to convince practitioners about the value of SM.

7.2.1.2. Company XYZ

The third case was conducted in a small-size organization, XYZ, which was established at the start of 2014; at the time the third case was conducted the company was just over one-year-old. XYZ has been developing an enterprise school management system, and targeting the USA market. In XYZ, the SM initiative was led by the CEO of the company who was invited to participate by the researcher via email. XYZ had 18 employees including the CEO, who was also acting as PM and owner of the company. The total IT staff contained one PM (also the CEO), two Team Leads (TL), one Designer, two Front-end developers, two Testing Engineers, one database administrator (DBA), one Network Administrator and ten developers. The staff was divided into two teams; one working in the administration (‘admin’) panel, and the other on the client-facing aspects of the product.

XYZ had a stable but undocumented development process. They were not using any measurement and were relying only on the experiences of the PM and TL for all kind of assessments. The PM was not satisfied with this situation in terms of the decisions being made, and was mainly concerned with learning how SMP could help to improve their productivity (yet having limited resources such as time, budget and staff). This PM was keen to consider SM but was also but concerned because, in the past, his experience had been that it was not easy to implement such processes with limited resources.

7.2.2. Methods

7.2.2.1. Participant Recruitment

Our primary goal in this phase of the research was to develop, implement, evaluate and refine SMPs in real-time with relevant practitioners working in SMEs. With this in mind the researcher contacted several SMEs via email, based on previous interview references. Two organizations agreed to participate in the research, one medium-sized company, ABC, and one small company, XYZ, as described in the previous section. The PM1 was the key representative of ABC in which two cases were conducted, under the coordination of PM1 and the assistance of the Software Quality Manager (SQM). The CEO was the key representative of XYZ, where the third case was conducted, with the coordination of the CEO and assistance of a senior Team Lead (TL1).

7.2.2.2. Preliminary Investigation

In each case the researcher set up an initial meeting with the key representatives of each organisation, to discuss the nature of his engagement with the company and to enable the researcher to learn more about the working context. The researcher had listed some topics to be discussed in the first meeting with the representative of each organization. The list was open-ended, though the topics listed (below) were concerned primarily with the companies’ development processes and environments prior to the implementation of SMP. The researcher took notes during the discussion and wrote these up in full detail afterward. For clarification and validation, the researcher had further discussions with the key representatives, and issues were also followed up at later stages during the SMPI. The following topics were initially discussed with the representatives.

- The organization, work domains and projects’ descriptions.
- Current processes.

- How are they managing the current work?
- How are the roles and responsibilities distributed amongst team members?
- Communication patterns and mechanisms.

Table 7.1 reports a summary of the information captured through these initial discussions.

Table 7.1 Contextual Factors

Domain	ABC	XYZ
Industry	B2B, B2C Branded Garments	Education
Sector	Commercial	Private
Product/Project		
Maturity	Custom Development	Custom Development
Software	Information and Inventory Management System	Education Management System
Application type	Web, Desktop, Mobile, Third party tools Integration	Web
Size	Medium	Small
Software Development Process	Informal Internally defined	Stable but undocumented
Organization		
Maturity/Certification	None	Newly Formed
Teams Size	6 to 19	5 to 8
Development Process		
Outsourcing	Offshore	In-house
Methodology	Agile (Kanban)	Claim Agile but were not following absolutely
Workflow	Kanban Based	Internally defined
Global Collaboration		
Collaboration Units	Pakistan, USA	Pakistan
Collaboration tools	JIRA, Emails, Spread Sheets	Spread Sheets, JIRA
People		
Roles	PMs, co-PMs, Architects, Analyst, DBA, Network Admin, QAs, designer, developer	PMs, TLs, Testing Engineer, DBA, front end developer, developer, designer
Communication	JIRA, Emails	Emails, Spread sheets

7.2.2.3. Project Teams

The following teams were created to implement each case:

Team A: was working under the supervision of PM1, who was the initiator of SMP at ABC. PM1 had a total of 11 years of experience and had been working at ABC for four years. He was managing the integration project, selected as an appropriate context for Case 1. Team A comprised one PM1, one TL, and 13 developers. There were three dedicated testers who were working for the integration team but who ‘belonged’ to the testing department, as per the organizations structure (ABC had a separate QA department that supported all teams working on different modules of the project). SQM was leading the testing department and assisted throughout Case 1 in ABC along with PM1.

Team B: also worked within ABC and consisted of one PM (from onshore), one co-PM, two TLs and 19 developers. This team was divided further into two sub-teams. There were five dedicated testers for this project, who belonged to the QA department. To implement a SMP with this particular team, other associated resources included; a Data Base Administrator (DBA), a Systems Analyst (SA), SQM and PM1. In this case it was decided that the co-PM of the selected project would carry primary responsibility for the whole process, with the assistance of PM1 and SQM.

Team C: was working on the admin panel of a product under development at XYZ. As discussed above, XYZ had two teams, one working on admin panel development and another working on the client-end development of the product. The admin panel team was chosen for SMPI and consisted of one PM (also the CEO), one TL, one testing engineer, one front-end developer and four developers. Additionally, the PM decided to add the DBA and two key developers of the second team for SMPI.

7.2.2.4. Data Collection and Analysis

As discussed in preceding sections the participants were recruited through consultation with key representatives of each company, such as the PM1 in Company ABC and the CEO in Company XYZ. Data collection occurred *in situ* with the researcher sitting alongside practitioners, observing, questioning and taking notes in physical notebooks. As data were collected the researcher noted emergent key concepts and actions. The notes were revisited after the event, clarifications were sought and made to ensure they were understandable, and discussions with relevant key persons in each company were held to member check the content prior to the researcher arriving at interpretations.

Although a basic structure for the conduct of Case 1 was developed through a preliminary investigation (as presented in section 7.2.2.2) and key steps were identified (detailed in section 7.3.1) further actions were taken as needed during the actual implementation. Data were not analysed separately; rather it was an ongoing process embedded in the case implementation. At the end of Case 1 the researcher drew from the analysis outcomes to design an initial framework (see Figure 7-3), which is discussed in Section 7.3.1.1.

7.3. Field Studies and Results

7.3.1. Design and Implementation of Case 1

Case 1 was designed and implemented in ABC. As was mentioned above, initially there was no agreement or acceptance by the top management of ABC to undergo SMPI. After the initial investigation session between the researcher and PM1, and an introductory session to explain SMPI and the research objectives to ABC's top management, they agreed to try out an experimental approach to implementing SMP. Based on their previous experience of process improvement attempts at ABC, the major concern of top management was that any solution needed to be simple, easy to understand and readily able to be merged with other existing development processes. In other words, the proposed solution should require minimal effort and cost to understand and implement, and should comply with their existing development methodology. In ABC, PM1 was the main participant who seemed to be passionate about SMPI. This facilitated the researcher's interactions with ABC and eased the processes of SMF design and implementation in this case. PM1 also suggested involving SQM in discussions, given he would be participating throughout Case 1.

In general, SQMs may be knowledgeable about such processes, given that software quality management can draw extensively on measurement. However in ABC, the SQM's primary responsibility was for the testing team, not taking initiatives in quality management, so the SQM in fact had quite a limited understanding of SMPI. He had some knowledge of software process improvement (SPI), which was an advantage. PM1 mainly coordinated with the SQM, to get the testing of his project done, but in general PM1 was responsible for planning, scheduling, assigning tasks to the development team and delivering releases on time.

In this case of SMPI the SQM was required to assist PM1, and the rest of the stakeholders were lined up to participate as needed. For example, top management participated mainly in the first meeting, key developers in some meetings, developers and testers for metrics collection and wherever they were required to be the part of the process. The key developers and TLs were to participate throughout the SMPI actively, wherever there was a need for their involvement, such as in preliminary meetings and measurement goal determination. Moreover, the TLs and key developers were considered responsible for the metrics data collection by subordinates or by themselves as required. The SQM was the second main contributor in the conduct of this case. He was involved in most of the stages, especially in activities' design and role assignments for SMPI and finally in the development of the SMF. (The actual process is discussed in more detail below.)

The aim was to develop the SMF rigorously, step by step within the organization, as a planned implementation considering all possible challenges. As discussed above, ABC was following the Agile Kanban methodology, and top management were anxious to create SMPI activities that would comply with this approach. As such, the initially defined SMPI activities were designed to comply with their existing context but also with the intention that it could also work independently of it. For example, meetings schedules were designed as per the existing Kanban schedule, in order to save time and to effectively merge with the Kanban structure. However, the whole process was designed to be flexible enough to merge with other development methodologies or even to work on its own.

The following activities were initially defined to implement a SMP while Case 1 was being conducted. These activities were developed in coordination with PM1 and discussed with the SQM before the preliminary meeting. A sketch of these activities, given below, was produced at the start of the implementation to provide stakeholders with a high-level understanding of how the process would work (with any intended attendees shown in square brackets):

- A1. Preliminary Meeting will be called in order to: [CEO, PM1, SQM, TL]
  - A1.1. Explain the SMP.
  - A1.2. Discuss business and project objectives and desired outcomes.
  - A1.3. Discuss SMPI objectives based on a and b.
  - A1.4. Discuss challenges and obstacles
- A2. Daily meeting to evaluate outcomes of A1. [PM1, SQM, Concerning roles]
- A3. Second Meeting will be called in order to: (after two or three weeks' maximum, depending on the maturity of the results we have at that time and also when the next sprint meeting is) [PM1, SQM, TL, Key Developers]
  - A3.1. Select a method for Goal definition and Metric selection.
  - A3.2. Define or Select goals from the predefined/existing list provided by the researcher.
  - A3.3. Select metrics to satisfy goals.
- A4. Daily meeting to evaluate outcomes of A1 and A3. [PM1, SQM, Concerning roles]
- A5. Collect Data for Selected Metrics. [TL]
- A6. Report metrics data to the corresponding person. [PM1, TL]
- A7. Data analysis. [PM1, SQM, TL]
- A8. Results Sharing.

After finalizing these planned activities, it was time to initiate the actual implementation of the SMP in conjunction with all relevant stakeholders. The forthcoming sections explain in detail how the process was carried out during Case 1 and what were its outcomes.

A1. Preliminary Meeting

According to our initially designed implementation plan, the very first meeting was called. The participants in the meeting were the CEO, three PMs (of different projects), the SQM, the DBA, TLs and key resources (developers and QA engineers) of each team. A few additional staff members were invited to the preliminary meeting compared to the initially defined list of participants. Inviting these additional staff members was suggested by top management. The main purpose of inviting more people was to explain SMPI to them and to get their views on it in the initial stages. As this was the very first time that ABC had sought to implement SMP, the objectives of this meeting were to:

- Show the participants that SMPI is an important process and part of their job.
- Motivate them for successful implementation of SMP (Rifkin & Cox, 1991a).
- Choose the project and the team to conduct SMPI.

In the preliminary meeting, the integration project was finalized as the project of choice based mainly on the availability of the team and the main interest of PM1. In fact, it was pre-planned to work on a project under the leadership of PM1 due to his interest. PM1 was the initiator of SMPI and the leading participant/representative of ABC, and so was motivated to implement SMP. The following steps were performed in the preliminary meeting.

A1.1. Explain the SMP

The first step in the preliminary meeting was intended to make the participants (more) aware of SMP and to answers their questions, such as ‘what are the reasons for implementing SM in ABC?’ Based on his previous investigations of the topic, the researcher introduced the idea of a SMP to the meeting participants. The researcher also had prior knowledge of SMPI obstacles, challenges, benefits and success factors, which were explored in the mapping study (Chapter 4) and the interview study (Chapter 5). In the meeting, a summary of these findings was shared and discussed with the meeting participants.

A1.2. Business objectives

The second step of the preliminary meeting was to discuss the business objectives. It was important to establish that the business objectives remained paramount, but that achieving them could be more effectively accomplished through SMPI. During the discussions about business objectives, it was found that top management were interested in achieving the following:

- Productivity increments, “more work less effort”.
- Increased quality.

A1.3. SMPI Objectives

The third step of the preliminary meeting was intended to set the SMP objectives while seeking to ensure that they complied with the business and project objectives. However, the SMP objectives had in fact been discussed in step one, to some extent, during the initial SMP discussion. Thus, top management seemed more interested in building the measurement implementation and management environment, instead of clearly defining the SMPI objectives. So, the objective at this stage became to discuss the creation of a simple and straightforward measurement implementation and management environment, and this complied with the research objectives. It was decided in this case that there was no need to go into the details of the SM objectives and how they would achieve the business objectives. (In addition, ABC intended to use a pre-listed GQM set on an experimental basis; this is discussed further below.)

A1.4. Challenges and Obstacles Discussion

The next step was to openly discuss potential SMPI-related challenges and obstacles in detail. A list of challenges and obstacles as identified through this research was shared and discussed with participants. This step was undertaken to understand which of the challenges or obstacles would likely pose a concern for ABC regarding SMPI, and to identify any additional challenges that could arise.

All of the challenges and obstacles to SMPI that were anticipated in ABC, either those known from the previous findings of the researcher and those newly identified during this case, are now discussed. It should be noted here, however, that challenges and obstacles may well vary from company to company and project to project.

Lack of Knowledge/Awareness: The first and foremost challenge to the participants was their lack of awareness regarding SMP. The company’s top management was not fully aware the benefits of a SMP, and the lower- and middle-level management had variable but limited exposure to SMPI. Most of the technical staff, such as the developers and testers, were not even aware of software measurement as a management process.

Solution: To address the lack of awareness a brief introduction to SMP for meeting participants was added in the initially-defined activities, and this worked effectively. For instance, the project manager and other senior personnel grew their knowledge and understanding of SMPs through the introduction of SMPI, and the CEO become more confident and passionate regarding its implementation. During a discussion after the preliminary meeting PM1 stated: "*The CEO is more confident and happy to involve on later stages.*" Also, a senior resource remarked later: "*In start I was not much sure how it will contribute in our work but now I can see the outcomes will be accommodating in future.*" SMPI was discussed only in the preliminary meeting, and not with the rest of the stakeholders (primarily developers and testing engineers) who were to participate in later stages of SMPI to collect metrics data. It was realized in later stages, however, that they should have been involved at the time of the SMP discussion during the preliminary meeting; or more likely, an alternative awareness session should have been arranged for such stakeholders who were new to SMPI and were not part of SMP discussion, whichever best suited the organizational culture and structure.

Reluctance to adopt: During implementation, it became evident through observation that stakeholders at all levels were reluctant to engage with SMPI, because of their busy schedule and low awareness levels of SMPI. The awareness issue was somewhat resolved for some at the start of the process, but still, they were constantly concerned about meeting their timelines. Also, as long as other stakeholders were participating in particular stages, they also considered it to be extra trouble in their busy schedule.

***Solution*:** Although the initial discussion made things clearer for some, the limited awareness problem was still there to some extent, as not all stakeholders were part of the preliminary discussions. This fed into a reluctance to engage. Therefore, it was decided to give a brief introduction session to all participants to develop their understanding of SM and to make clear its importance and to explain the implementation process to them, which worked effectively. For instance, whereas the TL initially remained concerned about the impact on their delivery timelines he came to accept that SMPI could be achieved in parallel with product delivery: "*he will make sure to get all work done by his team*". Personnel reluctance was also reduced when the PM and top management started taking an active interest in SMPI and pushed their team for implementation.

Misconceptions: A few misconceptions about SMP were identified in the interview study (Chapter 5), and some of these were found again during the conduct of this case, including:

- SMPs are only for organizations that are large or mature in their processes.
- SMPs must have experts to implement them.
- SMPs are beneficial for large organizations only.

Solution: It was decided between the researcher and PM1 to avoid acting on such whispers and discussions at the time. Such misconceptions could be removed only with the passage of the time and through the successful implementation of SMP, because initial discussions promoting the value of SMP had not been enough to satisfy everyone about such concerns.

Experts Required: The Company had no experts in SMP because it had not been used in practice. PM1 of the selected team had a basic but insufficient understanding of SMPI. Although the SQM and PM had been finalizing deliverables based on testing results, which indicated their use of some measurement-related activities, ABC did not consider it to be SM in any recognised sense. The top management was found to not be interested in hiring, or able to hire, a separate dedicated resource (an expert) for SMP, due to budget limitations. So, in the preliminary meeting the discussion was focused on how to implement SMP successfully when there is no local expert.

Solution: One of the objectives of this study was to develop a SMF that did not require any expert for measurement implementation. So, the main intention was to keep it simple, lightweight and flexible. Flexibility was to come from the fact that companies could use as many or as few of the features of the SMF as they wished, based on their structure and capacity, but still get adequate results from their SMPI. That said, it is important to recall there are some mandatory features of an SMF, as discussed in detail in upcoming sections. So, the solution to this obstacle of the need for 'Experts' was the development of a simple and easy to implement SMF, such as comprising the eight simple preliminary activities that were designed to implement SMP in ABC.

Time consuming: Limited available time has always been an issue for SMEs seeking to institute SM, as discussed by multiple researchers (Diaz-Ley et al., 2008; Wangenheim et al., 2003). In ABC, it was also a major concern, and its severity varied from project to project. Throughout the company, everyone was concerned about time; their main question was "How long will the SMPI process take?" and the immediate suggestion was to "try to keep it simple and short", to save time. The PM and the SQM initially stated that they had critical deadlines, and asked: "Are you sure it would not take that much time or would not be too disturbing for our developers and testers?" In the later stages of SMPI, such as at the time of metrics data collection, the developers and testers were also complaining that they were already overloaded, and asking how they could more easily collect data on assigned metrics. The Team Lead knew their concerns but pushed them to complete their metrics data collection regardless.

***Solution*:** The top management was the main body used to deal with the 'Time' obstacle. For them to do so, however, it was essential that they understood and embraced the importance of SMPI. The preliminary meeting was sufficient to make them realize its importance (as noted above in the changes of attitude of the CEO and senior personnel). The next necessary intervention was to ensure PM1 maintained his conviction to the cause; although PM1 was personally convinced of the value of SMPI, he was also concerned about his timelines for delivery, which he felt should not be affected by SMPI. In addition, the PM and the SQM came to appreciate that SMPI was going to be favourable for both themselves and ABC. The next step was to convince other stakeholders, such as developers and testers, who were also concerned about the associated time commitment in the context of their existing workload. They were motivated by the encouragement of their PM1 and the TLs. They also realized that the programme needs to be implemented as per the desire of top management. This top management interest gave them motivation, and they accepted it as a part of their job. However, this type of push may generate the threat of dishonest metrics data reporting. Warning of such a threat had already been communicated to the managers by the researcher and the advice to avoid it was gently reinforced by them.

Top Management: The meeting with PM1 revealed that his main concern was securing top management agreement to proceed, comparative to that of his team members. He stated that if the top management were convinced, then the company would implement SMP efficiently.

***Solution*:** To convince top management the first step to be taken was the preliminary meeting and the introduction of SMPI. This helped to get their confidence, so they were clear about the purpose of SMPI, and how this case would benefit ABC. During a discussion the PM1 mentioned that he had received an email from the CEO where the request was to: "*Let him know if any other resource required for this case study*". The next step was to keep them posted frequently on the SMPI progress. Keeping top management in the loop during SMPI worked well in maintaining their interest and enthusiasm day by day.

Immature Processes: Although ABC had its own internally defined development processes they were not considered to be mature, according to the initial discussion with PM1. ABC had chosen to use JIRA and had essentially built and maintained their processes through it. They believed they were following Kanban, but they were not particularly satisfied with their way of working at the time the case was being conducted. As is typical of immature processes, there was insufficient knowledge about software measurement. It was observed that this process immaturity was creating problems and confusion indirectly for them in the initial stages of

SMPI. For SMPI, a structured process was designed which then had to be followed, and the documentation generated accordingly.

***Solution*:** Although SMPI does not require a maturity of existing processes, the lack of maturity did negatively affect the perceptions of SMPI early on. It was in the initial plan to conduct SMPI step by step and that during each step, there was enough time given to understand all the detail of the process. So the concern of individuals unfamiliar with their processes, due to their immaturity and lack of documentation, was resolved as the implementation proceeded. The SMF and all its implementation guidelines were developed step by step through the implementation process. It was thus made as easy as possible for participants to understand and implement the process, without having any prior knowledge or experience of mature processes.

Lack of communication: It was evident that ABC lacked communications between different levels of the organisation, which is considered a success factor in SMEs (Eikebrokk & Olsen, 2007). For example, the key developers and TLs did not have direct access to top management, as they were required to report via their PMs. The PMs were supposed to report to top management offshore and onshore. This communication gap between the developers and testers and top management (CEO, CTO, on-shore PMO) could mean that the voice of the developers and testers was neglected, and their point of view rejected. Although ABC had sprint and daily stand-up meetings, the participants did not include top management and on-shore top management (as per the discussion with PM1).

Solution: During the SMPI the need for communication was a core consideration, and so the SMF was developed in a fashion where a developer could deliver his or her point of view to the top management. This was achieved by proposing the participation of relevant stakeholders during particular phases. Furthermore, the weekly and daily meetings in the initially defined SMPI activities seemed to be sufficient to overcome the communication obstacle. It was mentioned in the meetings that participants should ‘pin their ears back’ at each stakeholder suggestion and respect his/her point of view.

Global Software Development (GSD): As noted above, ABC was working on an outsourced project, which meant that they were dealing frequently with international clients and encountering all of the overheads commonly associated with GSD (including communication challenges, time difference impacts, and consequences relating to differences in culture and organization structure). Although during this SMPI these GSD-related issues were not considered specifically, some participants privately expressed their concern about the potentially negative interactions between GSD and the SMPI, in light of both being complex undertakings in their own right.

***Solution*:** Efforts were made to avoid any conflict during the employees' communication with onshore staff, such as in the case of defining meeting schedules and assigning roles and responsibilities for SMPI.

Inertia: It was observed by the researcher, and also was made clear upon discussion with PM1, that employees were used to following existing routines which, comparatively, were not very productive, but the employees were happy with them. Regarding SMPI, there were some effects of such behaviour. For example, employees were comfortable relying on experts' judgments for SM-related activities and were reluctant to shift to more data-driven approaches. More generally they were not in favour of new process adoption because they considered SMPI to be an overhead and that they were doing fine without it.

Solution: There was no instant solution to address this obstacle. As in regard to Misconceptions (noted above) it was realized that this problem could be resolved only through successful implementation of an SMP and its subsequent continuous use. In particular, Results Sharing step at the end of implementation was found to be sufficient for the employees to realize the importance of SMPI when it was being used systematically. So, to get their complete confidence in and agreement with SMPI, the first step was to achieve successful completion of not one but two cases in ABC, and the second step was to institute continuous implementation of SMP in ABC. For the latter it will be necessary to wait and see the results achieved after a couple of years of use.

After going through these obstacles and their proposed solutions in the preliminary meeting and in later stages, the team was encouraged enough about SMPI, but still it was observed that they had some hesitation. As discussed above, a few participants were still concerned about spending time on SMPI due to their other deliverable timelines. This hesitation could be solved only through implementation, so this was carried out as per the plan.

After the preliminary meeting the top management was also more positive about SMPI, which gave enough moral support to the researcher and PM1 during the entire SMPI process. Still, there were some concerns that persisted, as follows: 1) The team was still not totally convinced about participating in SMPI; 2) Though top management at this stage was positive about SMPI, still there was a concern due to the limited resources at the company's disposal, and particularly time; 3) PM1 and the SQM were concerned about their meeting their deliverable obligations. However, at this stage there was sufficient encouragement and interest that, collectively, the staff agreed to at least give it a try. Where possible, staff-related concerns were addressed on a priority basis, as per the Challenges and Obstacles discussion just above.

At this stage there was no need to select a project because it was pre-planned before the meeting that the measurement program would be applied to the project of PM1. The characteristics of the selected project were as follows:

Table 7.2 Project 1 Characteristics

Artefacts	Description
Project type	Third party tools integration with web based solution
Team size	PM1, TL, 13 developers, three testers and supporting resources SQM, DBA.
Programming language	Java, JEE
Environment	Eclipse, My Eclipse
Team members experience	3 – 11 years
Management tools	JIRA, SVN
Iterations	Three sprints
Iteration length	Three weeks

A2. Daily Meetings

The ABC Kanban meetings schedule was followed, so the SMPI daily meetings were synchronised with the ABC daily stand-up meetings; that is, SMP-related tasks were addressed in an additional discussion at the end of each meeting. During these meetings, the SMPI discussions related to the team’s daily tasks with the relevant individual(s) involved at each stage. Involving developers and testers in these frequent meetings helped to resolve their mistrust and give them more understanding about the process. Still, some minor issues arose, such as concern over the meeting process seeming to be so lengthy and time-consuming. From prior research it was understood that such remarks could be made particularly in the early stages, and a similar kind of response was expected from the staff in this case. The PM1sought to reassure and remind the team of the value that could be expected once SM was in place.

A3. Second Meeting

The second meeting was called three weeks after the preliminary meeting. In fact, the second meeting was intentionally synchronised with a scheduled Sprint meeting in ABC of Team A. That is to say, after completing the routine tasks of the sprint meeting, tasks related to the SMPI case were discussed. At this stage, only SM-related stakeholders stayed, the rest of the participants left, and the researcher joined the meeting. The following milestones were achieved in this meeting as per the plan.

A3.1. Method Selection

The first step of the second meeting was to select a suitable method to determine measurement goals and metrics. As mentioned above, ABC's top management had agreed to conduct the case on an experimental/test basis. So, taking advantage of this decision and avoiding any frustration or exasperation for the company participants, at the time of introducing the new process in ABC this step was avoided. Instead, the researcher shared a few samples of predefined Goals, Questions and Metrics (GQMs) with participants. One point to note, just to avoid any confusion about GQMs, it was not the GQM method of (Basili, 1992) itself that was presented, but only a predefined set of Goals, Questions and Metrics (GQMs) that ABC might have liked to consider, as shown in Appendix 7.1.

A3.2. Goal Definition and Metrics Selection

The second step was defining formal measurement goals (normally based on the step 1 results). This was potentially another difficult step given the potential for particular agendas to emerge, so it was recommended that all stakeholders in the process should participate if at all possible. If they were not involved at this stage, there is a higher likelihood that they would lose interest and commitment, which is a risk factor for successful SMPI. In the later stages of the process, the uninvolved stakeholder will not be clear about the goals and their application.

In this case, a predefined set of GQMs (see Figure 7-2) was in fact selected after discussion the with all participants in attendance, so the planned task of step 2 was accomplished in step 1 and did not require any further work. The final objective of this meeting was to assign the selected metrics to relevant resources (Team Leads, developers, testers and so on) for data collection. This task was performed by PM1 with the coordination of TL and SQM.

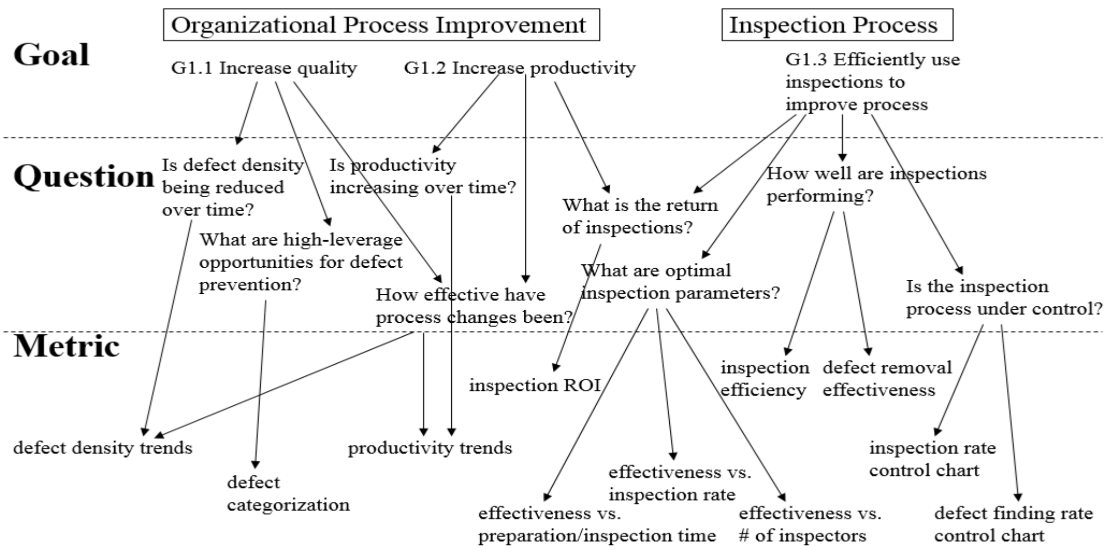

Figure 7-2 Selected Goals, Questions and Metrics for Case 1 (Lingard, 2012)

A4. Daily Meetings

The subsequent daily meetings were conducted in the same fashion as those that occurred after the preliminary meeting. These were again routine Kanban stand-up meetings but with SMPI meetings held with them, so as not to further overburden the team. In these meetings sometimes developers and testers would make suggestions about what might be interesting to measure. The major objectives of these meetings were to give participants more understanding about the selected GQMs and to help the assignees in metrics data collection whenever they hit a barrier. In the daily meeting assignees were mainly given guidance about how to collect their assigned metrics data accurately and efficiently.

A5 & 6. Metrics Collection and Reporting

The metrics data came to be routinely collected and reported by assignees to their TL and PM1. As per ABC's data privacy policy, in this particular phase of data collection and reporting the researcher was not involved. As a result, only a summary of the data collection process and its outcomes was shared with the researcher, in the form of effort and defect data collected and stored in the JIRA DB. Moreover, the ratio of time spent on each task and defect was recorded and compared to assess whether they were achieving their objective of increased productivity.

A7. Data Analysis

Although this particular case was experimentally-based, it used actual data. The specific results were not revealed to the researcher, and in fact the plan was not adhered to as the SMPI stakeholders were not consulted in terms of the accuracy of the results. The PM1, SQM and TL discussed and analyse the results.

A8. Results Sharing

In this case PM1 decided not to share the analysis reports with all of the SMPI stakeholders at this stage. The reason he gave to the researcher was that the process was still under development and so the results were not mature enough to share. Upon the researcher suggesting to PM1 that results sharing can in fact motivate stakeholders to engage in future implementations and give them a greater understanding of and appreciation for SMPI, regarding its real application and benefits, the PM1 stated that the results of the planned second case would be discussed and presented to all stakeholders.

As a result the analysis was in this case performed by PM1, the SQM, and the TL and the results were discussed with and presented to the CEO and to the on-shore PMs. They were not shared with the entire implementation team, or the researcher.

7.3.1.1. Case 1 Outcomes

Case 1 took place over a period of two months and 17 days. Additionally 10 working days were spent to evaluate the case 1 results. A first version of a SMF was developed by the researcher largely following a set of preliminarily defined activities of SMPI. Instead of developing a comprehensive SMF, emphasis was placed on keeping it simple, of an appropriate scale and lightweight, to achieve in parallel the objectives of this research and those of ABC. The initial intent was to follow the defined activities to implement the process, but during the implementation a few changes were made (as described above), such as the (non-)involvement of different participants in key stages.

During ongoing discussions with the key stakeholder during SMPI, and then after the case's completion with both PM1 and the SQM, it was made clear that, during the initial stages of the implementation, neither the TL nor the developers were convinced about the benefits of SMPI, due to their limited awareness of SM and their concern over time constraints. Initially the developers expressed concern about additional workload, and this was mainly addressed by the TL. They realized that to minimise the workload the organization should automate the process as much as possible. During the SMPI, the developers and testers were concerned about the time required for metrics data collection, but they realised that this could be reduced by using existing metrics calculation tools or by developing their own as per requirements. They in fact came to appreciate that through measurement they could actually gain far more clarity on issues of workload, time commitment and cost-benefit of various processes.

ABC was following Kanban, and so it was necessary that a balance be found between their existing development processes and any newly designed and documented procedures for organizational advancement. So the initial activities of SMPI were defined accordingly, wherein measurement-focused meetings were synchronised with Kanban meetings to avoid interruptions or an additional burden, and the company's existing JIRA DB was linked with measurement activities, wherever it was required.

Overall, Case 1 was managed effectively due in large part to the personal interest and drive of PM1, and with the positive support and influence of top management. After completing the implementation of the initially defined eight activities (to a greater or lesser extent than planned), the researcher compiled the case results and scheduled a meeting with PM1 and the SQM. The purpose of this meeting was mainly to validate the compiled results and to sketch out a measurement framework based on the results. In this meeting, the researcher discussed the whole process of SMPI step by step for validation. In addition, task checklists, details of roles and responsibilities, and SMPI meeting schedules were generated and evaluated, based on the case results. Thus, the first version of the proposed framework, SMF 1, as derived from the outcomes of Case 1, is shown in Figure 7-3.

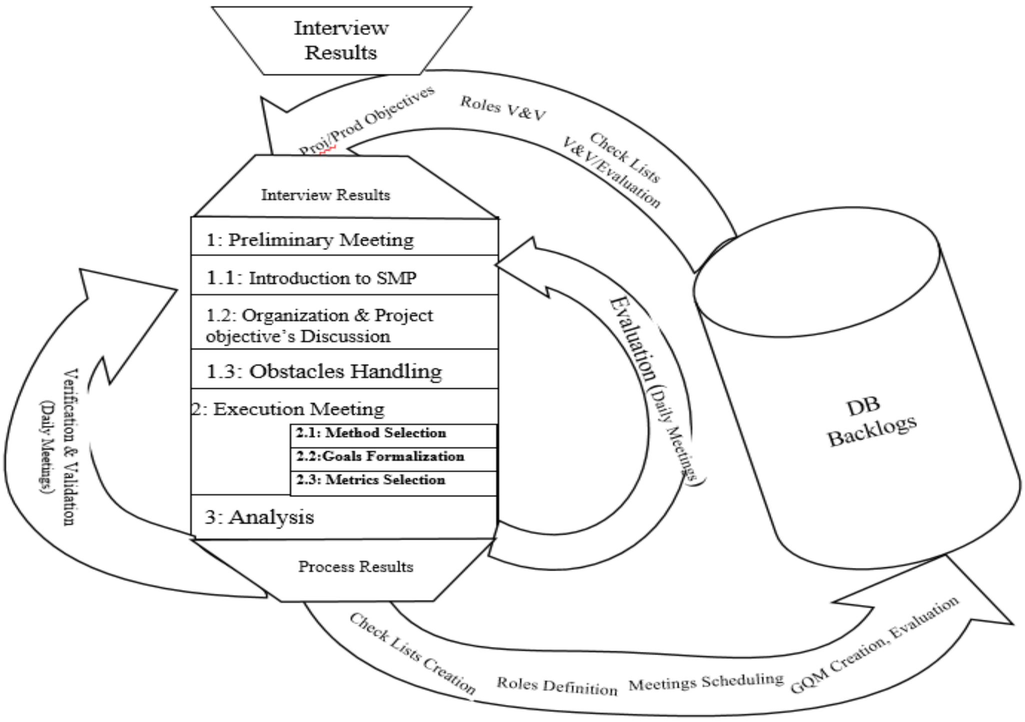

Figure 7-3 Initially Developed SMF 1

The Figure 7-3 is the final outcome of case 1 where interviews' results were input to base the framework. Also the identified challenges from interviews were used as input. The SMF 1 contains three major steps; first is preliminary meeting to kick-off SMPI, second step is execution meeting which is core of SMPI and the third is to analyse collected metrics data and generate report for sharing with all stake holders. The daily meetings help to evaluate and validate the current step and the preceding steps. Further the DB will be used to store data and processes which could be used in future.

7.3.2. Design and Implementation of Case 2

Case 2 was conducted in the same company ABC, to refine and validate the newly developed SMF1. At this stage, SMF1 was in mature infographic shape, and some of the stakeholders were familiar with the process. Moreover, the additional initially defined checklists, details of the proposed roles to perform each activity and an evaluated meeting schedule, all developed by the researcher for or during Case 1, were now in hand. As a result, it was expected that this second case would take less time to implement than did Case 1.

These initially defined activities and artefacts for SMF1 were further used, evaluated and refined in Case 2. The following activities were finalized for this case:

A1. ***How to measure***? Preliminary meeting in order to: [CEO, PM1, onshore PM, co-PM, SQM, TL, SA]
   a. Select SMPI objectives.
   b. Set Organization and SM objectives.
   c. Undertake Project selection.
   d. Address Challenges and Obstacles. Uses Checklist, DB.

A2. Brief introduction of SMPI and SMF1 to the team of the selected project.

A3. Daily meetings synced to stand-up meetings, to evaluate data of step A1. [co-PM, TL, SQM, any other concerned role]

A4. ***What to measure***? Execution Meeting in order to: [onshore PM, co-PM, PM1, SQM, TL, Key Developers]
   a. Give feedback on step one results.
   b. Select measurement goals. Uses Checklist.
   c. Choose corresponding metrics. Uses Checklist.
   d. Assign responsibilities for metrics data collection.

A5. Daily meetings synched to stand-up meetings, to discuss metrics data collection, if any assistance required. [co-PM, TL, SQM, concerning roles].

A6. Metrics data reporting. [co-PM, TL]

A7. Metrics data analysis. [co-PM, TL]

A8. ***What's Outcome?*** Results sharing meeting [All stakeholders of SMPI]
   a. Reports, graphs and results discussion.

Note that although roles to perform each activity were defined during the design of Case 1 they were refined at the end of that case to be more suited to general SMPI, rather than aligned to case 1 or 2. So for Case 2, the above labelled roles against each activity were slightly changed by PM1 with input from the SQM and the co-PM, in recognition that roles could vary as per organization and team structure. For instance, the selected team in Case 2 was working under the supervision of an onshore PM, but there was also an offshore co-PM. The roles to perform activities should thus be finalized based on timeframe, relevance expertise and workload.

7.3.2.1. A1. *How to measure?* Preliminary Meeting

The first activity A1 was a preliminary meeting, to discuss how the measurement program would be carried out. The core participants were the CEO, PM1, on-shore PM, co-PM SQM, SA, DBA, two TLs and a key developer. That is, senior personnel who had been involved Case 1 were invited, to inform any refinements to the process. So the meeting involved PM1 and SQM from Case 1 while the rest of the participants were new. The onshore PM was managing the selected module, with the assistance of the co-PM, and was the main stakeholder of the project. The onshore PM was able to explain the aims and objectives of the project.

The first step of activity A1 was to explain the objectives of SMPI to all the participants, which was in this case done by PM1. Additionally, PM1 gave a brief introduction regarding SMF1 to the gathered participants. The second step was to discuss the project's aims and objectives, which were clarified by a discussion between the onshore PM and the CEO. The third step was the project selection for SMPI, and this time the admin module of the project was selected. The team working on this module consisted of 19 developers, two TLs, one co-PM, one onshore PM and five testers assigned from the testing department. These testers were working under the same SQM as in the previous case, under the same management scenario. The fourth step involved the addressing of the challenges and obstacles. Many of the organizational challenges and obstacles had been dealt with during the Case 1 implementation, so the major challenge for Case 2 was to grow the awareness of the new team about the process. A presentation was prepared for this purpose.

Table 7.3 Project 2 Characteristics

Artefacts	Description
Project Type	Web-based Solution
Team size	One onshore PM, one co-PM, 2 TLs, 19 Developers, five testers and supporting resource PM1, SQM, DBA, SA
Programming language	Java, JEE
Environment	Eclipse, My Eclipse
Team Members Experience	1 – 10 years
Management Tool	JIRA, SVN
Iterations	3 sprints
Iteration length	3 weeks

7.3.2.2. A2. SMPI Presentation

The next activity A2 was designed to increase awareness of SMPI among the team of the selected module. One of the lessons learned during the Case 1 implementation was that either all SMPI stakeholders should be included in A1 Preliminary meeting, or if not, provide all those new to SM with a presentation regarding the SMPI process. In the current scenario, it was not feasible to include all stakeholders in A1, including the developers and testers. So a presentation was prepared and given to them by the co-PM, after the Preliminary meeting. This presentation described SMPI using SMF1 and its objectives.

7.3.2.3. A3. Daily Meetings

Having given at least a basic understanding of SMPI to all stakeholders via first two activities (A1 and A2), the third activity A3 was designed to confirm decisions made during A1 and to evaluate A1 outcomes. In step A3, daily meetings were conducted in the same fashion as in Case 1, synchronised with ABC's stand-up meetings. In this case, however, the actual added time in each meeting was much reduced, due to the generally increased awareness of ABC personnel compared to in Case 1 as well as to the existence of checklists, TODO lists and role definitions. The newcomers were thus more concerned to know about the advantages of SMP implementation, rather than details of its process. They were therefore more focused on discussing the organization's aims and objectives and relating them to the SMPI objectives. Relevant challenges and obstacles were being resolved by discussion each day, as awareness and understanding increased among the team.

7.3.2.4. A4. *What to measure?* Execution Meeting

After confirming 'How to measure?' the next major task was to investigate and determine 'What to measure'? This was the focus of the fourth activity A4, the Execution meeting, which was held two weeks after the preliminary meeting and was synchronised with ABC's regular sprint meeting. Again the researcher did not participate in the first half of the meeting as this was a purely routine Sprint review meeting with its own objectives. After the first half of the meeting had been completed, the second half was held where the researcher was invited along with other relevant participants. In that same part of the meeting other employees left, as they were not directly concerned with the project or the SMPI case.

The main objective of A4 was to define and/or select the specific measurement goals of interest and their corresponding metrics. Once again a set of pre-defined GQMs were selected from those samples provided (by the researcher), as shown in Figure 7-4.

Another objective of A4 was to allocate responsibility for the selected metrics to relevant individual(s). Based on Case 1 experience, it was realized that each responsibility should be allocated to one concerned person only: if it is related to development, then assign responsibility to a Team Lead, otherwise assign responsibility to the SQM if it is related to testing. The TL and SQM had a clear idea of their team members' availability with respect to workload and time, as well as their capabilities and suitability to collect the data for particular metrics. So in this case, both TL and SQM were advised to discuss and distribute metrics collection responsibilities among suitable team members.

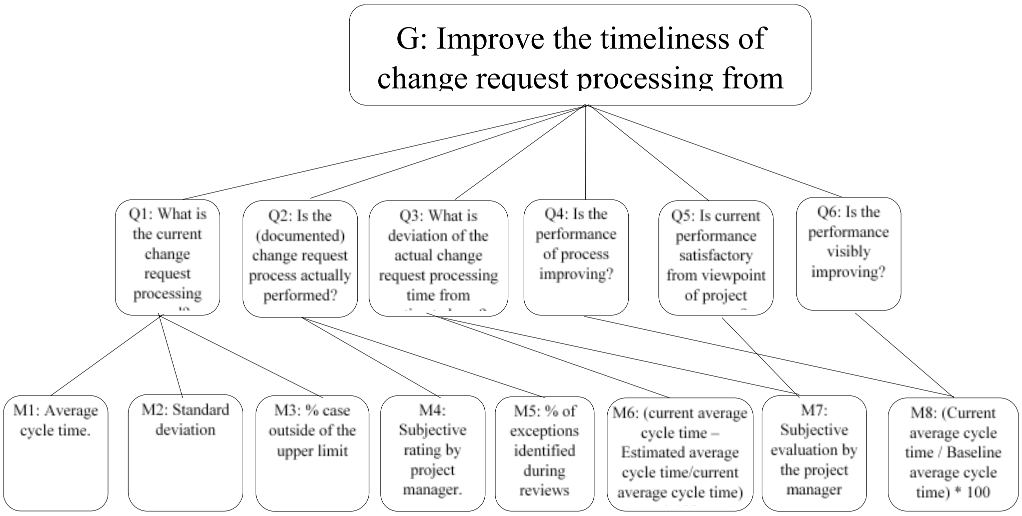

Figure 7-4 Case 2 GQMs (Van Solingen, Basili, Caldiera, & Rombach, 2002)

7.3.2.5. A5. Daily Meetings

The next activity A5 was the ongoing sequence of daily meetings, which again were synchronised with the regular ABC stand-up meetings. The objectives of A5 were confirm and give continued prominence to the selected set of goals and metrics to the team members, particularly those who were to collect these metrics data. Assistance to those individuals would also be provided as needed. In comparison to the Case 1 daily meetings, these Case 2 meetings were also used to refine the defined checklists, TODO lists and the roles as assigned to perform particular activities. The only problem that arose during A5 was uncertainty regarding how to collect some metrics data, and this was resolved through discussion among the team.

7.3.2.6. A6. Metrics Data Collection and Reporting

The next activity A6 was intended to gather the metrics data from assignees, where each assignee was to report the metrics results to his/her TL. TLs would then process the metrics results, generating the reports and sending these to the co-PM for the next activity, A7 Data analysis. In Case 1 it was observed that some of the assignees reported their metrics data directly to the PM1 and some to the TL, which was unworkable for the PM1 at that time. It was therefore decided that the approach should be more systematic, such that all metrics data would be reported to the corresponding TL, and then the TL would report the results to the co-PM. A6 was in fact performed in parallel to A5 – as individuals collected and reported data they would also convey any problems to their team and TL for consideration and support.

7.3.2.7. A7. Metrics Data Analysis

The next activity A7 was focused on the analysis of the metrics data. Data analysis was performed by the co-PM and two TLs, with guidance and assistance from the SQM and PM1. Again, at this stage the researcher was not permitted to participate due to company data privacy policy. Instead, topics for discussion with the researcher regarding A7 concerned checkpoints for analysis and information about the roles who could better perform the analysis. While this omission was not preferred, the researcher's non-involvement in data analysis does not affect the study's results because the aim of the study was to implement a sustainable SMP via a lightweight solution, irrespective of the metrics data analysis outcomes.

7.3.2.8. A8. *What's Outcome?* Results Sharing Meeting

The last activity A8 of Case 2 was designed to share the findings of SMPI with all stakeholders, including the onshore stakeholders of this particular project module. This activity was seen to be important in terms of securing the confidence of the stakeholders for future implementations having understood the benefits of SMPI.

A formal presentation of the results was prepared and given to all invited stakeholders. Cross-questioning was welcomed, and, according to the PM1, discussion both clarified the results and made the achievement of the SMPI and business objectives more transparent. As per organisational policy, the researcher was not part of this activity.

7.3.2.9. Case 2 Outcomes

As in Case 1, in this second case what was planned and what occurred in terms of who was involved in the various activities varied slightly. Sometimes more participants were added and sometimes the numbers were reduced, due to availability and or suitability to perform each activity. Case 2 lasted for 1 month and 20 days. The time spent in the SMPI process in Case 2 was comparatively less than that spent in Case 1, because of the familiarity of some participants (such as the leading roles PM1 and SQM) with the process activities and the use of the pre-prepared checklists of SMF1. This second case in fact contributed to the evaluation and validation of the activities, checklists, and role assignments of SMF1 (and this is further discussed in detail in the Findings and Recommendations section). In this second case in ABC the challenges and obstacles were not noted explicitly, because most had been resolved in the conduct of Case 1. Overall Case 2 served a particularly valuable purpose in terms of informing the refinement and improvement of the SMF in ABC.

7.3.3. Design and Implementation of Case 3

Case 3 was conducted in a recently established, small software development company, XYZ. Comparatively speaking, small companies typically require more support as they tend to have even more limited expertise, process maturity, and spare time and resources, so it was important to define a simple set of activities to begin with. As noted above, Case 2 and 3 were conducted in parallel, in two different companies ABC and XYZ respectively. As in Case 2, for this case the basic framework SMF1 was available. As such, the initially planned activities to be conducted in Case 3 were derived from SMF1, by the researcher in conjunction with the PM (who was also the CEO of XYZ Company).

A1. Brief introduction of SMPI and SMF1 to all stakeholders.

A2. ***How to Measure***? Preliminary meeting and Measurement Plan meeting [PM, TL, Key developer(s)]

  a. Discuss Organization and Project objectives. Uses DB.
  b. Explore and Address Challenges and Obstacles. Uses Checklist, DB.

A3. Daily meetings to evaluate A2 findings. Uses DB. [PM, TL, Concerning roles]**.**

A4. ***What to measure***? Execution Meeting in order to: [PM, TL or Key developer(s)]

  a. Select measurement goals and metrics. Uses Checklist.
  b. Assign responsibilities for metrics data collection.

A5. Daily meetings to discuss issues in understanding or collecting data on assigned metrics and get their feedback. Uses DB. [PM, TL, Concerning roles].

A6. Gather Metrics results. Uses DB.

A7. Metrics data analysis. Uses DB. [PM, TL, Concerning roles]

A8. ***What's Outcome?*** Results sharing meeting. [All stakeholders].

The intention at the time of designing these activities was to develop a second version of SMF1, but one which would address the particular needs of small organizations and potentially draws a line between small and medium companies. So these activities were directed towards the development of SMF2.The ultimate goal was to provide a single, lightweight solution for SMEs. The following sections explain how the process was carried out at Case 3.

7.3.3.1. A1. SMPI presentation

After discussing and finalizing the SMF2 activities with the PM, the actual work in SMPI took place. The first activity A1 was intended to create greater awareness about SMPI in all project stakeholders. A presentation was prepared on SM programs in general and on the planned SMF2 activities in particular and this was delivered to all company employees, to give them a first level of understanding of the fundamentals of software measurement and its importance. All employees were invited and encouraged to attend this awareness session by the PM, irrespective of whether or not they were going to be involved in Case 3. This presentation had a positive impact on the SMPI stakeholders, in that a majority understood the basics of the process and its importance. Some of them were convinced of the value of implementation, but the majority was still reluctant due to a range of factors (as discussed in upcoming sections).

7.3.3.2. A2. *How to Measure?* Preliminary meeting

After presenting the SMP and SMF2, the next activity was a meeting to discuss organizational and SMP project objectives, and to proactively identify and mitigate SMPI-related challenges and obstacles. A meeting was scheduled and then called as per the plan, where the participants were the PM, TL, two key developers and senior testing resources. The organization's aims and objectives were discussed at the start and then the researcher revisited the challenges and obstacles encountered in Case 1. The expected challenges and obstacles and their possible solutions in this case were then discussed, and are considered in upcoming sections. In this meeting, it was confirmed that SMP should be implemented with the team working on the admin panel of the project. The selected project properties are as shown in Table 7.4:

Table 7.4 Project 3 Characteristics

Project Type	Desktop and Web-based Solution
Team size	1 PM (CEO), 1 TL, 1 Front end developers, 1 Testing Engineers, 4 Developers
Programming language	VB.Net for Desktop and JEE for The Web-based Solution
Environment	Visual Studio, MyEclipse
Team Members Experience	1 – 10 years
Management Tool	JIRA, VSS
Iterations	1 sprints
Iteration length	2/3 weeks

In regard to challenges and obstacles some issues were resolved on the spot and did not require more intensive discussion or intervention. One of note was developers' resistance to accepting change, and the major source of resolution of this obstacle was PM influence. As noted above the PM was also the company's CEO, and as he was interested in SMPI, so the first obstacle of resistance from developers to the change was mitigated to some extent. It was also further mitigated through the initial presentation of SMPI and SMF2. While this may not have convinced all involved of the value of SMPI, it certainly initiated their thinking about measurement implementation. Other challenges and obstacles were identified during Case 3, as follows.

Lack of awareness: A lack of awareness (and consequently understanding and appreciation) was the major concern of XYZ Company comparative to ABC. In ABC, some of those involved, such as PM1 and SQM at least, had some knowledge about measurement processes. In XYZ, the PM did not have much knowledge about SMPI and his team did not know about it at all.

Solution: Having conducted Case 1 in ABC it was realized that a brief presentation and discussion about SMPI and SMF could resolve such a challenge to some extent. As a result, a presentation about SMP and SMF2 was given to all stakeholders, which provided them with a basic understanding before the actual implementation began. In later stages a TL expressed "*I was totally demented when I was asked first time to participate in SMPI project. The reason was that I don't have any idea about this process and I was already struggling with my deadlines. But presentation upon SMPI give me enough understanding and confidence to precede on.*"

Multiple roles: The other major challenge in XYZ was that the leading people were playing multiple roles. As noted, the PM was CEO as well. The TL was sometimes acting as both PM and analyst. The developers sometimes were playing tester roles as well – although this is not so unusual in agile cross-functional teams. Still, in such a situation they were afraid of having to assume another responsibility that they expected would inevitably increase their workload. In particular, the TL was concerned about his workload and that of his team and he was quite vocal about overloading.

Solution: This challenge was mitigated based on the initially defined activities and allocating corresponding roles to perform them. Careful role assignment for each activity helped to distribute work among all stakeholders according to their availability and suitability, so the burden was distributed intelligently, to avoid any clashes or complaints. Ensuring that the PM has sufficient authority to make such allocations can play a vital role in small organizations in terms of getting work done efficiently and effectively.

Time and budget limitations: Spending time and budget on processes could be a major concern of any small company, especially when they perceive it to be principally cosmetic, believing that they are performing better without it. This phenomenon was evident in XYZ. During the initial stage of the SMP initiative and before beginning the actual implementation, a discussion between the researcher and the PM revealed his concern about resource limitations in terms of time and budget, when considering SMPI. The company was developing their product within a defined budget and was planning to launch within a specific time frame. They were thus understandably concerned about the time and budget implications of SMPI.

Solution: Any implementation of a new additional initiative will require resources. While this challenge cannot be avoided its effect can be reduced to a minimum. To tackle this challenge in XYZ the first step was to raise awareness about the process. Ensuring that personnel understand the value proposition for SMPI can lead to better acceptance. Awareness can be raised through a presentation session, such as in A1. Second, it was emphasised to the stakeholders that they are actually supposed to spend some time to achieve the benefits – reflecting the notion that 'what you get out is related to what you put in'. Moreover, the already developed SMF2 activities would also save stakeholders' time and effort – the availability and simplicity of the checklists and other artefacts were seen as a particularly positive aspect of the proposed implementation by the relevant stakeholders at XYZ.

Resource limitations: As mentioned, XYZ was a recently established company and so was working with limited resources in all aspects. Their concern was that they did not have sufficient human resource for their current product development, let alone to dedicate to the SMPI process.

Solution: To mitigate the human resource limitation challenge in XYZ, as well as in general for SMPI in SMEs, the design phase of SMF and the assignment of roles for each activity were carefully considered. Activities were designed to be simple and short, so that in principle SMP could be implemented with existing resources. Comparative to SMF1, the intent was to develop SMF2 as PM-centric. As a result, minimal resources were required in Case 3 – by design the PM was to carry out the whole process and his involvement in each activity was a must. The involvement of roles was proposed as optional. Moreover, by defining roles to perform each activity and having predefined material, such as checklists and GQMs, overall the implementation hours required of SMPI stakeholders was kept to a minimum.

Reluctance to adopt: At the outset it was observed that all of the stakeholders at XYZ were reluctant to implement SMP except the PM1. Later, even when senior personnel (such as TL and many senior developers) had also agreed to trial the approach, several developers and testing engineers were found to still be reluctant regarding their proposed participation in the implementation, due to a combination of their lack of awareness and their concerns about it having a negative impact on their ability to meet deadlines. Moreover, as per discussion with some developers, their indirect response was that SMP was a cosmetic requirement, and they were doing very well even without it.

Solution: To overcome this challenge, initial steps were already taken in the shape of A1 and A2. The SMP presentation was effective in convincing them to an initial extent, based on expected added value, and further most became more convinced through daily meeting discussions. Step-by-step implementation was thus very important to convince them completely, and the more important thing was to involve them at each stage to give them maximum understanding. So the challenge of reluctance was dealt with by the implementation itself to some extent, but also through the sharing of results.

Learning curve: The perceived learning curve was another concern of the PM and the TL. They shared an example of this potential obstacle with the researcher, stating that at the time of the company starting up they sought to follow some quality improvement processes, but this was abandoned due to the associated learning curve. Moreover, during the discussions about process improvement, the PM expressed a related frustration in stating that, “Small companies are nurseries for large companies, where developers learn and move to large companies. So they cannot afford to teach all the time newcomers”. This suggests that they were highly concerned to have a solution that required minimal time to learn.

Solution: To mitigate this obstacle the pre-defined activities for SMF2 were presented to the participants so that they could gain an initial understanding of their ease of the use and their potential usefulness. All of the activities of SMF2 were designed to be self-explanatory and were complemented by the implementation guidelines from SMF1, such as the role descriptions and the checklists. The participants were informed that they would be required to follow the instructions only, without the need to spend too much time on each activity. The presentation and discussion of SMF2 in A1 and A2 respectively mitigated this obstacle. It was observed that the team became more convinced of the value of SMPI after the A1 and A2 activities. Casual discussions during and at the end of the implementation indicated their significant concern over the learning curve had largely disappeared.

Experts required: The experts required obstacle was raised during activity A4, the Execution Meeting. Company representatives mentioned their perceived importance of the need to have an expert to support their measurement goals determination and to link them with organizational goals. Furthermore, it was highlighted that XYZ did not at that time have any SMPI experts, and that they could not afford to employ such a person.

Solution: These concerns were legitimate, but were perhaps over-estimated, in that the initially designed SMF2 activities were intended to be easy to manage, thus requiring limited specialist expertise. The specific point raised at XYZ, being the requirement for an expert to support

GQM determination, could be addressed by their use of the pre-listed GQMs (as per Case 1). XYZ was specifically encouraged to use these commonly used GQMs in the initial stages of their SMPI, although such metrics and GQMs could change with the passage of time. Furthermore, it was reiterated that SMF2 had been designed to be deployed and managed by an existing qualified PM, rather than requiring additional specialist expertise.

Workload: Workload concerns were expressed, though this was understood as a consequence of XYZ's work commitments, timelines and limited resources. The TL was not ready to own another process initially, specifically that which would require metrics data collection by his team members. He was complaining that they were already running out of time to produce their functional deliverables, and any new process would inevitably increase their workload.

Solution: As discussed above, keeping the SMF2 simple and clear, and providing pre-developed implementation material, such as GQMs, checklists, and defined roles, were intended to address this concern.

Poor communication: Another problem identified in XYZ was a lack of communication between the PM and team members, an uncommon problem in small start-ups. The reason could have been the additional layer provided by the TL: each team member was supposed to report the TL, and the TL was their representative to PM. Regarding SMPI it was necessary to seek the opinion of all participants, including junior developers and testers, as they were working closely on development work and so knew more about the realities of that development and the data associated with it. As such they could provide informed suggestions, such as which metrics data could achieve particular goals most effectively.

Solution: To overcome communication issues the SMF2 includes fortnightly and daily meetings which should address this potential deficiency with the passage of time.

7.3.3.3. A3. Daily Meetings

After completing the preliminary meeting the next planned activity was to follow this with daily meetings. These meetings were conducted in the same fashion and for the same purpose as in Company ABC, such as to confirm decisions and evaluate the results of the preliminary meeting. Here, the only difference was that the Company XYZ was not conducting meetings on a daily basis, but on average three to four meetings in a week. Although SMF2 encouraged daily meetings, XYZ stakeholders were not available on a daily basis for SMPI, due to the organizational meeting structure and their development and delivery commitments. Even so, this 'deficiency' was ignored because the process was running smoothly.

7.3.3.4. A4. *What to Measure?* Execution Meeting

One week after the preliminary meeting, when the results of A1 had stabilised, in that the participants had sufficiently discussed the SMPI aims and objectives and the initially identified challenges and obstacles had been resolved, the execution meeting was conducted. The execution meeting was synchronised to occur with Company XYZ's scheduled meeting in which the main objectives were to select the goals and metrics from the pre-listed GQMs. Allocation of responsibility for the selected metrics to relevant individuals was an additional objective of this meeting.

Ross & Haddad (2010) recommended that small organization should implement 'sweeping' metrics. In this case, pre-listed GQMs sets were shared and discussed to enable XYZ to choose a basic but appropriate set of GQMs. As noted XYZ was quite a new company working on a new product, so the CEO was more interested in quality measurement. As a result, one of the pre-listed GQM sets was selected – that for testing, as shown in Figure 7-5. After finalizing the GQM set selection, the PM worked with the TL to assign the selected metrics to relevant individuals.

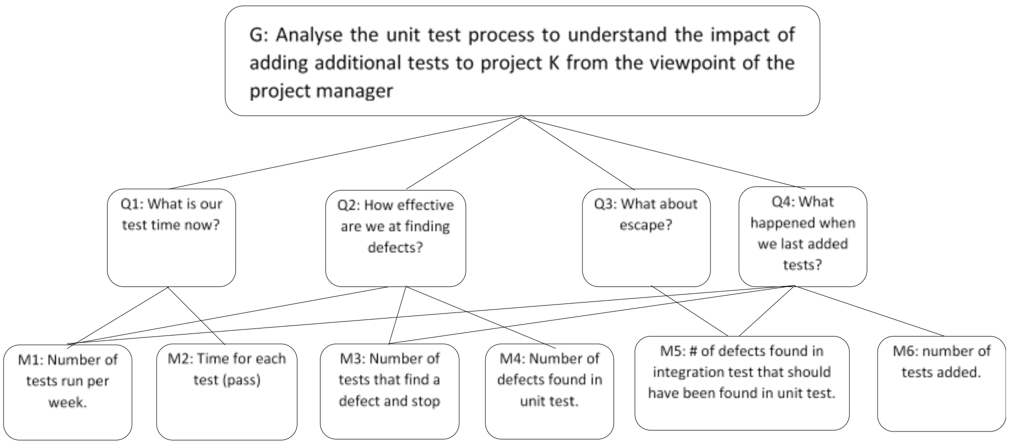

Figure 7-5 Case 3 GQM (Dow, 2007)

7.3.3.5. A5. Daily Meetings

Post-A4 daily meetings were conducted in the same fashion as in A3, i.e., typically in three to four meetings a week, to evaluate the execution meeting findings. The objective of these daily meetings was to increase understanding of the selected GQM set among the SMPI stakeholders who were not part of A4 but who were supposed to collect the metrics data. Unlike in ABC, we observed in XYZ's daily meetings that the individuals did not have sufficient knowledge of metrics data collection. The related issues were discussed and resolved in these meetings.

7.3.3.6. A6. Metrics Data Collection and Reporting

The next activity A6 was gathering metrics data from the assignees, under the direct supervision of TL. Comparatively, in ABC most developers had already been collecting data independently. The TL involvement in XYZ was therefore important because it was the first time such data had been collected and many of the junior developers were not clear on how this could or should be done. The TL was also organizing (though not analysing (A7)) results in parallel to save time in results processing to follow. Another senior individual pointed out that a key developer of the team was also assisting TL and performing the same job, collecting metrics with other junior individuals. In the end, TL compiled the collected data with the help of the key developer and submitted it to the PM for the next activity A7. 0

7.3.3.7. A7. Metrics Data Analysis

The next activity (A7) was the analysis of the collected metrics data. The main participants who conducted the analysis were the PM and the TL. The researcher was not part of this activity due to company rules regarding data privacy. The combination of TL and PM was found to be ideal in performing A7.

7.3.3.8. A8. *What's Outcome?* Results Sharing Meeting

The final activity A8 was held in order to ensure the analysis results were shared with all stakeholders. Results and analyses were generally presented in the form of graphs. In XYZ the TL was responsible for presenting the results to participants because he was involved in A6 and A7 and so had a good degree of understanding of the results.

As with the medium-sized ABC Company, in XYZ the researcher was not allowed to participate in the results sharing meeting. After the meeting, however, a discussion session was held involving the researcher, PM, and TL in order to review the SMPI overall and to enable the researcher to obtain feedback on the program's efficacy. This session was very worthwhile, the feedback was constructive, and more extensive than the researcher expected. All aspects of SMPI and SMF2 were considered, and the previously designed activities, checklists and role responsibilities were evaluated. The following section discusses the core findings of Case 3.

7.3.3.9. Case 3 Outcomes

Due to the very limited resources of XYZ it was of the highest priority that no extra resources should be consumed for SMPI via SMF2. This was one of the key reasons that SMF2 was refined to be PM-centric, wherein PM should take primary responsibility for SMPI. In fact, in both companies it was evident that either PM or TL is ideally suited to drive SM and should take responsibility for SMPI and its success. Furthermore, to quickly achieve an acceptable foundation for SMPI (especially in a small-scale organisation) a set of predefined goals and corresponding metrics should be provided.

Unsurprisingly it was also confirmed that the ideal candidate for presenting results was the individual who conducted the analysis, given their advanced level of understanding. In this case the TL performed this task, corresponding to their extensive involvement in A6 and A7. The PM mentioned in later discussions that the results sharing through the TL was effective, giving more confidence to the team and also clarifying for him the SMPI objectives. Evidence further suggests that the discussion and Q&A sessions could be very fruitful for the company. It built the trust of the team especially in terms of reporting correct data. It also helped to save implementation time due to the ease of clarifying team queries in the daily meetings. Sharing the results had an additional benefit in terms of conveying or clarifying the actual meaning of SMPI to all participants. That said, in XYZ there were still some concerns expressed about its overhead and its usefulness; however, as with any change it can take time for an organisation and its employees to become accustomed to a new process. In this case, the defined checklists/TODOs, roles and responsibilities, and activities of SMF2 were refined and evaluated according to small company needs. Figure 7-6 depicts the resultant SMF2.

7.3.4. Field Studies' Outcomes

This section presents the outcomes of all three cases based on discussions with leading participants in both ABC and XYZ companies.

Overall the majority of participants from company ABC had accepted the utility of SMP implementation through the proposed SMF, and top management planned to use it on a regular basis. The PM1 had started to document the whole process and planned to automate as many aspects as sensible. During Case 2, the PM1 even tried to make SMF1 activities a part of JIRA in particular stages where it was suitable and possible. The PM1 was more motivated than top management to continue the SMPI.

Many of the participants of XYZ Company (excluding PM) remained reluctant to some extent, and continued to be concerned about time-consumption, although the response of the CEO was very positive. The PM was also satisfied with the SMPI process via SMF2. On the question of continuing the SMPI, the CEO's remarks were, "For the time being we might not continue it on a regular basis, due to workload but we are keen to implement it in near future". He was also thinking of making it a formal documented process before implementation.

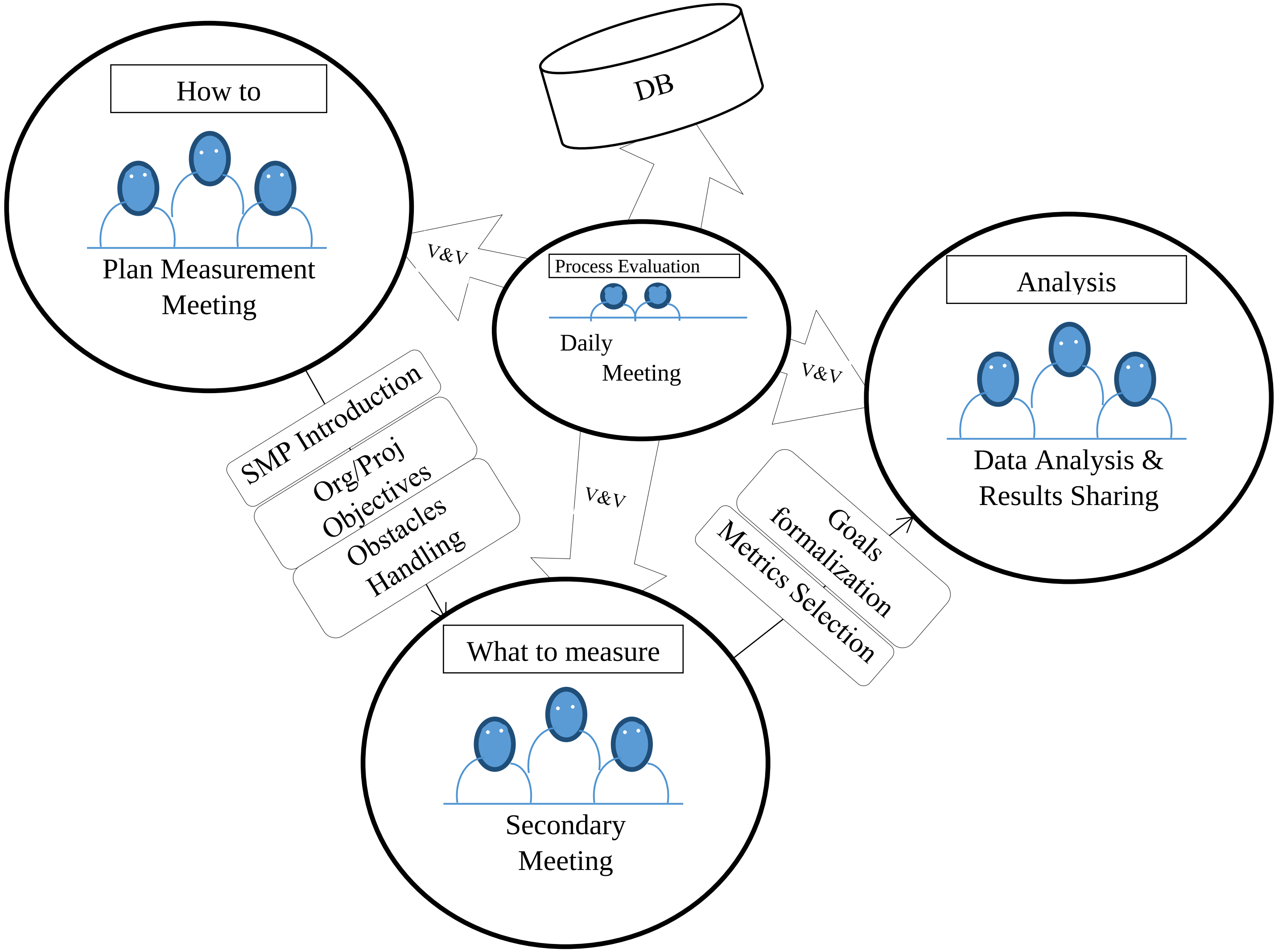

Figure 7-6 Initially Developed SMF 2

7.3.4.1. Time Spent on Process Implementation

The Case 1 implementation took more time comparatively because it was the first time that the company had participated in any systematic form of SMPI. It was also the first time the researcher had designed support activities to perform SMPI (although the researcher has previous experience of implementing SMP in industry (Gencel et al., 2013)). That said, on the positive side the PM1 and SQM had some relevant prior knowledge of software development processes. It was observed that the Case 2 and 3 implementations took approximately 60% of the time required in Case 1. Case 1 took 2 months and 27 days including 10 days for Case 1 results evaluation, whereas the Case 2 and 3 implementations took 1 month and 20 days. This shows that there was to some extent a one-time investment up front. However, the actual time required could also vary depending on the set of metrics to be collected, analysed and reported.

7.3.4.2. Other findings

This section elaborates on various data in terms of the case organisations' characterises in Table 7.5 and practitioners' knowledge in Table 7.6 with respect to the research domain. Additionally, Table 7.7 highlights the variances in SMF4SME development with respect to each case. Finally, Table 7.8 lists down the most commonly identified challenges in both organizations during implementation.

Table 7.5 Empirical Data from Field Studies

	Case 1 & 2	Case 3
Empirical Background		
Main Method	Case Conduct	Case Conduct
Sub-Method	Discussion	Discussion
Background	Real Time	Real Time
Empirical Focus	Empirically based	Empirically based
Subject of Investigation	Software Measurement	Software Measurement
GSE Background		
Perspective	Service provider	Product owner
Number of Locations	Two	One
Location of Originator	USA	Pakistan
Location of Supplier	Pakistan	Pakistan
Study		
Claims	None	None
Focus of study	SMPI	SMPI
Application Domain	Web, Desktop	Web
Development Methodology	Agile (Kanban)	Claim agile but mostly internally defined

Table 7.6 Why were XYZ and ABC not Implementing SMP?

Reason	ABC	XYZ
Because it involves extra budget?	Yes	Yes
Because it requires expert person?	Yes	Not sure
Because it requires a lot of time to employ?	Yes	Not sure
Because the organization was not aware of its benefits at all?	No, aware up to some extent.	Not sure

Table 7.7 SMF development variance in each case

S.#.	Variances
1.	In SMF1, presentation upon SMPI was not given to all SMPI stakeholders, whereas it was arranged in Case 2 and 3 and added to initially defined activities.
2.	In case1, during second activity A2 at the time of GQMs selection individual(s) who are supposed to participate in metrics data collection were not included. It was encouraged in Case 2 and 3 to involve them at least at the time of GQMs discussion or a session in daily meetings should be given for GQMs awareness.
3.	People from onshore were involved in a Case 2, which was more effective to understand the organization and or project objectives especially.
4.	SMF 1 was developed mainly in medium-size ABC Company, whereas SMF 2 developed in small-size XYZ Company on their needs.
5.	In SMF 2 it was decided, a lot of onus will put on PM, to follow the developed guidelines and activities.
6.	In Case 1 there were no Checklists, well-defined activities and roles to perform them. These were defined and evaluated in Case 2 and 3.
7.	The SMF 2 has more mature and evaluated set Roles comparatively, and Responsibilities to perform each activity.
8.	In SMF1, the first Activity A1 was the preliminary meeting whereas in SMF2; the first activity A1 was SMPI presentation. Actually, in a small setup, it is easy to introduce SMPI and SMF to all stakeholders because they are less in numbers, which could save the time of the preliminary meeting.
9.	SMF1 has method selection option for GQMs determination whereas it removed from SMF2 for small companies.

Table 7.8 Commonly identified challenges

Challenge
Reluctance to use
Time consuming
Lack of awareness
High learning curve
Resource limitations
Experts required
High implementation cost
Poorly defined escalation procedures
Lack of process/product knowledge
Measurements goals determination
Lack of communication between different levels

Based on the analysis of the field studies results from both companies a third version of SMF was developed, namely the ‘Software Measurement Framework for SMEs’ (SMF4SME). The following sections now briefly introduce each phase of SMF4SME. A more detailed discussion of each phase and the activities is provided in the Findings and Recommendations section 7.4.

7.3.4.3. Overview of the proposed SMF4SME

The SMF4SMEs is divided into three major phases, where each phase connects to a database (DB). Each phase starts with a major meeting followed by short daily meetings, where the major meeting is synchronised to coincide with a routine project meeting, such as a Sprint planning meeting in Scrum. Likewise, the daily meetings are synchronised with routine daily meetings, such as daily stand-up meetings. These meetings could vary from company to company or project to project, depending on organizational structures and processes. Moreover, in the case of synchronising major meetings with a company’s sprint meetings, the SMF4SMEs meetings depend on the successful completion of each task in the preceding meeting. For example, the execution meeting is conducted based on the completion of the Kick-off meeting tasks (where the Kick-off meeting was a preliminary meeting in each case conducted). These meetings and their detail are discussed in upcoming sections, while the immediately following sections briefly explain each of the three major phases of SMF4SME.

7.3.4.4. Planning

The first phase is Planning and it is focused on “How to measure?” It starts with a Kick-off meeting – though it is important to mention that companies who are going to implement a measurement program or the very first time should organize a seminar or meeting to explain to their SMPI stakeholders:

- what is software measurement?
- what are the advantages expected from software measurement?

(as during the field studies it was realized that covering off these issues helps to address or even head off some obstacles that can arise in the initial stages). The first major task of a Kick-off meeting is to discuss the organizational and SMPI aims and objectives, which could in turn provide a useful basis for defining measurement goals later. The second major task of the Kick-off meeting is to identify and discuss all possible challenges and obstacles and to identify – and apply – potential solutions. If obstacles cannot be resolved on the spot then their consideration should be assigned to suitable individuals (as chosen by PM, SQM, or TL moderator of A1) to resolve before the Execution meeting. In the daily meetings that follow the Kick-off meeting decisions are reviewed and confirmed, and the assignor will discuss challenges and obstacles with assignees and resolve them.

7.3.4.5. Execution

The second phase (Execution) emphasises “What to measure?” It also starts with a meeting which could again be synchronised with a routine company meeting, such as a sprint meeting if following Scrum or any other fortnightly meeting. This phase is further divided into two stages, focused on data definition and data collection. The activities to perform in the first stage are to select a method to enable goal determination and corresponding metrics selection, and possibly to select the desired measurement goals and metrics from the pre-defined GQMs. Small companies and those who are implementing SMP for the very first time are advised to use this latter approach for goal and metric determination. After completing these activities, companies will have a set of goals and corresponding metrics to drive their collection of data. The activities to perform during data collection are to assign metrics to relevant individuals (undertaken by the PM, SQM, or TL moderator of A4) and to conduct daily meetings to assist them in metrics data collection. Another activity could be that the assignee reports the data collected to the assignor. The execution phase also includes follow-up short daily meetings, where the assignee can discuss any confusion regarding metrics data collection.

7.3.4.6. Analysis

The third phase is the Analysis phase, answering the key question “What’s the result”? This phase could again start with a major meeting, but this is optional: if it is established that either the PM or TL is going to perform the analysis then there is no need to hold a meeting; rather, analysis should be performed on collected data. Immediately an urgent meeting could be called at this stage based on reported data criticality. The person responsible will perform analysis on the reported metrics data and prepare the results to present to all of the stakeholders in the SMPI process. It is important to share/present and discuss the results with all stakeholders in order to gain their confidence for ongoing implementation and to demonstrate to them the usefulness of SMPI.

The proposed solution SMF4SMEs consists of three phases, and each phase has three activities. A brief introduction to all three phases of SMF4SMEs was given in the previous section, whereas this section presents each phase and its corresponding activities in detail, as follows.

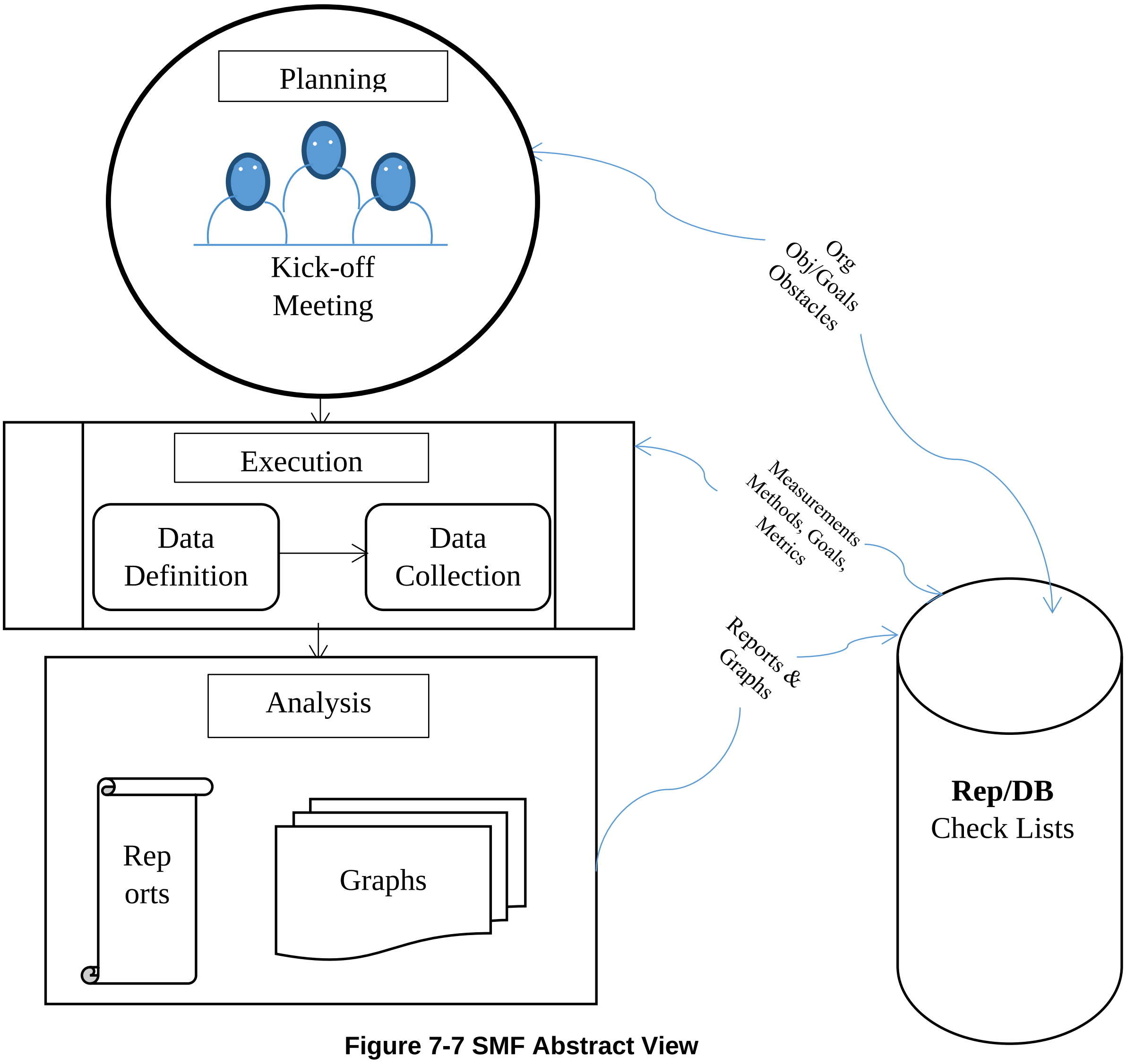

Figure 7-7 SMF Abstract View

7.1. Findings and Recommendations

This section presents the core findings and synthesis of this research work, in the form of the proposed solution SMF4SME. Moreover, it presents the complete structure of SMF4SME, the implementation guidelines, and practice recommendations. Additionally, SMF4SME's characteristics, implementation outcomes, risk factors and success factors are presented.

7.1.1. Detailed Definition of SMF4SMEs

SMF4SMEs address three questions: How to measure? What to measure? What's the result? These questions map to three phases, Planning, Execution, and Analysis, which in turn consist of three main activities. Some of the activities need to be carried out only one time (noted by "OT"). These OT activities should be undertaken if the company is implementing a software measurement program for the first time or if those involved in the initiative are new to the process. A red asterisk (*) indicates that an activity is mandatory. The framework also provides checklists (Chk.L) for some activities to guide practitioners on the actions to be taken. All data generated during the process should be stored in a database (DB). The framework also provides recommendations as to who should or could be involved in each activity. The SMF4SMEs phases should be undertaken in sequence, and the meeting(s) in each phase could be synchronised with existing weekly, fortnightly or monthly meetings in the organization. The Work Breakdown Structure (WBS) of each phase and the respective activities presented is shown in Table 7.9.

Table 7.9 SMF4SME' Work Break Down Structure (WBS)

Phase 1: Planning (*How to Measure?*)	
A1.	A kick-off meeting in order to: (**Chk.L**) [*CEO/CTO, *PM, *SQM, *TL, SA, DBA, *Onshore stakeholders].
	a. *Discuss the purpose of SMPI. b. *select project(s) to be measured. c. *Discuss business and project objectives and desired outcomes, **DB.** d. *Determine potential challenges and obstacles to SMPI, (**Chk.L**), ***OT*, DB** [*PM, SQM, TL].
A2.	*Brief introduction of SMPI and SMF4SMEs to the team(s) of selected project ***OT*** [PM, SQM, *TL].
A3.	Daily meeting to evaluate data from A1 Such as 1: Confirming decisions. 2: Defining actions and responsibilities. 3: Address challenges and obstacles [*PM, *TL, SQM, Concerning roles] **DB.**
Phase 2: Execution *(What to Measure?)*	
A4.	Execution meeting in order to: [*PM, *SQM, *TL, *Key Developer, Team].
	a. Feedback on phase 1 results. A short talk about activities performed up to now. b. Select a method for measurement goals and metrics determination (**Chk.L**). i. Determine required measurement goals and select corresponding metrics to satisfy goals, by using suggested method(s) (**Chk.L**). (b **OR** c) **AND** d c. Select measurement goals from library DB**.** d. Select metrics from the library to satisfy goals. Metrics should select at time of each goal definition **DB.** e. *Allocate selected metrics to concern team members for data collection. [PM, *TL, SQM].
A5.	Daily meeting to evaluate data from A4, such as 1: Confirming goals and metrics. 2: Giving more understanding about goals and metrics to team members. 3: Guiding team members in data collection, if they stuck somewhere. [*PM, SQM, TL, Concerning roles].
A6.	Team members report collected metrics data to the corresponding role. [PM/TL/SQM].
Phase 3: Analysis (*What's the Result?*)	
A7.	*Results analysis meeting(s). [*PM, *TL, SQM].
	a. Urgent, based on results criticality, or Daily meeting for results discussion and analysis conduct, or an important meeting, need-based. **DB.** b. Generate reports and graphs of measurement results in **DB.**
A8.	*Results Sharing Meeting [All stakeholders of SMPI].
	a. Reports, Graphs and results discussion.
A9.	*Decision Making. [PM, TL, SQM].
	a. Make decisions and schedule actions based on SM results. b. Evaluate actions and Improvements.
Chief Executive Officer (CEO), Chief Technology Officer (CTO), Project Manager (PM), Software Quality Manager (SQM), Team Lead (TL), System Analyst (SA), Data Base Administrator (DBA)	

Note: The role abbreviations noted against each activity are recommended for involvement based on the researcher's field studies experience. The user may customize these according to his or her organizational structure, or if certain aspects are not applicable. For instance, if global development is not relevant then there will be no onshore stakeholder. Or, if there is no SQM role this could be replaced by another role concerned with assuring quality outcomes.

<u>Phase 1:</u> Planning (*How to Measure?*) (Designing SMP)

The first phase of SMF4SMEs is focused on Planning and determining "How to Measure". Phase 1 consists of three main activities A1, A2, and A3. The detail of each activity and sub-activities is provided as follows.

7.1.1.1. Kick-off Meeting (A1)

This section describes the first activity A1, namely the Kick-off Meeting, of SMF4SME, and its four sub-activities:

a. Discuss the purpose of SMPI.
b. Select project(s) to be measured.
c. Discuss business and project objectives and desired outcomes,
d. Determine potential challenges and obstacles to SMPI

Kick-off Meeting Considerations:

This section emphasizes what should be considered when conducting the Kick-off Meeting, in order to maximise the likelihood of a successful SMPI.

Introduction

The Kick-off Meeting provides a good opportunity to energize the team to implement SMP, where mainly top management (and onshore stakeholders, if they exist) should participate. In this meeting, those in leadership and management positions can establish the basis for SMPI and can contribute to the understanding of all stakeholders of the SMPI process. The key themes addressed in the meeting should cover, at a relatively high level, what software measurement is, why it is important and how the measurement program will be implemented.

<u>Agenda</u>

A clear agenda should be established for the kick-off meeting. The Agenda should contain information regarding the deliverables of each phase of SMF4SME, a communication plan and meetings schedule and, more importantly, the purpose, objectives, and goals of both the organization and upcoming projects. The agenda should be circulated to participants before the meeting to make them aware of the purpose and intended outcomes of the meeting.

Setting Expectations

- Hold the meeting at a convenient time of daily that aligns with regular weekly or fortnightly meetings based on the organisation’s existing project meeting schedule.
- Emphasize the teamwork needed to achieve the required SMPI goals through SMF4SME. Team activities should be clearly stated.
- Mention to participants that their contributions as per defined roles and responsibilities are important at particular stage(s) for successful SMPI, and that they have a shared responsibility for its delivery.

SMEs and startups may have development staff working long hours, and they might feel that SMPI will only increase their workload. At this stage it is also important to explain that the person leading SMPI (most likely the PM) will be supporting them in monitoring and maintaining workload levels.

Communication Plan

Communication is one of the key success factors for SMPI in SMEs, especially when they have tightly constrained resources. The Kick-off Meeting should stress the importance of a communication plan for effective process implementation. The scheduled meetings play a vital role in enabling effective and fruitful communication, supplemented by emails and the sharing of the final results and analysis reports.

Feedback Discussion

There should be a ‘Question and Answer’ session at the end of the meeting to give participants the opportunity to express their questions and any concerns freely, or if there is a time constraint they should be permitted to send their feedback via email. The meeting should be succinct, clear and to the point, so no-one loses interest. The meeting minutes should be shared with all participants.

Kick-off Meeting sub-activities:

This section explains the sub-activities of A1 as follows.

SMPI objectives

A brief introduction to SMPI and SMF4SMEs to all participants is required at the start of the meeting. This is especially important if the organization is going to implement SMP for the first time or have new participants involved in this activity. There should be an explanation of the fundamentals of software measurement and the advantages an organization can achieve by its implementation in general.

Project Selection

The next step is to select the project (or projects) through which the organization wants to implement SMP. Undertaking project selection before outlining aims and objectives could narrow the discussion toward the particular project and so save time. The main issue that needs to be considered at the time of project selection is the availability of the team in terms of their time for SMPI. There must be a realistic assessment (normally by the PM) as to whether the team members have the time available, to improve the prospect of implementing SMP effectively. On the other hand, project selection could also depend on the companies' requirements of SMPI in a particular project. However, in such scenarios, team availability could be compromised and so needs assessment.

Aims, Objectives, and Goals

The next step is a discussion of the aims, objectives, and goals of the project, product, and organization and how these could be achieved through the implementation of SMP. The PM of the selected project or product should have the aims and objectives on hand to discuss with participants in the meeting. Done well, this gives the right initial direction and contributes to a strong base to implement SMP.

Challenges and Obstacles Handling

The challenges and obstacles identified in Cases 1 and 3 (presented in sections 7.3.1 and 7.3.3) should be discussed with the meeting participants. Specific challenges and obstacles considered relevant to them should be addressed resolved on the spot if possible, otherwise each should be assigned to relevant individual(s) (chosen by the PM, SQM, or TL moderator of A1) to be resolve at a later time. Any additional challenges or obstacles should also be identified, and resolved or assigned. The newly identified challenges or obstacles and their resolving process/solution should also be added to the DB so that they can be addressed if they arise again in future.

7.1.1.2. SMPI Seminar (A2)

The second activity in Phase 1 of SMF4SMEs is a SMPI seminar, which could be a one-time activity but should also be added to the company's induction agenda when training new staff. If the team who is working on the selected project was not part of the Kick-off Meeting they should attend to gain awareness of software measurement and its implementation through SMF4SME. In order to maintain momentum this activity should occur as soon as possible after the Kick-off Meeting.

7.1.1.3. Daily Meetings (A3)

The third activity A3 of SMF4SMEs is the daily meeting. These meetings should be short and to the point. In these meetings the PM and/or TL can discuss daily progress on assigned issues and help to resolve any difficulties. These meetings should be part of routine daily meetings (such as stand-up meetings in Scrum), to maximise attendance. The objective of A3 is to help in confirming and completing the decisions and outcomes of A1.

<u>Phase 2:</u> Execution (*What to Measure?*)

The second phase of SMF4SMEs is Execution, which must begin after completion of Phase 1. This phase is mainly focused on "What to measure?" Having completed the necessary planning, now the SMPI participants are in good shape to decide what they should measure. At this stage, the SMPI team should have good knowledge of the organizational objectives and should have recognised, and ideally resolved, any challenges and obstacles. It is therefore time to decide what particular aspects of their work should be measured to meet project and organizations goals. This phase also consists of three main activities, explained in the following subsections.

7.1.1.4. Execution Meeting (A4)

The fourth activity (A4) of SMF4SMEs is the Execution Meeting. Phase 2 of SMF4SMEs also starts with a meeting where the PM, TL, and key developers are mandatory participants in a small company, and the Software Quality Manager (SQM) is a mandatory participant along with PM and TL in medium-sized companies. Other stakeholders are either optional or as needed but not essential, but they should be encouraged to attend the meeting as this should improve awareness and contribute positively to process reliability.

The main objectives of this meeting are to decide what aspects of the selected project should be measured, and who will collect the data to measure those aspects. To achieve these objectives, it is important to define what goals and metrics will be used to measure those aspects and which methods need to be used for defining goals and metrics. A4 consists of two sub-activities: 1) Determine measurement goals and metrics, and 2) Assign selected metrics to relevant resources for data collection. The first sub-activity, measurement goal and metric determination, can be achieved in two ways: 1) Select a method from the provided checklist (presented in Table 7.11) to determine measurement goals and metrics, or 2) Select measurement goals and metrics from the pre-listed GQMs (Appendix 7.1). This section, A4 Execution Meeting, is further divided into two subsections, covering data definition and data collection, respectively.

Data Definition

One of the key objectives or sub-activities of the Execution Meeting is defining formal measurement goals based on the aims and objectives discussed in the Kick-off Meeting A1. In light of its importance, all the stakeholders of SMPI are encouraged to participate.

Goal determination and metrics selection are subject to method selection, and formal methods can provide systematic support for this activity. For medium-sized organizations a method could be selected from the SMF4SMEs list (Table 7.11) or others existing. It is totally optional to select a method for goal determination if the organization has enough resources and wants to follow formal methods. Smaller organizations with comparatively limited resources are discouraged from selecting formal methods for goal determination, and should not stress on method selection. Instead, it is recommended that small organizations use the SMF4SMEs GQMs set to achieve their SMPI objectives, to adopt the associated processes slowly and steadily, starting with small advances as encouraged by (Rifkin & Cox, 1991a). (A caveat to this recommendation could apply to small organizations that have established, mature processes.)

After method selection, the next critical step is measurement goal determination, requiring the attention of senior management. Well-resourced organizations can consider goals in detail, perhaps supported by existing templates (Díaz-Ley, et al., 2008d) to help management to specify their perspective, purpose, and context. Once finalised, the newly determined goals and metrics should be added to DB for future use.

The metrics required to satisfy each goal should also be chosen at the time of their definition, given that at that time the individuals who are determining the goals are likely to have some clarity regarding each goal's purpose, perspective and focus, which should usefully inform their selection of the most relevant metrics. If in any scenario individuals cannot choose metrics at the time of goal definition it is important that, at the time of metric selection, at least one individual who took an active part in goal definition should contribute to the metrics selection process.

Data Collection

The last major sub-activity of A4 is to assign the selected metrics to relevant individuals for data collection. The TL is likely to be a suitable candidate to perform this task; however, he or she can perform this activity jointly with the PM, if useful from a managerial perspective. If any of the assignees were not involved in goal definition and metric selection, then they should be well oriented before metric assignment. During the metrics assignment activity, the assignor should ensure that each assignee has both sufficient authority and time to collect the data. The user can use the existing data for metrics data collection where possible such as Bugzilla or Jira reports to save the time.

7.1.1.5. Daily Meetings (A5)

A5 is the fifth activity of SMF4SMEs in Phase 2, namely Daily Meeting. These daily meetings mirror the A3 equivalents, as follow-up activities to the Execution Meeting/A4. The main objective of these meeting is to confirm and act on the Execution Meeting outcomes, such as confirming the goals/metrics and to ensure team understanding, especially for any metrics assignee who were not part of A4. Moreover, if metrics assignees face problems in data collection, they can raise this at the next Daily Meeting.

7.1.1.6. Data Gathering (A6)

The sixth activity of SMF4SMEs is Data Gathering (A6). In this activity each assignee is to collect the required metrics data and report this back to the assignor, typically the TL or PM depending on the chosen scenario. At this stage the primary workload will shift from top management (PMs and TLs) to development-focused employees (developers and testing engineers), although the senior personnel should still be prepared to follow up and help out assignees as needed in their metrics data collection. After gathering metrics data from assignees, the results should be reviewed by PM or TL A6 moderators for validation.

Phase 3: Analysis (*What's the Result?*)

The third phase of SMF4SMEs is Analysis. This is the final phase of SMF4SMEs which needs to be performed after metrics data gathering and reporting from assignees to the assignor. The objectives of this phase are to perform analysis of the metrics data, share the analysis outcomes with all stakeholders, and make decisions based on those outcomes. Phase 3 also consists of three main activities, described as follows.

7.1.1.7. Analysis Meeting (A7)

The seventh SMF4SMEs activity, and the first in phase 3, is the Analysis Meeting. Analysis Meetings are held on an as-needed basis, unlike the Kick-off and Execution Meetings. An Analysis Meeting could be deemed as urgent, based on reported data criticality. As such these meetings could occur on a daily basis or every other day, they could be short or extensive, depending on the analysis results obtained and consequent actions required. As per the SMF4SMEs recommendations involvement of one or both of the PM and TL is mandatory; it may be that they might have conducted the analysis themselves, or with specialist support. The major task in this activity is to perform appropriate analyses and to generate reports and graphs to support the effective presentation of the results.

7.1.1.8. Results Sharing Meeting (A8)

Results sharing takes place as the eighth activity of SMF4SMEs (A8) in Phase 3. The major task of this activity is to share the generated reports and graphs with all SMPI stakeholders. This presentation will reiterate the purpose of SMPI and will then consider its outcomes. Done well, it should encourage future implementations. The meeting also provides an opportunity to seek feedback for SMPI improvement. In addition, the generated reports and graphs should be stored in a repository for future use in decision making, project planning and the like.

7.1.1.9. Decision Making (A9)

Activity A9 in SMF4SMEs ‘closes the loop’ in terms of informed action. The objective of this activity is to enable the organisation to make sound decisions based on the results of the SMPI analyses. As such, the implementation of this activity depends entirely on the needs of the company, teams or individuals at given points in time.

Figure 7-8 SMF4SMEs depicts the proposed SMF4SMEs in infographic form. The left-hand side depicts the suggested activities for smaller organizations and the right-hand side shows the recommended activities for medium-sized organizations. The centre “SMEs” column shows the activities to be performed by organizations of either size. The only difference between small and medium organizations is due to very limited resources in small organizations. So a very simple checklists suggested for small organizations, whereas medium organization can go into more depth depending on resources availability. At the core both will follow same process.

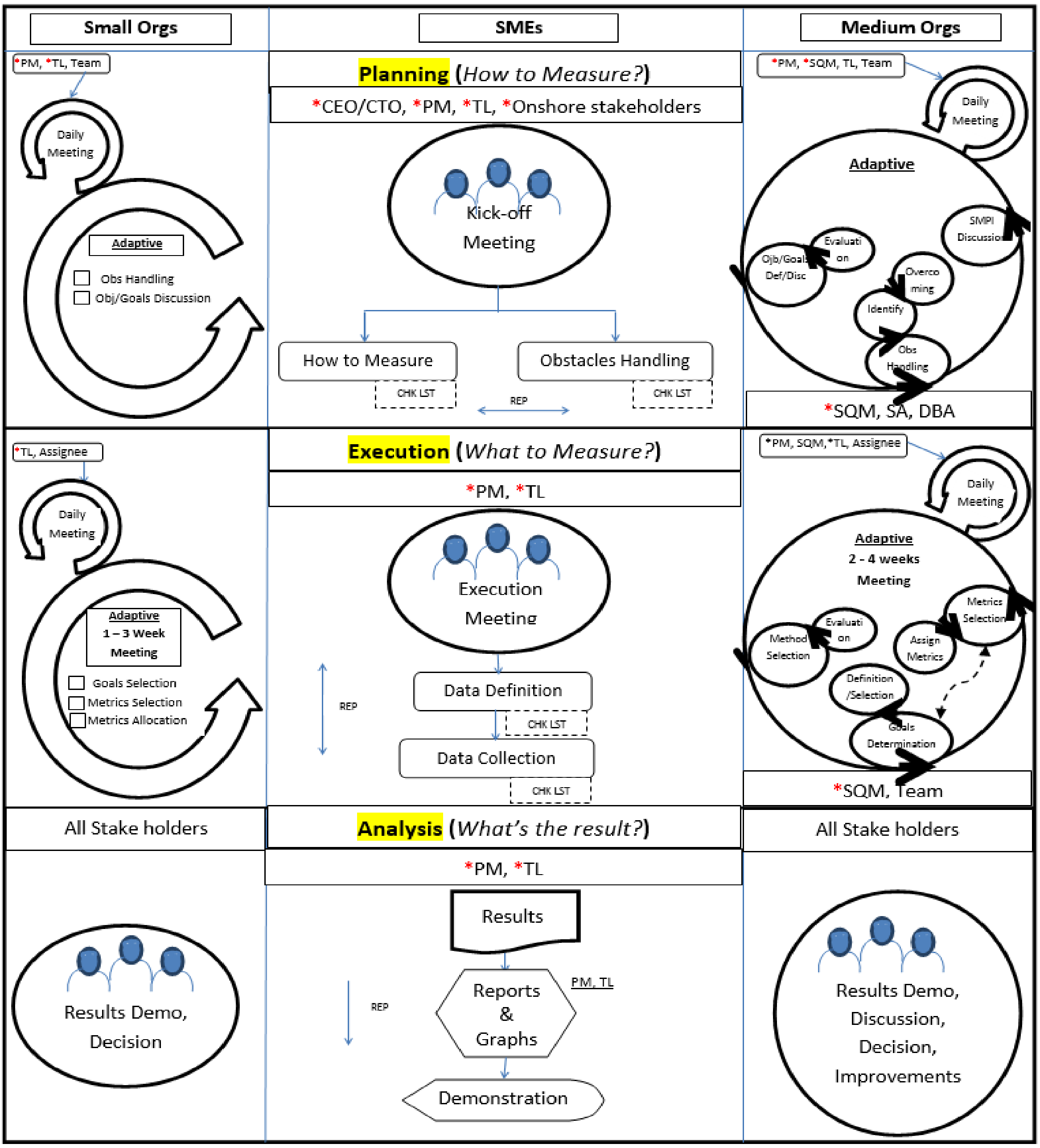

Figure 7-8 SMF4SMEs

7.1.1.10. Activities vs. Roles and Responsibilities

This section describes the roles involved and their responsibilities in terms of who should perform each SMPI activity, as drawn from the researcher's experiences in the field studies. The PM should distribute the roles and responsibilities among suitable stakeholders to ensure

Table 7.10 Activities vs. Roles & Responsibilities

Phase	Role	Activity	Entity	Responsibility	Outcome
Planning	*CEO/CTO, *PM, *SQM, *TL, SA, DBA, *Onshore.	A1: Kick-off meeting (*How to Measure?*)	Organizational Aims/ Objectives/ Goals, SMPI objective, challenges/obstacles checklist	Discuss the organizational goals in a particular project context, how they could be achieved via SM. Determine the challenges/obstacles of SMPI.	Clarified organizational and software measurement objectives. Updated challenges/obstacles checklist
	PM, SQM, *TL	A2: SMPI Seminar	SMF4SME	Explain the SMF4SMEs activities to the team of SMPI, who were not part of Activity A1.	Team confidence and awareness about SMF4SMEs
	PM, SQM, *TL	A3: Daily Meeting	SMF4SMEs DB	Evaluate data of activity A1, such as confirming the decisions, define actions and responsibilities, and resolve challenges/obstacles with the consultation of the concerned individuals.	Confirmed decisions, defined actions, updated challenges/obstacles checklist.
Execution	*PM, *SQM, *TL, *Key developers, Team	A4: Execution Meeting (*What to measure*)	Check List of measurement goals, metrics and their determination methods	Determine measurement goals and metrics based on A1 activity results, either through listed method(s) or choose from the predefined list. Assign metrics to available and relevant individual(s) to collect data.	Updated goals/metrics checklist.
	*PM, SQM, *TL	A5: Daily Meeting	Selected/defined goals and metrics	Evaluate data of Activity 4, such as confirming and briefing goals/metrics, assisting in metrics data collection.	Confirmed goals/metrics, focused & on track.
	TL/PM/SQM	A6: Metrics data reporting	Collected data	Collect metrics data from individual(s).	Measurement Results of Analysis
Analysis	*PM or *TL, SQM	A7: Results analysis	Measurement results	Arrange an urgent or daily meeting(s), based on reported results' criticality. Available roles coordinate to generate reports and graphs of measurement results	Results transparency
	All stakeholders of SMPI	A8: Results sharing	Reports and graphs	Demonstrate the final outcomes (analysis reports and graphs) to all stakeholders.	Confidence development of all stakeholders, for future SMPI. Updated DB with reports and graphs.
		A9: Decision Making	Reports and graphs DB	Evaluate actions and improvements.	Help in decision making, assistance in project management.

workload balance and to reduce over-reliance on himself/herself. The TL could be concerned about developers' time commitments so he or she might not be encouraging the PM to involve developers in the process in the early stages, but the PM is responsible for making sure each participant (role) noted against each SMF4SMEs activity is aware and committed.

Table 7.10 presents the roles and responsibilities associated with each activity. Additionally, it lists the entities needed and the expected outcomes of each activity.

7.1.1.11. Activities vs. Check Lists

To line up the various activities with their corresponding actions and give further direction to SMF4SMEs users several checklists were generated during the field studies. Use of these checklists is optional, however, and could vary organization to organization and even project to project, depending on the process maturity of those involved. Also of note here is that checklists have not been developed for all activities; rather, they are provided only for those activities where actions are required that may be time-consuming and/or require particular expertise. Table 7.11 lists the suggested checklist/ToDo's against each activity.

Table 7.11 Activities vs. Check Lists

Phase	Activity/sub activity	Check List/ ToDo's
Planning	Kick-off meeting (*How to Measure*)	Introduction to SM
		Meeting Agenda
		Project/Product and Organization Aims and Objectives
		Setting expectations
		Communication Plan
		Feedback & Discussion
	Challenges/Obstacles	High Learning Curve
		Reluctance to use
		Time Consuming
		Lack of awareness
		Verifying perspective of PM vs. Developers about measurement goals
		Fear of consequences
		Dishonesty in reporting metrics
		Lack of commitment
		Lack of communication
		Lack of process/product knowledge
Execution	Methods selection	*Standard:* CMMI ISO/IEC 15939
		Methods/Tools/Frameworks: GQM GQM LIT Keep it Simple MIS-PyME

	Goals determination	Purpose
		Perspective
		Focus
		Link to organization and project goals
	Metrics selection	Define scope of metrics
		Choose at time of goal definition
		Should be relevant to goals
		Assignee availability
		Assignee suitability
Analysis	Results evaluation	Use for Project timelines/ Planning
		Use to estimate future products
	Reports and graphs generation	Generate reports
		Generate graphs
	Results distribution	Present/Share with all stakeholders of SMPI

7.1.1.12. Activities vs. Precautions

As previously described this framework was developed by implementing SMP in real-time in two software development SMEs, so during the implementations some precautions were identified and noted down by the researcher. This section lists those identified precautions as potentially needing to be undertaken when implementing SMP through SMF4SME. Taking such precautions could be helpful in the successful implementation of the framework. Table 7.12 presents the phases/activities versus the various precautions noted.

Table 7.12 Activities vs Precautions

Phase/activity	Precaution
Measurement goal determination	To determine measurement goals there is a need to define very clear objectives for SMPI in activity A1.
Metrics Selection	The metric(s) should be selected for each measurement goal at the time of goal definition, because at that time the perspective is clearer, which may help in the selection of the most relevant metrics.
	Organizations new to SMPI should start the process with a small set of goal-oriented metrics.
Metrics Data Collection	When choosing size metrics to collect the team should carefully verify the collected data, because size metrics data is critical and a key to measuring productivity and efficiency.
Obstacles handling	To avoid dishonesty in metrics reporting, the assignees should be informed that the reported data will not be used to evaluate their performance, nor how they will be rewarded.
	The metrics data should be shared only with relevant stakeholders, or with teams where it is specific to them, to get the confidence of metrics data reporters.
Analysis	The analysis report should be shared so as to achieve results transparency with all stakeholders, and to motivate metrics data collectors so that they can realize the advantages/usage of data.
	The hiding of results from stakeholders can result in rumours and can demotivate them in future.
	In the results presentation/discussion session, consider the point of view of each participant irrespective of their designation.
	The analysis results should also be stored in the repository, to support future decisions.

7.1.2. SMF4SMEs Risk Factors

This section lists the risk factors identified during SMF4SMEs development, and which require attention during implementation.

1. Regarding the roles and responsibilities, users may customize the recommended roles to perform each SMF4SMEs activity based on their organizational structure, or if certain aspects are not applicable. However, not involving the recommended key individuals in the various activities may reduce the chances of successful SMPI.
2. If top management, owners and on-shore personnel do not participate in the Kick-off Meeting the company is likely to establish only a weak basis for SMPI and would put at risk other stakeholders' interest and commitment. This is because top management can motivate individuals for SMPI and can clarify organizational objectives more accurately.
3. While optional, the use of checklists and precautions should be given due consideration, otherwise the SMPI process could be (perceived as) time consuming and inefficient.
4. Failure to link organization and measurement goals could derail any efforts to achieve SMPI objectives.
5. Ignoring challenges and obstacles is likely to result in delays, repeated work and eventually failure of SMPI.

To avoid or mitigate these risks the key users should follow the SMF4SMEs instructions rigorously, and make sure the whole team is following the implementation guidelines.

7.1.3. SMF4SMEs Success Factors

The following success factors should be considered for rigorous implementation of SMF4SME.

1. The SMPI initiator should read at least once the detailed descriptions and implementation guidelines/instructions of the SMF4SME. Careful adherence to the guidelines is also strongly encouraged.
2. Teamwork and individuals' cooperation in each phase can increase the likelihood of the successful implementation of SMF4SME.
3. The commitment and continuous support of the SMPI management team (likely comprising PM, TL, SQM) can enhance the chances of success when using the SMF4SME.
4. Communication (primarily through the Major and Daily Meetings) is key, plus SMF4SMEs training and education as per activity A2, is also beneficial.
5. Evaluation and customization of activities according to company needs/requirements.

6. Utilising the afforded flexibility when selecting a suitable method for defining goals and corresponding metrics should enable a ‘best fit’ approach for each organisation.
7. Explicit support for the early identification of challenges and obstacles, and their solutions, can contribute to successful implementation of SMF4SME.
8. Documentation of the daily processes executed as part of the SMF4SMEs supports growing measurement maturity, and the sharing of results and analyses with all stakeholders lends transparency and enables learning.
9. As far as possible data collection and reporting should be automated(S. Rifkin & Cox, 1991a), to save time and improve stakeholders’ motivation. User may also use the existing data such as from Bugzilla or Jira.

7.1.4. SMEs’ properties which could be helpful in SMF4SMEs success

Schätz (2006) notes four particular characteristics of SMEs that, when considered in light of SMPI, may help such companies to successfully apply SMF4SME:

1. SMEs personnel are good at “*multitasking*”, which in turn increases their process exposure. This broad exposure could be useful in metrics data collection across different development phases, and the multitasking capability may mean they are better able to cope with additional responsibilities in their workload.
2. SMEs do not have “*extensive processes*” so it should be feasible to integrate SMF4SMEs with their existing processes/methodology.
3. SMEs are more “*people oriented*” than process oriented, and communication is a key to their success. Given a strong communication culture it should be possible to synchronise the communication activities of SMF4SMEs with existing communication activities, such as short daily meetings.
4. SMEs are often “*owner-driven*” so the owner’s proactive influence, commitment and engagement can drive process initiation and adoption.

7.2. Discussion

This research has investigated the previously identified challenges and obstacles to SMPI, through literature and industrial reviews, specifically for SMEs. The resulting objective was “*To develop a framework to enable SMEs to implement simple, sufficient and straight-forward SMPs.*” Based on three field studies conducted in industry a novel framework, namely the SMF4SME, was proposed, developed and refined to achieve this objective.

In effect the research objective can be divided into two parts: the first part requires the identification and resolution of the challenges that might be encountered during SMP implementation. This was informed by the literature review, the industry interviews and the field studies. As such, a prototype list of identified challenges and obstacles was shared and discussed in the Kick-off Meetings in Cases 1 and 3, and some solutions were identified. Table 7.13 presents the current list of commonly identified challenges, and their proposed resolution through SMF4SME. The second part of the research objective requires that any solution be 'fit for purpose' in an SME context. It is asserted here that the SMF4SMEs that has been developed as a result of this research is simple and straight forward, as per the WBS structure in Table 7.9. For instance, it does not require the employment of specialist expertise or prior knowledge to implement. A complete implementation guide has also been provided in the form of activities, checklists, roles and responsibilities and precautions.

Table 7.13 SMPI challenges and their resolution

Challenge and Obstacle	Solution/mitigation
Reluctance to adopt	Phase1, Activity A2, introducing SMPI through SMF4SMEs and its benefits.
Time consuming	A minimal set of simple activities to perform, plus the ready availability of GQMs and checklists. Setting up the DB for measurement data management may take some time in the first implementation but reduce it in future.
Lack of awareness	Provision of self-explanatory activities, plus certain implementation guidelines.
High learning curve	No specific knowledge required, simple and straight forward WBS of SMF4SME.
Resource limitations	Efficient resource utilization plan such as through the activities vs roles and responsibilities structure, and the proposed meetings model.
Experts Required	No expert required, due to availability of checklists which guide particular actions.
High implementation cost	Reduced implementation cost by eliminating the experts and learning requirements, reduced implementation time, risk management in Phase 1, Activity A1.
Poorly defined escalation procedures	Although this challenge does not affect SMPI directly it could impact upon it; SMF4SMEs provides a structured process to perform activities.
Lack of process/product knowledge	Phase 1 Activity 1, provides an opportunity for stakeholders to learn about the project/product and specifically how to achieve its objectives through SMPI.
Measurement goal determination	Provision of pre-listed GQMs, or, if users want to define their measurement goals, checklists are available to help/guide in determining suitable goals.
Lack of communication between different levels	A strong model of meetings in each phase including daily and major meetings.

Further, the second part of the objective focused on the development of a lightweight solution. 'Lightweight' in this context requires two key aspects, lean and sustainable.

The lean requirement meant that the solution had to be simple and straightforward, and should comprise a set of 'necessary and sufficient' elements. To achieve this, extensive discussion between the researcher and leading participants in the field studies (specifically PM1 from ABC and PM from XYZ) led to a mutual understanding that in turn helped in identifying, defining and separating the necessary and sufficient activities of SMF4SME. The intent was to develop activities that are easy to understand, required minimal time to implement and had no learning curve to speak of. The decision to provide checklists to reduce dependence on technical experts (which are not commonly available in SMEs) for some activities, and which could also be costly or time-consuming, further contributed to achieving this aim.

With respect to sustainability, SMF4SMEs was designed to adhere to an early definition of sustainable development attributed to Brundtland et al., (1987): "…sustainable development is development that fulfils the current requirements, without compromising future needs." This means that a solution should be developed to have a long life, not just to solve current issues. In regard to software measurement such an aim is especially important given that research reports that most organizations do not implement SMP (Bourque et al., 2004; Soini, 2011; Wallace & Sheetz, 2014), and those who implement SMP do not practice it for more than 2 or 3 years (Howard, 1991), principally due to limited resource availability. Thus, SMF4SMEs was developed to require minimal resources while addressing current and future needs. By successfully addressing the commonly encountered challenges and obstacles noted above it should address current needs. Its iterative structure and the availability of the data management DB should enable companies to continually evaluate and improve their processes over time. SMF4SMEs does not mandate any specific documentation structure, enabling companies to define and use their own documentation procedures and templates. Additionally, the roles and responsibilities, precautions and checklists, add to its sustainability by providing as-needed guidance and support. Finally, SMF4SMEs is agnostic in regard to process and methodology. If the methodology used by a company changes in the future SMF4SMEs could still be integrated with that new approach.

7.2.1. SMF4SMEs and Agile (and specifically Scrum)

While it is noted just above that SMF4SMEs is process-agnostic it was important that it could fit with commonly used Agile approaches, given that software development SMEs have been increasingly transitioning to agile-based development methodologies (Escobar-Sarmiento & Linares-Vasquez, 2012). Scrum, being one of those most commonly used methods, consists of three main steps, 'To Do', 'Doing' and 'Done'. The first step, 'To Do', is focused mainly on what is to be delivered by the project and so specifies requirements. In the second step ('Doing) the implementation is carried out, and in the third step ('Done') the completed work or modules are shipped and delivered. These steps are sequential but repetitive. SMF4SMEs has three phases of a similar nature.

Thus, Phase 1 of SMF4SMEs could be integrated with Scrum's 'To Do' step if the implementation of both are synchronised. Otherwise, Phase 1 can use the 'To Do' step data as a basis. For instance, product or project backlogs generated by 'To Do' could be used in the Kick-off Meeting to inform the definition of SMP aims and objectives. The second step of Scrum, 'Doing', consists of the actual implementation of features (requiring development, integration, and testing), where progress and outcomes are communicated in daily meetings. Likewise, the SMF4SMEs Phase 2 of Execution consists of the implementation activities of measurement (such as defining goals/metrics and collecting metrics data). Here too the emphasis is on the use of short daily meetings, which could be run simultaneously with Scrum's daily stand-up meetings. The third step of Scrum, 'Done', involves module shipment and backlogging, whereas the third phase of SMF4SMEs is Analysis. In this case there is more of a distinction between the two. In Analysis (Phase 3), the major activities are the generating of reports from the metrics results, presenting these outcomes to stakeholders, and the integration of these components into the DB.

The degree to which SMF4SMEs and Scrum can be integrated (or at least aligned) was tested in the previously reported field studies. In Cases 1 and 2 of this study, which were conducted at ABC, the SMF4SMEs major meetings were synced with sprint meetings, and the daily meetings were synced with daily stand-up meetings. The meeting participants of ABC in the daily stand-up meetings of Scrum and the daily meetings of SMF4SMEs were around 80% in common. In Case 3 XYZ was following an Agile approach, though to a lesser extent than ABC. Even so, the SMF4SMEs meetings were successfully synchronised with XYZ's Scrum equivalents.

7.3. Summary

This chapter has addressed Software Measurement Program Implementation in small and medium software development enterprises. In particular the need to address the previously acknowledged challenges and obstacles was given specific consideration. The most important challenge of resource limitation (in terms of time, budget, and expertise) required the most extensive attention, as it was found to be the root cause of other issues. As a result a framework called SMF4SMEs was proposed, evaluated and further refined through three field study cases. The SMF4SMEs is specifically designed for software development SMEs which may involve multiple organisational levels.

Chapter 8 Empirical Validation of SMF4SME

In the previous Chapter 7 the Software Measurement Framework for Small and Medium Enterprises (SMF4SME) was presented, drawing on the results of three field studies conducted in two companies. The SMF4SMEs comprises nine core activities as well as elements such as checklists, roles-and-responsibilities, precautions, challenges, risk and success factors, and an implementation guide. Chapter 8 now presents the results of the subsequent empirical validation of the SMF4SME.

A survey was designed and distributed to relevant industry participants to seek their feedback. The main purpose was to inquire into the elements (such as checklists, roles-and-responsibilities) of the SMF4SMEs that needed improvement in order to deliver successful software measurement program implementation in SMEs (SMPI in SMEs). In total, data from 110 respondents were collected and analysed.

In this component of the thesis the main research question is **RQ5:** *Does SMF4SMEs fulfil the requirements of SMPI in SMEs?* The core objective is **Obj5:** *To validate and evaluate the perceived usefulness of the SMF4SME*.

This Chapter 8is organized as follows; Section 8.1 presents the research method adopted for this phase of the investigation work, Section 8.2 presents the findings of the survey, Section 8.3 is a discussion of the findings and Section 8.5 gives a brief summary of the Chapter 8.

8.1. Research Method

Surveys conducted via questionnaire are typically used to capture in quantitative terms the activities, attitudes or perceptions of a sample of a population of interest. Surveys may be cross-sectional, in which the data is collected only once, or longitudinal, where the data is repeatedly collected over periods of time (Creswell, 2009). The survey conducted in this research was cross-sectional in nature. The reasons for the selection of all of the methods used in this research are discussed in detail in Chapter 3.

8.1.1. Pilot Study

A pilot study was conducted to pre-test the structure of the questionnaire and to check the wording and sequence of the survey questions before sharing the instrument with the extended targeted audience. Pilot studies are recommended for good study design, and while they do not guarantee success they greatly increase the likelihood (Teijlingen & Hundley, 2002). Specifically, the survey as designed was shared with a thesis supervisor who was not involved in its design and two further senior researchers. One of the two researchers had been employed in the software development industry for more than 20 years and the other had more than five years of experience in the software development and testing fields. Their feedback outlined the strengths and weaknesses of the questionnaire, meaning that confusion could be reduced and ease of navigation improved.

8.1.2. Research Population

The population represented by those companies involved in the previous components of this research, as reported in Chapter 5 and Chapter 7, was limited to SMEs, but there was no need to impose such a limitation on company size when planning the distribution of the survey in this research phase. The purpose of keeping the survey open to all sizes of organization was to obtain feedback on SMF4SMEs from as broad a range of industry representatives as possible. Moreover, large organizations are generally expected to be more mature with respect to process, so their feedback could be useful in comparative analyses of responses. Further, finding SMP practitioners in SMEs is not an easy task, especially when such organizations are typically immature in terms of their attitude and approach to process improvement and measurement.

The intent was to gather responses from individuals carrying out a range of activities, including CEOs/CTOs, PMs, SE, SQM, QA, TL and all other roles related to software development and testing, excluding designers and network engineers. This population was targeted because they are likely to have a view related to SMPs and because the framework included activities that were suggested as being performed by such roles. An invitation letter was designed (Appendix 8.1) specifying the survey link, the estimated time to complete the questionnaire and the intent of the study. Further, in an effort to target relevant participants, a statement was included indicating that individuals from the software industry were being invited to participate in the survey (Lazar & Preece, 1999; Porter & Whitcomb, 2003). Moreover, it was explicitly mentioned that confidentiality would be assured (Iversen & Mathiassen, 2000).

The survey was distributed to software enterprises in several countries through the personal contacts of the researcher and supervisors. Numerous sources and channels were used to invite practitioners to maximize the response rate, including LinkedIn and other professional networks. The survey was also distributed to the case study companies (ABC and XYZ) in which the SMF4SMEs was developed, in order to seek continuous feedback from the practitioners involved.

As the instrument was intended to serve as an additional means of validating the SMF4SMEs there was no need to constrain the population beyond the considerations just described. As a result the exact response rate is unclear, as the practitioners receiving the invitation email containing the survey hyperlink were requested to pass it on to other practitioners. The population (and by consequence, the response rate) is therefore unknown. The survey was completed by 82% of people who attempted it, resulting in 110 valid individual responses. A summary of the characteristics of the survey participants is presented in Table 8.1.

Table 8.1 Participants Characteristics

Participants Characteristics	Frequency
Experience	
1 - 5	42
6 - 10	42
11 – 15	16
>15	10
Executive/Top Management	
CEO/CTO	2
Project Manager	16
IT/Product Manager	2
Project Director	1
Off-Shore PM	1
Software Quality Manager	2
Assistant Project Manager	2
Business Analyst	2
Technical Director	1
Other Roles	
Principal/Senior Software Architect	2
Software/Solution Architect	2
Team Lead	18
Development Lead	1
Principal/Sr. Software Engineer	8
Software Engineer	36
Software Deployment Engineer	1
MWD Engineer	1
Backend/Web/Software Developer	4
Consultant/Engineer	2
Senior Software Quality Engineer	1
Software Quality Engineer	5
Software Measurement Knowledge:	
Yes	70
No	40

Participants' beliefs regarding SM effect on quality and productivity:	
Strongly Positive	47
Positive	61
No Effect	1
Negative	0
Strongly Negative	0
Rather not say	1
Company Characteristics:	
Company Size	
Small	42
Medium	50
Large	18
The proportion of people having some SM Knowledge:	
1 – 10%	16
11 – 20%	17
21 – 30%	14
31 – 40%	8
41 – 50%	10
>50%	20
Rather not say	2
Do not know	23

The survey addressed all elements of the SMF4SME; nine activities, the characteristics, risk, and success factors, and the checklists (See Appendix 8.2). The questionnaire was comprised of four sections:

1. Section one gathered participants' demographic information.
2. Section two gathered participants' and companies' information in context.
3. Section three used the gathered information to evaluate the perceived usefulness of SMF4SME.
4. Section four sought participants' general opinions on the proposed SMF4SME.

8.1.2.1. Characteristics of the participants and their companies

Most of the respondents to the survey were Software Engineers (SEs) and Project Managers (PMs). Out of the 110 participants, 36 (33%) were software engineers, and 24 (22%) were in project managerial positions. In addition, 29 (25%) were from executive/top management positions. The remainder were performing a range of other roles. Forty-two respondents (38%) had between 6 and 10 years of experience and 70 participants (64%) claimed at least background knowledge of SM. Of the 110 participants, 92 (84%) were from SMEs and 18 (16%) were from large organizations.

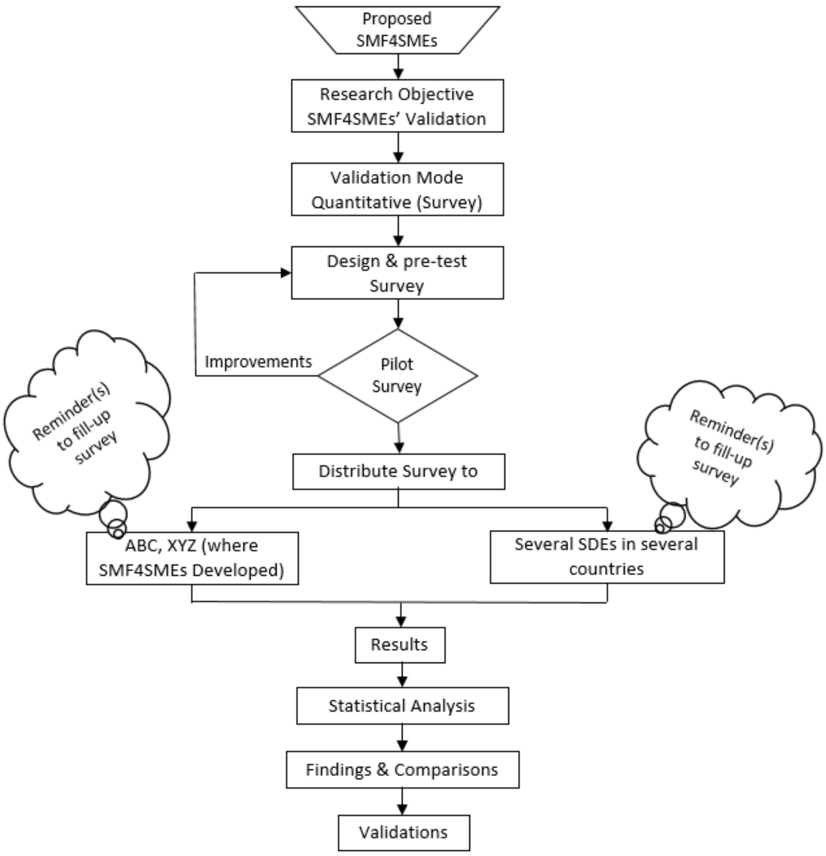

Figure 8-1 The Process of the Survey Research

8.2. Core Findings

This section presents the key findings from the survey results, while general and supplementary findings are presented in Appendix 8.7 and 8.8. The results presented here are based on the feedback of all of the survey respondents irrespective of their company size. That said, and as noted above, 92 of the 110 participants (84%) indicated that they were from SMEs.

8.2.1. Participants and Companies

This section elaborates on the properties of the participants and their companies in regard to domain experience and prior knowledge. As discussed in the literature review and industrial review chapters, many SMEs have not implemented SMPs. Therefore, during both SMF4SMEs development and the subsequent survey design non-mature SMEs were given consideration. The intent of this research is to support non-mature SMEs in their SMPI. Table 8.2 briefly summarises some of the properties of the participants and their companies.

Table 8.2 The properties of the participants and companies.

Experience	
1-5 Years	> 5 Years
42 (38%)	68 (62%)
Roles	
Others	Top-Management
81 (74%)	29 (26%)
Prior SM Knowledge	
Yes	No
70 (64%)	40 (36%)
Participant Companies Size	
SMEs	Large
92 (84%)	18 (16%)

The results shown in Table 8.2 indicate that indeed most of the participants were from SMEs, the targeted organization type for this research and, in particular, the proposed solution SMF4SME. The majority of participants responding to the survey cited more than five years' experience, meaning that most could be considered to be at least intermediate, rather than novice, practitioners. Though none of the participants were found to have the specific title of SMPI engineer/analyst or similar, 64% of respondents did indicate at least some prior SMP knowledge. Of the 110 participants 15 were from ABC and 14 were from XYZ. Therefore, 26 % of the results are drawn from the companies in which SMF4SMEs was developed. These results are analysed separately to the other in later sections to determine if this involvement had any effect on responses, positive or negative.

8.2.2. SMF4SMEs Compatibility

After gathering data on the general characteristics of the participants and their companies, the first substantive part of the survey described SMF4SMEs and sought respondents' views regarding three aspects of the proposed framework:

1. 'Current Practice' asked if the participant or the team he/she is working in is currently performing SMF4SMEs activities in their organization.
2. 'Lean and Sustainable' asked if the participant believes that each activity of the SMF4SMEs would be lean (simple and straightforward) and sustainable (fulfilling the current requirements without compromising future needs) in their place of work.
3. 'Cost and Time Efficient' asked if the participant believes that each activity of the SMF4SMEs would be cost and time efficient in their place of work.

The first point, Current Practices, sought to reveal a baseline on practices in the respondents' organisations with respect to SM. The second and third points were derived from the core intentions of the SMF4SME, where the purpose was to provide a lightweight framework for SMPI in SMEs. During the course of the survey a few respondents contacted the researcher noting a degree of confusion regarding “current practice”. Specifically, the confusion related to uncertainty regarding the conduct of any given activity in participants’ current practice for *any* task in their SDLC or particularly in relation to SMPI. Most such participants responded positively to “current practice” irrespective of whether or not they were using it for SMPI specifically. Table 8.3 shows the participants’ responses against the given options for each activity of SMF4SME, where A1 to A9 represent the activity numbers. (The highest proportion in each case is highlighted.)

Table 8.3 SMF4SMEs Compatibility

	Current Practice (CP)		Lean and Sustainable (LS)		Cost & Time Efficient (CT)	
SMF4SMEs’ Activities	Yes	No	Yes	No	Yes	No
A1. **Kick-off Meeting**	77.3%	22.7%	84.6%	15.5%	83.6%	16.4%
A2. **SMPI Seminar**	27.3%	72.7%	77.3%	22.7%	85.5%	14.6%
A3. **Daily quick meetings**	69.1%	30.9%	80.9%	19.1%	77.3%	22.7%
A4. **Execution Meeting**	32.7%	67.3%	69.1%	30.9%	72.7%	27.3%
A5. **Daily quick meetings**	69.1%	30.9%	80.0%	20.0%	70.9%	29.1%
A6. **Data Gathering**	26.4%	73.6%	72.7%	27.3%	77.3%	22.7%
A7. **Analysis Meeting**	28.2%	71.8%	76.4%	23.6%	69.1%	30.9%
A8. **Results Sharing**	33.6%	66.4%	77.3%	22.7%	79.1%	20.9%
A9. **Decision Making**	31.8%	68.2%	78.2%	21.8%	72.7%	27.3%
Average	43.9%	56.1%	77.4%	22.6%	76.5%	23.5%

Three of the nine activities could be considered to be Current Practice as they were employed by more than two-thirds of the respondents. From a structural perspective this result is positive, as the three activities in question are the Kick-off and Daily Meetings, part of the core communication model of SMF4SME. In fact, the intention of asking this part of the question was to determine whether companies already had such activities in their practices, so that SMF4SMEs activities could potentially be merged with organizations’ current practices to minimize implementation overhead. Given what is known from the prior stages of this research it was unsurprising to find that the remaining six activities, which are more focused on SM, do not have the same current traction. That said, none were used by less than one in four respondents, a not entirely discouraging indication of potential uptake. More than that, respondents’ perceptions regarding the ‘Lean and Sustainable’ and ‘Cost and Time Efficient’ aspects of all nine activities in SMF4SMEs are strongly in favour.

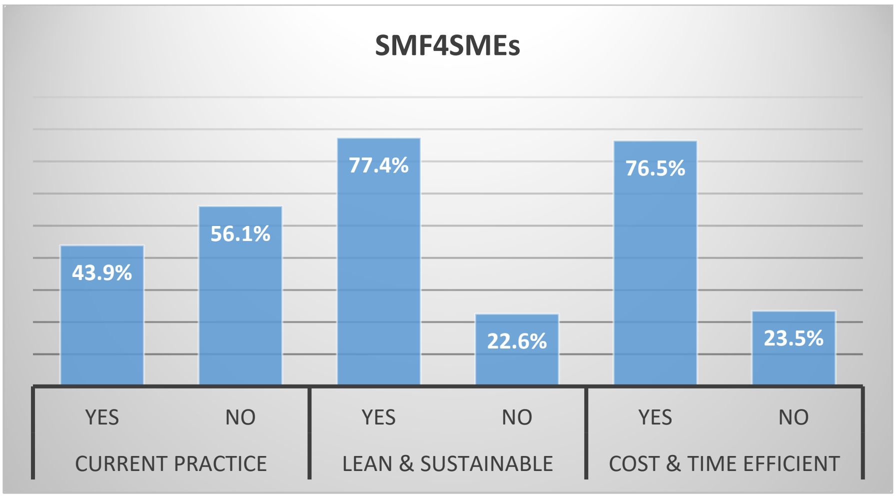

Figure 8-2 SMF4SMEs collective fulfilment of core characteristics.

The findings summarised in Figure 8-2 show that while most of the respondents did not have SMF4SME-related activities in their current practice many of them evaluated the proposed SMF4SMEs as lean and sustainable and time- and cost-efficient. Further comparisons of these responses, considered with respect to SMEs vs. large organizations, and ABC and XYZ vs. respondents from other organizations, are given in Section 8.3.

8.2.3. SMF4SMEs Characteristics

The desired characteristics of SMPI in SMEs were identified and presented in Chapter 6, and as such they provided a basis for developing the SMF4SME. In the survey participants were asked to give their feedback on the extent to which they believed the developed solution fulfilled the required characteristics. Results are shown in Table 8.4, based on the responses of all 110 participants.

Table 8.4 SMF4SMEs Characteristics

Characteristics	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Visible	35.5%	45.5%	13.6%	5.5%	0.0%
Speedy	27.3%	52.7%	17.3%	2.7%	0.0%
Flexible	29.1%	50.9%	16.4%	2.7%	0.9%
Portable	27.3%	50.0%	14.5%	7.3%	0.9%
Informative	35.5%	53.6%	7.3%	3.6%	0.0%
Cost-effective	18.2%	50.9%	20.9%	6.4%	3.6%
Supports sharing	33.6%	45.5%	17.3%	3.6%	0.0%
Lean & sustainable	23.6%	52.7%	19.1%	3.6%	0.9%
Imposes low overhead	27.3%	35.5%	28.2%	7.3%	1.8%
Easy to use and manage	40.9%	45.5%	10.0%	2.7%	0.9%

The results show that participants' strongest agreement was with the characteristics 'Informative' and 'Easy to use and manage'. These are positive results, given that usability is one of the major challenges in SMPI in SMEs, due to SMEs' immature processes and absence of experts. Furthermore, as in the previous section, the results for 'Lean & sustainable' and 'Cost effective' were encouraging.

Though most of the results across all of the characteristics fall into the 'Strongly agree' and 'Agree' categories, the least favoured characteristic is 'Imposes low overhead'. While the agreement rate is satisfactory this result does indicate lingering concerns about the workload implications of SMPI. While the implementation overhead could be reduced, however, it cannot be entirely eliminated.

Figure 8-3 shows that most of the participants agreed that SMF4SMEs appeared to fulfil the desired characteristics. 'Disagree' responses may have arisen in some scenarios as SMF4SMEs may not fit some participants' organization structure or requirements. Overall, 'Strongly disagree' responses are fewer than 1% of the total.

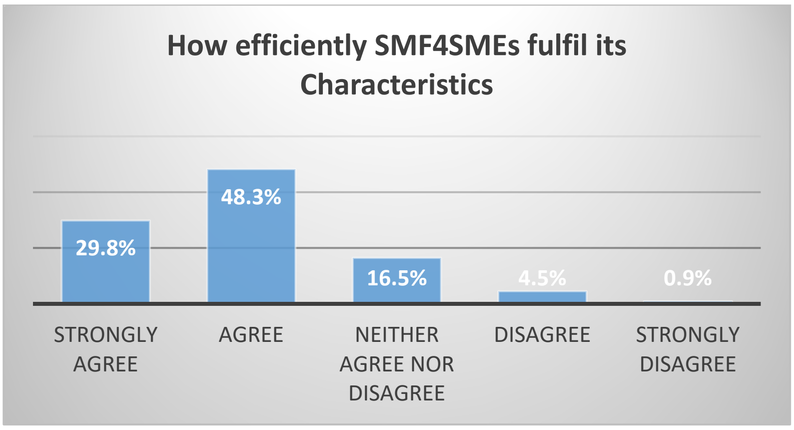

Figure 8-3 SMF4SMEs collective fulfilment of desired characteristics.

8.2.4. SMF4SMEs and SMPI Challenges/Obstacles

Success in SMPI has been impeded by numerous challenges/obstacles so these have received extensive attention throughout this research and were given high priority during the development of SMF4SME. A list of challenges was derived through literature and industrial reviews, and was presented in Chapter 6. In the survey, participants were provided with a five-item ranking scale to indicate their expectation of how well, or how poorly, SMF4SMEs would address the SMPI challenges.

In previous phases of the research (reported in Chapter 4 to Chapter 7) resource limitation was found to be the challenge that was of most concern. Other major concerns among the various possible challenges/obstacles include the implementation cost of SMPI, and difficulties in measurement goal determination. Table 8.5 shows respondents' views on how well SMF4SMEs might cope with or mitigate the listed challenges.

Table 8.5 SMF4SMEs and SMPI Challenges/Obstacles

Challenges/Obstacles	Very well	Well	Adequately	Poorly	Very Poorly
Reluctance to use	30.0%	43.6%	20.9%	4.5%	0.9%
Time consuming	27.3%	39.1%	28.2%	4.5%	0.9%
Resource limitation	27.3%	43.6%	24.5%	4.5%	0.0%
High learning curve	27.3%	40.0%	28.2%	4.5%	0.0%
Experts requirement	21.8%	51.8%	17.3%	9.1%	0.0%
High implementation cost	22.7%	40.9%	24.5%	10.9%	0.9%
Lack of the process/product knowledge	28.2%	44.5%	21.8%	4.5%	0.9%
Measurements goal determination	23.6%	52.7%	19.1%	4.5%	0.0%
Poorly defined escalation procedures	17.3%	49.1%	24.5%	7.3%	1.8%
Lack of awareness about measurement process	32.7%	42.7%	19.1%	3.6%	1.8%
Lack of communication between different levels of Organization	28.2%	48.2%	17.3%	6.4%	0.0%

The results suggest that, in general, respondents believed that SMF4SMEs would address all of the challenges listed at least adequately. Some concern was still evident in regard to the need to have specific measurement expertise in the team, the absence of well-defined escalation procedures and the anticipated cost of programme implementation. Further refinement of the framework, as well as growing experience in its use, should in part address these concerns.

The overall findings shown in Figure 8-4 demonstrate respondents' positive expectations in terms of SMF4SMEs addressing the SMPI challenges/obstacles. These results are encouraging and suggest that the proposed solution could be taken up in practice.

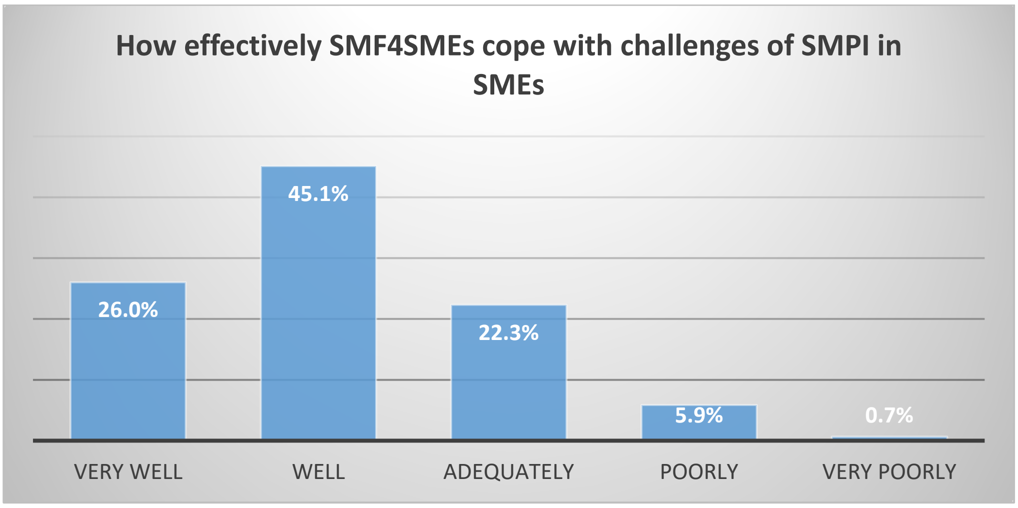

Figure 8-4 Extent to which SMF4SMEs addressed challenges

8.2.5. Are the SMF4SMEs' elements adding value?

SMF4SMEs includes a number of elements (shown in Table 8.6) designed to increase the likelihood of successful SMPI in SMEs, in response to specific requirements and expectations identified in the literature and industrial reviews. These elements were intended to reduce the major issues encountered by those with prior experience of SMPI in SMEs, revolving around awareness, reluctance, complexity and resource limitations. The central element is the checklist that specifies in sequence all the activities of SMF4SME. The associated definition of roles and responsibilities was also built in to address a reported issue of concern for practitioners. The risk factors, success factors and precautions were also provided to enable more detailed understanding of the SMF4SME, to be used as needed. Table 8.6 reports the feedback of the survey participants regarding how useful they expected these elements to be in facilitating successful SMPI in SMEs.

Table 8.6 SMF4SMEs Elements

Elements	Extremely good	Somewhat good	Neither good nor bad	Somewhat bad	Extremely bad
Risk Factors	30.0%	57.3%	11.8%	0.0%	0.9%
Success Factors	30.9%	60.0%	8.2%	0.9%	0.0%
Activities vs Check Lists	41.8%	41.8%	13.6%	2.7%	0.0%
Activities vs Precautions	34.5%	51.8%	10.9%	1.8%	0.9%
Activities vs Roles and Responsibilities	37.3%	51.8%	8.2%	1.8%	0.9%

Opinions were positive regarding all of the framework elements, with most respondents describing each as either somewhat or extremely good. Also of note was the view that the Risk Factors were considered neutral at worst. Overall findings regarding the SMF4SMEs elements, as shown in Figure 8-5, suggest that practitioners might well looks for and value such elements in a measurement solution.

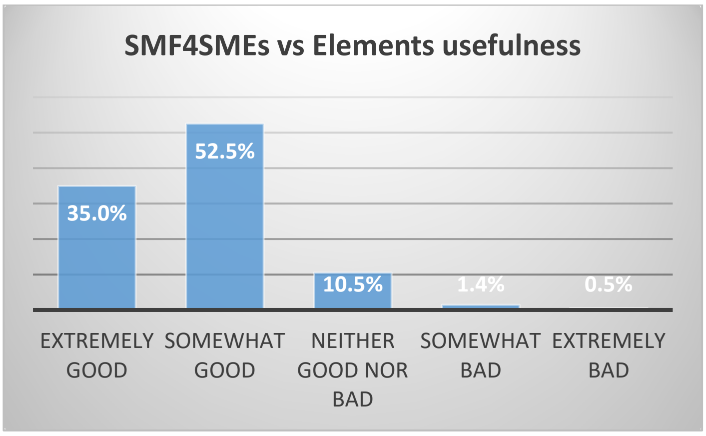

Figure 8-5 Usefulness of SMF4SMEs elements

8.2.6. Why would practitioners consider using SMF4SMEs?

The next part of the survey sought participants' opinions on SMF4SME, including why they or others might be inclined to use SMF4SMEs for SMPI in their setup. Participants were provided with a list of framework properties, as shown in Table 8.7, which were identified in the first research phase. They were then asked to rank the importance of each property from 1 to 5, where the lowest rank was 1 and the highest was 5.

Table 8.7 Why people will be using the SMF4SMEs

	1	2	3	4	5	Rather not say	Don't know
Convenience to user	5.5%	6.4%	33.6%	30.0%	19.1%	2.7%	2.7%
Easy to use and manage	3.6%	10.0%	21.8%	41.8%	19.1%	2.7%	0.9%
Availability of Check Lists	4.5%	6.4%	25.5%	27.3%	33.6%	1.8%	0.9%
Suitable in SME environment	6.4%	10.0%	22.7%	38.2%	19.1%	0.9%	2.7%
Degree of customization possible	5.5%	7.3%	27.3%	40.9%	11.8%	1.8%	5.5%
Roles and responsibilities definition	3.6%	10.0%	26.4%	32.7%	20.9%	1.8%	4.5%
Flexibility to integrate with software development methodologies	5.5%	5.5%	21.8%	36.4%	20.9%	4.5%	5.5%
Implementation guidance e.g. precautions, risk and success factors	3.6%	8.2%	20.9%	32.7%	27.3%	1.8%	5.5%

The results presented in Table 8.7 show that participants saw particular value in the availability of the checklists and the provision of implementation guidance. That said, all of the properties were afforded support. To some extent a degree of user inconvenience was expected, but the results suggest that the cost-benefit of use would be positive overall.

8.2.7. Participants' Opinions Regarding SMF4SMEs

In concluding the survey participants were asked to provide overall opinions and comments on SMF4SME's suitability, likely use, strengths, and weaknesses. They were also asked to identify any gaps and to suggest improvements that could be made to SMF4SME.

Most participants remarked that they felt the provided elements of SMF4SMEs were a good addition to existing approaches to software project management. A selection of excerpts is provided here, and the complete set of feedback as contributed by 60 participants is provided in Appendix 8.4:

1. "*SMF4SMEs appears to be an effective tool as it got clear answers to questions as what would be the role of a person and how we implement the SM strategy. Its checklist is easy to follow and fast to handle so they are most suited for an SME like us.*"
2. "*We found SMF4SMEs a great tool SM process which is suitable for Small companies. Its roles & responsibilities, and check Lists and other guidelines are well structured and easy to use. It is time efficient, but I think daily meetings are a bit excessive.*"
3. "*This is an area we have not investigated. While the process looks promising, we are not an agile software development house. Hence, we would need to evaluate it against our current Waterfall-like processes which are currently being re-evaluated.*"

4. “*It will improve the software quality. Build customer confidence. Improve inter-department communication. Improve process*.”
5. “*As off-shore PM, it will give us really great opportunity to keep an eye on work quality and how it is progressing. It will also help us achieving our business goals.*”

Around one in ten respondents also provided feedback on additional opportunities to improve SMF4SME. Illustrative excerpts from that feedback are as follows:

6. “I think that information would be easier to determine after piloting the process.”
7. “Maybe to make it more specific industrial vertical (domain) as well.”
8. “Automate the framework as much as possible.”
9. “Provide the risk factors for the activities mentioned above, so the users get aware and prepare the better program.”
10. “What I can suggest is to focus on culture and see how that can affect uptake of new frameworks.”
11. “I can tell you that this framework goes against our organizational culture.”
12. “The value proposition over current methodologies is unclear.”
13. “Integrate it with some software development process model and giving roles to the team members other than pm, TL, etc.”

8.3. Discussion

This section considers participants’ comments on the SMF4SMEs and their overall responses to the survey questions corresponding to the survey objectives. The main objective of the survey was to evaluate the perceived usefulness of the proposed SMF4SMEs according to practitioners working in the software development industry. Usefulness was to be considered in terms of providing suitable support to SMEs in implementing measurement programs.

The results in the preceding sections show that the overall response was in favour of the SMF4SMEs perceived usefulness. Participants were provided with either 5- or 6-point scales to answer each question. Typically, participants selected the second highest (or second most positive) scale item for each property of the SMF4SME. The overall evaluation can therefore be taken as signalling that the respondents believe that the SMF4SMEs would fulfil the SMPI needs of SMEs.

8.3.1. Achievement of perceived usefulness

8.3.1.1. Comparative analysis of the usefulness of SMF4SMEs

The information shown in Table 8.8 show the average results considered across a range of comparative dimensions, including type of organization and participant experience, for the overall achievement of each aspect of SMF4SME. Given respondents typically chose one or other of the two most positive items in each scale the percentages for each are also shown.

Table 8.8 Average results across comparative dimensions

	Organizations					
SMF4SME' Aspect	ABC-XYZ (29)		Rest-of-SMEs (63)		Large (18)	
Characteristics	Strongly Agree	Agree	Strongly Agree	Agree	Strongly Agree	Agree
	46.2%	49.7%	24.6%	46.7%	21.7%	51.7%
	Total: 95.9		Total: 73.3%		Total: 73.4%	
Challenges	Very well	Well	Very well	Well	Very well	Well
	44.5%	51.4%	21.2%	41.7%	13.2%	47.0%
	Total: 95.9		Total: 62.9%		Total: 60.2%	
Elements	Extremely Good	Somewhat Good	Extremely Good	Somewhat Good	Extremely Good	Somewhat Good
	52.4%	44.1%	26.3%	55.9%	36.7%	54.5%
	Total: 96.5%		Total: 82.2%		Total: 91.2%	
	Experience					
	Senior (68)		Junior (42)			
Characteristics	Strongly Agree	Agree	Strongly Agree	Agree		
	31.6%	46.5%	26.9%	51.2%		
	Total: 78.1%		Total: 78.1%			
Challenges	Very well	well	Very well	well		
	27.5%	46.1%	23.6%	43.5%		
	Total: 73.6%		Total: 67.1%			
Elements	Extremely Good	Somewhat Good	Extremely Good	Somewhat Good		
	37.6%	52.9%	31.4%	51.9%		
	Total: 90.5%		Total: 83.3%			
	Roles					
	Top-Management		Other-roles			
Characteristics	Strongly Agree	Agree	Strongly Agree	Agree		
	33.4%	47.6%	28.5%	48.5%		
	Total: 81%		Total: 77%			
Challenges	Very well	Well	Very well	Well		
	20.7%	46.4%	27.9%	44.7%		

	Total: 67.1%		Total: 72.6%	
Elements	Extremely Good	Somewhat Good	Extremely Good	Somewhat Good
	44.1%	46.2%	31.6%	54.8%
	Total: 90.3%		Total: 86.4%	
	Prior Software Measurement Knowledge			
	Yes (70)		No (40)	
Characteristics	Strongly Agree	Agree	Strongly Agree	Agree
	32.3%	50.7%	25.5%	44.0%
	Total: 83%		Total: 69.5%	
Challenges	Very well	Well	Very well	Well
	29.6%	48.6%	19.8%	39.1%
	Total: 78.2%		Total: 58.9%	
Elements	Extremely Good	Somewhat Good	Extremely Good	Somewhat Good
	38.9%	48.9%	28.0%	59.0%
	Total: 87.8%		Total: 87%	

Results of particular note from the table are as follows:

- Respondents from the two companies involved in the field studies were more positive than those of others – perhaps due to their clearer understanding of SMF4SME, or how it could be used in practice;
- More experienced respondents and those holding management roles tended to be more positive about SMF4SME;
- Those who claimed to have prior software measurement knowledge felt that SMF4SMEs had the desired characteristics and dealt with measurement challenges more effectively than those not familiar with software measurement;
- While differences including those just listed were evident, overall opinion regarding the usefulness of SMF4SMEs was overwhelmingly positive.

8.3.1.2. Participants' comments

This section presents a summary of the participants' free-text comments on the SMF4SME, as provided at the end of the survey. Out of 110 participants 60 provided their feedback, even though it was optional step. The feedback is presented according to organization type, comprising respondents from ABC and XYZ, respondents from other SMEs, and respondents from larger organisations. (More fine-grained feedback from participants taking account of their knowledge, experience, role, and organization type/size is provided in Appendix 8.4.)

ABC Feedback: ABC is a medium-sized organization in which the SMF4SMEs was initially designed, through Case 1, and then evaluated, through Case 2. These back-to-back cases were conducted on two different projects in ABC. The responses of ABC's participants in the survey were mostly in favour of SMF4SME; the majority of the respondents were involved in SMF4SME's development and so had some understanding of the framework and the process.

Most of the ABC participants commented on the specific elements of the framework (such as checklists, roles, and responsibilities), and considered them to be useful. Their comments (listed in detail in Appendix 8.4) show that these practitioners were looking for definitions of roles-and-responsibilities in relation to performing SM activities: "*The SMF4SMEs got clear answers to the questions like what would be the role of a person and how we implement the SM strategy.*" Moreover, the provided checklists were considered as a time saver and an important motivation for practitioners considering the implementation of SMP: *"The SMF4SMEs checklists and other guidelines are great ways to do the measurements in a timely manner*." Further, the participants commented positively about the visibility of work that was achieved through use of the SMF4SME: "*The SMF4SMEs is a good step towards keeping the processes and progress more visible and in control*." Finally, and importantly, the CEO commented that "the *SMF4SMEs will give me more control and visibility of my business*."

In terms of critical feedback the respondents commented on the length of the implementation guidelines and suggested that they be made more succinct – though no specific suggestions were made as to what could be removed or reduced: "*the SMF4SMEs guidelines are very lengthy*."; "*the SMF4SMEs guidelines should be converted into user manual*." In terms of the framework's use one respondent noted a degree of concern over meeting overload: "*the SMF4SME's Daily meetings are a bit excessive.*"
Some of the participants from ABC also suggested improvements for SMF4SME. One participant recommended that "*further automating the SMF4SMEs can reduce quite a good workload from my team*." While the fact that SMF4SMEs facilitated the definition of both measurement and business goals was welcomed there was a desire to see these steps better connected ("*link GQM with our business goals*") and others requested further support for this step ("*add some examples for them.*"). Overall, however, the respondents from ABC seemed to be satisfied with the SMF4SMEs and stated as much, for instance: "*it is suitable for small and medium size organizations*."

XYZ Feedback: XYZ is a comparatively smaller organization. XYZ was 'home' to Case 3, which was conducted during SMF4SMEs development to further refine and evaluate the framework. XYZ's respondents to the survey noted their small size and requested that more templates be provided: "*a small setup same like us need some more enhanced SMF4SMEs checklists with more details. I would suggest adding more examples and details in your* *checklists*". Further, another participant commented similarly: "*it will be great if the SMF4SMEs provide some template of reporting the different metrics*."

As with ABC's participants, the elements of SMF4SMEs were found to be reviewed favourably by respondents from XYZ: "the *SMF4SMEs has really good features checklists, roles responsibilities, and above all the list of goals and metrics*."; "*… are extremely helpful*"; "*… are so much effective*". One participant commented particularly on the value of SMF4SME's integration with their current development methodology: "the *SMF4SMEs is merged with our current methodology which mainly save the time of implementation*."

The XYZ participants were found to be somewhat concerned about goal definition steps of the framework, both their clarity and their separation: "*give more understanding of measurement goals definition*."; "*add business goals in that list and link with measurement goals,*" "*…business and measurement goals link any example*!" and "*…some standard set of business goals and their link to measurement goals*." These comments are also in line with those made by the respondents from ABC.

While generally supportive of the guidelines overall they commented critically on their length: "*The SMF4SMEs implementation guideline is quite a lengthy*." Another objection from the XYZ participants was in regard to the frequency of the daily meetings: "*Daily meetings are not good for our work structure…*" They suggested that "*2, or 3 quick meetings a week should be enough, followed by a sprint meeting on the last day of the week*." Similarly, a couple of participants commented on daily meetings as "*…quite time-consuming*" and suggested, "*…need-based or 2 or 3 meetings a week*." Another participant commented on the mixed utility of the GQM approach: "the *SMF4SMEs also providing the questions with goals and metrics which is good, but we don't have any interest in them. They are good for better understanding*". This issue was also observed during the field studies: participants were interested in measurement goals and the metrics they should collect, but not in the questions.

In terms of further improvements they suggested that framework automation would be beneficial: "the *SMF4SMEs metrics data collection and results analysis should be automated to save more time*." Further, they asked to add "*measurement related activities at the time of requirement engineering*" and more generally suggested "*adding the guidance about your framework SMF4SMEs implementation during each development phase*."

Overall the XYZ respondents seemed generally satisfied with the SMF4SMEs proposal. One participant commented on the SMF4SMEs comparative to CMMI: "*I have some exposure to* *the software process improvements using CMMI; I find comparatively this framework quite simple and easy to handle. I like especially the way of providing the support products*". In general, participants saw the SMF4SMEs as "*simple and straightforward*," "*a perfect proposal for SM Activity,*" "*a good proposal from SM process*", and "*an effective proposal for SM processes*."

<u>Rest-of-SMEs Feedback</u>: After excluding the respondents from ABC and XYZ there were 63 survey participants from other SMEs ("Rest-of-SMEs"). As noted above the feedback from these participants was generally less positive than that received from the ABC-XYZ respondents, and they provided more suggestions for improvements.

That said, participants in this group were still satisfied overall with SMF4SME. Positive feedback traversed a range of aspects: "*Benefit in managing easily roles and responsibilities as per the organization requirements*." A participant mentioned that these elements could be used "*to achieve organizational goals*." Another participant remarked that the "*Processes and activities described in the SMF4SMEs are delicately designed*."

Several participants noted a need for alignment and/or integration with their existing methodology or process. One of the participants commented "*We would need to evaluate the SMF4SMEs against our current Waterfall-like processes which are currently being re-evaluated*." Another participant commented that "*Integrating the SMF4SMEs with our existing individual performance assessment*." would be important. Although individual's assessment is a barrier in SMPI as discussed earlier in thesis, still this could be an option if someone wants to use for specific purpose. Another participant commented similarly that "the *SMF4SMEs should integrate with software processes, and there should be an explanation about how to merge the SMF4SMEs with each software development process*".

A further participant asked "*how the SMF4SMEs will handle non-functional requirements such as usability and user experience*" – a good question. The key point to note in this regard is that the SMF4SMEs is primarily concerned with enabling organisations to create a functioning SMPI environment; specific support for particular SDLC aspects (such as handling non-functional and functional requirements) could be incorporated as specific instances of measurement (and could be demonstrated in further work). One participant suggested that "*Client participation and interaction should be highlighted more*". Again this is reasonable – client collaboration was not addressed in any major way yet in development of the current version of SMF4SME, but could be considered in future development.

Concerns over the daily meetings and implementation guidelines were also pointed out by participants from this group. Rest-of-SMEs participants pointed that any approach should "*minimize meetings so developers can focus on code time, which means utilizing smarter software to aggregate those metrics that PMs care about*", and "*Strictly following daily meeting approach seems a countable con while accessing it critically*." Further, they commented that the "*Implementation guideline is quite a lengthy document*" and suggested "*Shorting that to attract people to use your framework*." Regarding goals and metrics, a participant commented as follows: "*I think providing a list of goals and metrics is great*" and suggested "*Need some addition - standard matrix required.*"

There are a few useful excerpts from the Rest-of-SMEs participants' general comments on the usefulness of the framework, such as: "it *will improve the software quality*", "*Build customer confidence*", "*Improve inter-department communication*", and "*Improve process*". Further, they suggested that the SMF4SMEs "*Need[s] more work on user visibility, diagrammatic access to all users and motivation,*" "*automation and then more centralized control through project leads*", and that the "*flow of information and communication should be stronger for the success of any process*."

Overall these participants were found to be satisfied with the SMF4SMEs proposal. They noted that the SMF4SMEs "*process looks promising*", "*is really good and suits our company very well*", "*is a good proposal indeed*", "*is the need of time when everyone is busy especially in the SMEs*", "*very efficient*", "*helpful for the SMEs due to its flexibility*", "*is time-saving and easy to manage", and is "quite simple as per its activities*". This positive feedback is particularly affirming given the intent of this research, to provide an approach that is suitable for SMEs, and given that these respondents were from SMEs other than those involved in the field studies conducted as part of this study.

Large organizations feedback: Unsurprisingly there were relatively fewer survey participants from large (non-SME) organizations – of the 110 respondents just 18 were from larger organizations (and only five of these provided comments). Even so, these organizations' participants could see the potential utility of SMF4SME: "*This framework is quite easy to understand*."; "*Roles and responsibilities, success and risk factors are good*"; and "*checklists and roles and responsibilities division is good to manage the measurement process*."

A concern expressed by large organization respondents consistent with those made by others regarded the scale of the implementation guidelines: "*The provided guideline is too lengthy to follow*" and suggested that the "*Guidelines should be small and concise*." Further suggestions made were to "*add some practical examples of the complete process*", "*The framework should be easily adaptable and manageable and professionally worked out*." Another participant asked "*Can we introduce something which helps to communicate the measurement decisions to the developers at PBI (product backlog item) level*." Similarly consistent was respondent disquiet over daily meetings: "*Minimize daily meetings, should be maximum twice in a week and should be a more focused follow-up of each activity signed offs after implementation of each activity*."

8.3.1.3. SMF4SMEs' Characteristics

Based on the findings of the reviews of the research literature (Chapter 4) and industry practice (Chapter 5) a list of properties/characteristics was formulated as being relevant to any lightweight SMF. These characteristics should be met if the SMPI challenges faced by SMEs are to be overcome via any proposed solution. Table 8.9 presents these characteristics and describes how they are fulfilled through the framework proposed here, SMF4SME.

Table 8.9 Required Characteristics and SMF4SMEs

Characteristic	How fulfilled
Visible	Daily meetings ensure measurement is raised and addressed frequently.
Speedy	Results are available after each phase completion. Framework produces overall results quickly.
Flexible	Determination of measurement goals can be achieved with or without a formal method. Synchronization of meetings schedules with routine meetings. Customization of roles and responsibilities. Optional checklists.
Portable	Independent of methodology/process. Could be integrated with any methodology/process.
Informative	Descriptive Check Lists, Roles and responsibilities, Precautions, Activities.
Cost-effective	No need for experts to be hired. Not too time consuming for arranging extra meetings and GQMs determination.
Supports sharing	Daily and Weekly Meetings. Using backlogs in Agile. Meetings discussions, and feedback.
Lean & sustainable	Framework following short time span, its use is economical, easy to use and manage, easy to learn and quality activities. Above all consists of 3 phases having nine steps in total.
Easy to use and manage	WBS, Implementation guidelines, Database.
Imposes low overhead	Database, Check Lists. No specific knowledge required for implementation, supported by predefined measurement goals and set of metrics.

8.4. Summary

The survey presented in this Chapter was conducted to further evaluate the perceived usefulness of the SMF4SMEs as developed in earlier phases. A survey was designed and distributed to software development organizations and to members of companies ABC and XYZ. In total 110 practitioners responded to the survey: 29 were from the ABC and XYZ SMEs, 63 were from other SMEs, and 18 were from large organizations. Of the 110 participants, 70 stated that they had prior SM knowledge, 68 had experience of six years or more, and 29 held top management roles. This mix of characteristics lend credibility to the results, in that the respondents seem sufficiently qualified to complete such a survey.

The findings regarding the core activities of SMF4SMEs indicate that they can be considered to be lean and sustainable and time-and-cost efficient. Further, the activities associated with meetings (underpinning the framework's communication model) fit with the common practices of SMEs – albeit the general opinion was expressed that fewer additional daily meetings be implemented in support of SMPI. Feedback regarding the fulfilment of the desired characteristics of a suitable solution, and its addressing of relevant challenges, are quite satisfactory. The comparative analyses based on organizations and participants were encouraging, in that the more experienced respondents and those in management in SMEs were positive regarding the perceived usefulness of the framework.

Of the 110 participants, 60 commented on the SMF4SME. The majority of the participants were satisfied with the proposed SMF4SMEs and its elements, especially the roles-and-responsibilities, checklists, and predefined goals/metrics list. Some are seeking enhancement of the checklists, particularly in terms of working examples and templates for goals, metrics, and analysis reports. The participants also commented consistently on the length of the implementation guidelines and suggested that it should be made more concise – though how in particular that might be achieved, given there were corresponding requests for more information (e.g., regarding goal definition) was not reported.

Part 4: Conclusion

This part of thesis summarises and reflects on the overall findings of this study with respect to the research questions and objectives stated at its outset. The limitations of the research and threats to its validity are also considered. Finally, the contributions of the research are described and opportunities for future work are identified.

Chapter 9 Discussion and Reflection

This Chapter 9 discusses the findings of the research reported in this thesis and considers those findings in relation to the extant literature. These considerations are divided into three phases: problem identification, solution design, and evaluation, so as to align with the adopted research methodology of Design Science Research (DSR). Moreover, each phase discusses the findings in relation to the corresponding research questions as listed in Chapter 1 (and restated here).

This research was undertaken in order to both understand and improve how software SMEs (SMEs) implemented SMP in their working environment. The initial intention was to look at how SMEs selected only those metrics that are consistent with achieving company goals. During the literature review, however, it became evident that SMEs are 'one step behind' this particular issue. That is, the very definition of key functional process and product measurement continues to be difficult for many software development enterprises (SDEs). Moreover, the specific concerns of SMEs related to SMP initiation, definition, and implementation are inadequately explored in the current literature – in spite of the importance of SMEs to many economies. As such there is a need to investigate how SMEs can successfully implement SMP. As such, this research addresses how SMEs could initiate, plan and implement an effective measurement program by addressing the recognised SMPI challenges in SMEs.

The first phase of the research was problem identification. The existing literature was critically reviewed and then, based on the findings of that review, an industrial review was conducted. This revealed some additional insights but also served to validate the problems identified in the literature review but from the practitioner point of view. Following problem identification the next phase was solution development, which was conducted *in situ* through field studies in the SMEs ABC and XYZ. A Software Measurement Framework for SMEs (SMF4SME) was iteratively developed, evaluated and refined through three field studies; two in the medium-sized organization ABC and one in the small-sized organization XYZ. The third phase of the research sought to further evaluate SMF4SMEs through a survey of SME practitioners' feedback on the perceived usefulness of SMF4SME, garnering 110 responses.

Figure 9-1 depicts the findings of each research phase in summary form, and these are further discussed in this Chapter 9. The items highlighted in yellow are the key terms used in this

Chapter 9, and the items shown in green are the novel contributions of this research work. The explosion shapes in Figure 9-1 show the outcomes of each phase.

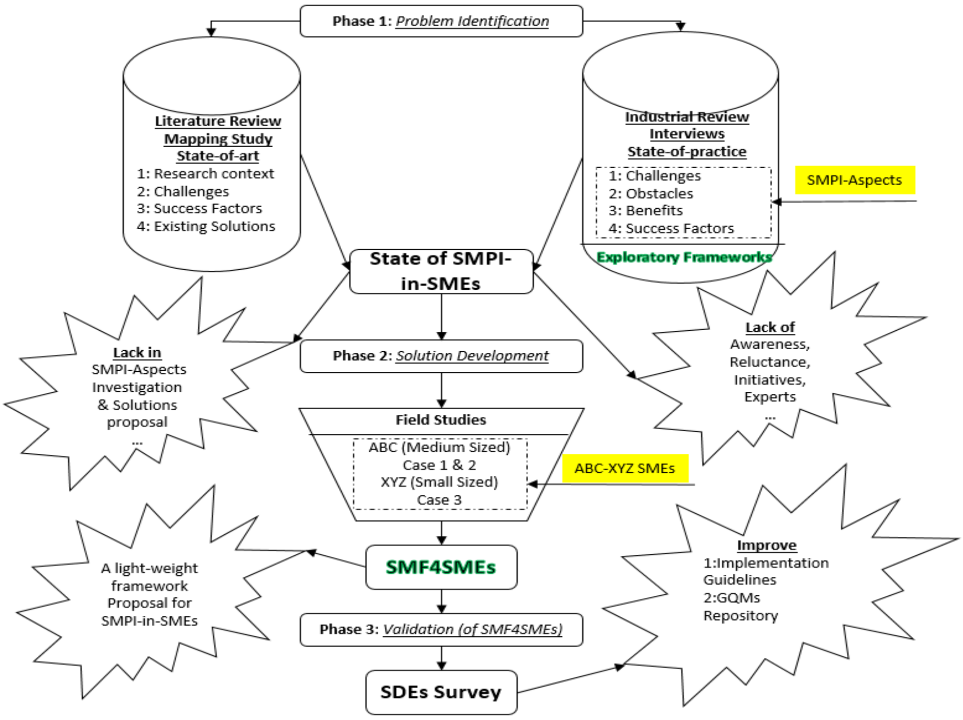

Figure 9-1 Research Findings

The remainder of this chapter is structured as follows. Section 9.1 presents the problem identification phase of DSR and discusses the findings of the literature and industrial reviews. Section 9.2 addresses phase 2 – solution design – with a focus on the findings determined through the field studies. Section 9.3 reports on the findings of Phase 3 of the research, which centres on the framework's evaluation through an industrial survey. Finally, Section 9.4 gives a brief summary of this Chapter.

9.1. Phase 1 Problem Identification

The first research phase was conducted in two steps to determine the current state of SMPI in SMEs. The first step was intended to ascertain the state-of-the-art through a review of the existing research literature. A systematic mapping study methodology was adopted to ensure that the researcher was able to produce a comprehensive overview of existing knowledge on SMPI in SMEs. Drawing on the results of the literature review the second step was intended as an exploration of SM practices in industry, emphasising the challenges faced and any success factors, based on 22 face-to-face interviews with SMEs practitioners.

The results of the literature review were presented in Chapter 4. In general these confirmed prior research outcomes. However, aspects of the findings discussed in these sections built on those previously reported results in the SMPI in SMEs body of knowledge. Additionally, a number of challenges, obstacles and success factors were listed which had not been highlighted in any previous research regarding SMPI in SMEs. Furthermore, the findings of the industrial review, presented in Chapter 5, describe the current challenges and obstacles, and the risk and success factors as reported by more than twenty SMEs practitioners.

Taken together the findings show that very little attention has been paid to the topic of SMPI in SMEs which suggests that the application of SMPI in this sector is not performed at an adequate level. Greater emphasis has been placed on internal core measurement-related activities focused on measurement goal definition and metrics selection, as compared to SMP definition, initiation and management activities. Measurement goal definition and metric selection are certainly important steps though they are known to be difficult, especially for SMEs. Meanwhile, SMP initiation, definition, and implementation are overlooked, due to a lack of guidance. As a result practitioners do not use SMP, they have neither the evidence nor the confidence to say how long a project or product will take to complete, or how much budget is required. Instead, they tend to rely on experts' judgments only.

9.1.1. RQ1 Findings and Discussion

The first research question asked "**RQ1:** *What is the state-of-the-art of SMP-in-SMEs?*" This question was addressed through the systematic mapping study, providing a comprehensive depiction of the current state of knowledge as reported in the literature (and also informing issues to further investigate through the industrial review).

The core outcomes of this step in the research were the lists of SMPI challenges and success factors. The challenges that SMEs may face when embarking on SMPI had not been reported previously, and none had been highlighted in the particular context of SMPI in SMEs. Further, upon investigation of the existing SMPI solutions, just two were found that had targeted their effort to SMEs. Even then, they were focused on addressing the (genuine) challenges of GQM definition, whereas the core problems identified at the time of the literature review centred on solution complexity, creating reluctance due to limited awareness, feeding into hesitance regarding SMP initiation.

To the best of the researcher's knowledge, the only solutions found for SMPI in SMEs were GQM-Lightweight and MIS-PyME. GQM-Lightweight was designed to reduce the overhead of GQM and to incorporate some reusability features to make it more applicable for SMEs.

MIS-PyME follows GQ(I)M and additionally includes a measurement capability maturity model (MCMM). This seems in fact to be in contrast to what is needed in SMEs – in GQ(I)M the “I” stands for “indicator” and is additional to ‘standard’ GQM, and the inclusion of a MCMM layer may make use of the process more complicated and more costly to implement. MIS-PyME seems most applicable to relatively mature SMEs that have achieved some CMMI levels already. Further, MIS-PyME was developed in a medium-sized organization in which SMP was already embedded, through the efforts of a measurement expert. The focus of SMF4SMEs is different – it is intended to be simple, and is focused on SMP initiation, planning, and management. It is quite possible that the existing solutions would indeed work in particular conditions with organisations already some way down the SMPI pathway, but if an organisation is unable to initiate the SM process then there is quite simply no SMP to fully define (through GQ(I)M), or assess (through MCMM).

Further, the researcher was unable to find any independent validation of GQM-Lightweight and MIS-PyME in related research. These solutions seem not to be widely acknowledged beyond the work of the authors who had proposed them, and there is no explicit guidance as to how they each cope with SMPI challenges. This apparently limited traction in industry, coupled with what seemed to be a mismatch between the challenges faced by SMEs and the nature of the solutions, led the researcher to seek further direct input from industry as to the desired characteristics of a new solution.

9.1.2. RQ2 Findings and Discussion

The second research question in the problem identification phase was “**RQ2:** *What is state-of-practice (in industry) of SMPI in SMEs*?” In this research step the objective was to turn to the industry to investigate the practice of the context area, SMPI in SMEs. The methodology adopted was qualitative in nature, involving conducting practitioners’ interviews from SMEs.

The industrial review was more focused than the literature review, where the emphasis was to understand the SMPI success factors, challenges, and any solutions adopted in SMEs. It extends the findings of the literature review and contributes further toward the identification of SMPI challenges and success factors. The results of the industrial and literature reviews had some aspects in common. Additionally, however, the industrial review revealed a number of challenges and success factors that had not been discussed in the literature. The identified challenges were then categorized as obstacles and challenges, based on their nature. The benefits of SMPI were also identified through the interview data analysis. Hence, the industrial review outcomes collectively considered four aspects of SMPI: challenges, obstacles, benefits, and success factors. Each aspect in turn addressed multiple factors. The (limited) prior research that had specifically investigated the context of SMPI in SMEs did not highlight most of the factors considered across the four aspects of SMPI, nor did the existing solutions address them explicitly during their development. The identified aspects of SMPI were represented as exploratory frameworks and in turn formed a basis for the proposed lightweight solution for SMPI in SMEs that emerged in the solution development phase of this research.

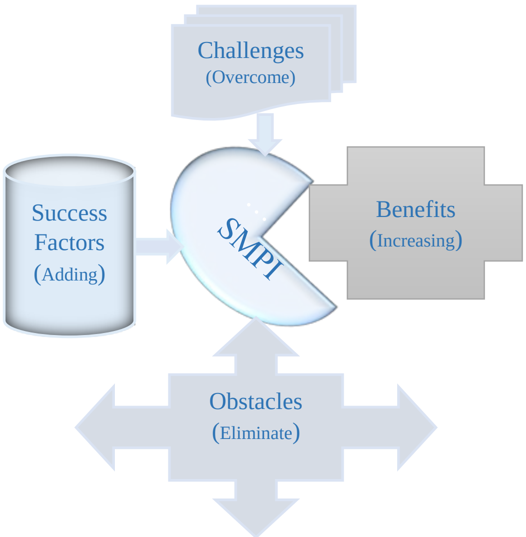

Figure 9-2 SMPI-Aspects

By employing grounded theory (GT) techniques (Glaser & Strauss, 2009; Hoda et al., 2012) the exploratory frameworks have a level of robustness that might not be achieved through interview review alone. Constant comparison enabled the determination of a form of consensus regarding insights into the current state of practice. Further, the application of GT in this research step enabled the researcher to elaborate the relationships between each factor in each aspects of SMPI. SMEs practitioners were generally found to be more interested in and satisfied with agile based methodologies, rather than using SMPI to improve productivity, quality, visibility and other characteristics. As Ruiz et al. (2011) noted when discussing SMPI through ISO/IEC and CMMI, the use of such models typically increases the difficulty of adopting SMPI because of their breadth of coverage. Most of the interviewees were found to be largely unaware of SMPI, and were initially reluctant to use it. That said, after further discussion of the *wider business objectives* of SMPI, most of the same interviewees agreed that the right implementation of SMP could contribute to '*Company Success*.'

9.1.3. RQ3 Findings and Discussion

The third research question in the problem identification phase of the research was "**RQ3:** *What are the differences in the challenges and success factors for SMPI implementation as identified* *in the literature and industrial reviews?"* At this stage the objective was "to analyse comparatively the state-of-the-art and state-of-practice: to identify the research gap in the context of SMPI in SMEs". Based on this comparative analysis the conclusion was drawn that to achieve successful SMPI in SMEs effective initiation and planning are crucial, and where the first step should be to provide awareness to process stakeholders, supplemented by ongoing follow-up through existing communication channels. Ideally the SMPI process should be transparent to all stakeholders, and the solution should be equipped with implementation guidelines and maximum support material, so that the stakeholders can apply minimum effort in identifying and defining the material relevant to them.

9.1.4. Phase 1 Outcomes

The findings of the literature and industrial reviews signalled that there are very few existing solutions that support SMP definition, initiation, and management. Moreover, those solutions have inherent complexities and particular foci. On the other hand, practitioners in SMEs were still relying on *ad hoc* approaches for SMPI-related activities. They required targeted guidance on simple processes for SMPI definition, initiation and implementation which comply with their limited awareness and constrained resources.

9.2. Phase 2 Solution development

The second phase of this research was centred on the development of a proposed solution to the problems that had emerged in Phase 1. To be successful the solution needed to be a simple and lightweight SMPI solution that coped with the challenges and obstacles faced by SMEs. Additionally, it would need to fulfil current requirements without compromising future needs. The contributions of this research phase are the identification of the desired characteristics of SMPI in SMEs and the proposed lightweight SMF4SME, discussed as follows.

9.2.1. RQ4 Findings and Discussion

Building from the literature and industrial review outcomes the next research question to be addressed was "**RQ4:** *Can SMP be implemented effectively and efficiently in SMEs?"* To answer RQ4 this section discusses the findings of the researcher's field study experiences in defining, initiating, and implementing measurement programs in companies ABC and XYZ, where the objective was to provide appropriate support to SMEs in SMPI. In particular this section considers the strategy followed in the development and implementation of SMPs by taking the characteristics of the companies into account, thus identifying practices that could be applied in other similar environments. The participants from the ABC and XYZ field studies were not expert in SMP, and the companies' culture was poor regarding SMP. As a result most of the participants were reluctant to participate in the SMPI process initially for solution development, but they were convinced through implementation with the passage of time.

A framework referred to as SMF4SMEs was developed in iterations in the chosen companies, in order to make SMPI initiation and implementation easy for SMEs. The SMF4SMEs was developed through field studies in which the researcher had a coaching role, providing SMPI knowledge as needed and supporting the participants in their defining of suitable measurement plans. The final iteration of SMF4SMEs comprised nine core activities, implementation guidelines, and supporting elements such as precautions, checklists, risk and success factors, roles-and-responsibilities definition, and guidelines for integration with companies' development methodologies. It is contended that SMF4SMEs should improve the adoption of SMPI in SMEs because it is specifically designed for SMEs: their characteristics, size, knowledge level, processes maturity, limited resources (e.g. budgetary constraints, experts), and strict timelines. Therefore, such companies, which conventionally do not take on SMPI initiatives (Diaz-Ley et al., 2008) due to limited resources, should benefit.

The richness of SMF4SMEs comes through its nine defined activities where the main value is provided in the supporting elements such as roles-and-responsibilities definition, checklists, and listed precautions. In particular, the definition of roles-and-responsibilities and the availability of checklists should be of value to non-mature SMEs as they typically do not have measurement experts and knowledge in house. The involvement of top management in clarifying the business objectives and in framing suggestions for measurement program initiation in line with organizational goals is crucial in motivating other stakeholders.

The first part of SMF4SMEs was conducted with an emphasis on SMP planning and giving awareness to the participants. The first implementation of the framework took place during Case 1, in medium organization ABC, because the process was being developed from scratch through that implementation working with practitioners in real time. While much the same steps were performed for Case 2 in ABC and Case 3 in XYZ the intent in those cases was to evaluate and refine the proposed solution.

The second part of SMF4SMEs is challenging and more technical, emphasizing as it does the GQM definition and metrics data collection. While there was no pre-set need to define the measurement goals using GQM, especially for SMEs with non-mature processes the provision of pre-populated checklist of GQMs within SMF4SMEs proved to be effective. The aim is to provide a list of 'commonly useful' GQMs that fulfil SMEs' basic SMPI needs.

The third part of SMF4SMEs centres on the analysis of the collected metrics data but emphasizes that the analysis results must be shared with all SMPI participants. This is somewhat in contrast to conventional approaches to measurement, where results were 'held' by managers, and this fostered a suspicion that such data could be used for performance measurement of individuals. This can clearly affect participant willingness to collect metrics data, and can feed into participants provided data they think their managers want to see, as opposed to the 'true' data (Haddad et al., 2012). It is therefore important that participants realize that the metrics data will be used for project or product improvement purposes and not for their performance evaluation. In addition, through the effective sharing the SMPI results, they are also able to gain a clearer picture of data usage, develop more awareness of the potential value of measurement, and so have greater confidence in their participation and programme implementation in future.

The implementation effort and cost were kept as low as possible through reusability, illustrated by use of the predefined activities of the first case during the refinement of SMF4SMEs activities via implementation of the second case, in ABC, and the third case, in XYZ. These refinements could be considered part of the evaluation of SMF4SME. Implementation effort was reduced by approximately 40% to 45% during the second and third implementations.

The SMF4SMEs puts great emphasis on communication because this is considered as a particular strength of SMEs (Hashim, 2015), facilitating information flow and knowledge sharing. The SMF4SMEs communication model maps to 'standard' weekly and daily meetings, a key to making SMPI successful. Another issue that arose during the industrial review was about balancing the necessary learning curve with staff turnover. The job switching rate is higher in SMEs where people move frequently across SMEs or 'up' to the large companies. To tackle such issues the SMF4SMEs activities were kept as simple and self-explanatory as possible, with additional elements included to support the implementation.

This section was founded on evidence that SMEs have various problems in adopting SMPI, and are hesitant to take SM initiatives due to their specific characteristics and limitations. Therefore, a customized approach was proposed for SMPI in SMEs, in the form of the SMF4SMEs framework. It may be argued that such a development would be unnecessary in the presence of universal and validated models for SMPI. However, models proposed to date are neither universal nor validated (and certainly not for SMEs); hence the measurement implementation process was customized to the SMEs environment.

The SMF4SMEs was developed and refined through three back-to-back cases, where the first could be considered as primarily a development cycle and the others as verification and validation cycles. This process afforded the researcher an opportunity to seek suggestions from the participants, to analyse problems more deeply, and ultimately to make the SMP more useful. As the projects proceeded so further participants became involved in SMPI, as they became more knowledgeable and more comfortable with the implementation. Overall the implementation results suggest that use of SMF4SMEs can minimise the implementation effort required and can 'fit in' with the resource limitations faced by SMEs. Appropriate use of the supplementary elements appears to provide a sufficient level of support to enable SMEs to meet their requirements for SMPI.

9.2.2. Phase 2 Outcomes

The SMF4SMEs was developed in response to the accumulated findings of the literature and industrial reviews and was customised to match the characteristics required of SMPI in SMEs. It is also flexible enough to integrate with any development methodology. During the field studies it was observed that an SMP should be established with a small group or unit comprising fewer than 20 people, and that the duration of the implementation should not exceed more than six months; ideally it should take three to four months. The proposed solution definition should not focus on defining SMP for a particular type of project, as this might result effectively in 'over-fitting', making it difficult to apply in other settings. Rather, it should be generic, and in organizations with limited resources, such as SMEs, there should be a focus on the reusability of their SMPs. Another concern was that while the business goals should be distinguished from measurement goals, and the proposed SMP solution should focus on delivering against the measurement goals, a link between the two should be created and made explicit to all.

The results of the application of SMF4SMEs in practice (in companies ABC and XYZ) indicate that the framework is suitable for establishing effective SMPI in SMEs. It was observed that the framework and its elements could minimise SMPI effort in the contexts of initiation, definition, planning, execution, and implementation management. The ABC and XYZ participants were satisfied with the SMF4SMEs development and reported that the framework covered most of their SM needs. The framework was therefore well integrated into their development methodologies.

9.3. Phase 3 Solution validation

Phase three was conducted to further assess, and quantitatively validate, the findings of the solution development phase of the research. This phase was also conducted to obtain a degree of independent insight into the perceived usefulness of the SMF4SMEs and its elements in the SMEs context (although the opinions of practitioners working in non-SMEs were also sought).

9.3.1. RQ5 Findings and Discussion

The third phase of this research addressed the research question "**RQ5:** *Does SMF4SMEs fulfil the requirements of SMPI in SMEs?*" The objective of this research phase was to evaluate the perceived usefulness of the proposed framework according to practitioners working in SDEs. A questionnaire-based survey was designed specifically for this purpose.

The overall results of this phase were promising and confirmed the perceived usefulness of SMF4SME. The results suggest that the provided elements are fit for purpose, and can play an important role in successful SMPI in SMEs. While the checklists and definitions of roles-and-responsibilities to perform each SMF4SMEs activity were considered as being of particular value, by respondents from SDEs of all sizes, all of the elements were rated positively by the survey participants. In terms of areas needing improvement, respondents noted that the guidelines were lengthy and so implementation could still be time-consuming; and that the determination of measurement goals continued to be particularly difficult – even though this had been offset to an extent by the provision of 'pre-specified' GQMs.

Table 9.1 Challenge resolution through each SMPI in SMEs solution

Challenges Resolved?				
Challenges	SMF4SME	GQM-Lightweight	MIS-PyME	HMP
RL	Yes	Partially	Partially	No
LA	Yes	No	No	No
SC	Yes	Yes	Partially	Partially
TC	Partially	Partially	Partially	Partially
HLC	Yes	Partially	No	Partially
HIC	Yes	Partially	No	No
MGD	Partially	No	Yes	No
Resource Limitations = RL, Lack of Awareness = LA, Solution Complexities = SC, Time Consuming = TC, High Learning Curve = HLC, High Implementation Cost = HIC, Measurement Goals Determination = MGD				

Table 9.2 Fulfilment of desired characteristics by each SMPI in SMEs solution

Characteristics fulfilled?				
Factors	SMF4SME	GQM-Lightweight	MIS-PyME	HMP
PI	Yes	No	No	No
EU	Yes	Yes	Partially	No
CM	Yes	No	No	No
RRD	Yes	No	Partially	No
MD	Partially	No	No	No
MDR	Yes	Yes	Yes	Partially
MCTM	Yes	No	Partially	No
SA	No	No	/Yes	No
CE	Yes	Yes	Partially	Partially
IS	Yes	No	No	No
Process Initiation = PI, Easy to use = EU, Communication Model = CM, Roles & Responsibilities Definition = RRD, Metrics Dashboard = MD, Measurement Data Reusability = MDR, Motivation & Commitment of Top Management = MCTM, Solution Automation = SA, Cost Effective = CE, Involve all Stakeholders = IS				

9.3.2. Phase 3 Outcomes

This phase comprised the quantitative assessment of SMF4SME, which went some way to empirically validating the SMF4SME's nine activities and their corresponding elements. Both the overall and comparative analysis provided strong evidence that SMF4SMEs should support successful SMPI in SMEs.

9.4. Summary

The measurement of software – in its many forms – is still not established as a recognised sub-discipline in software engineering, as it is in more established branches of engineering. The intangible nature of software work products, and the creative dimension of the software process, mean that measurement in this context remains an open challenge. Moreover, while ongoing research seeks to establish 'rules' for SMPI, very little of this research is being conducted specifically for SMPI in SMEs. The practices of many SMEs are *ad hoc*; many are start-up companies, whose primary goal is to become profitable. As such they may pay little heed to software process improvement. However, the downside of this focus on growth and profit is that they may lack control of and insight into their processes, which could actually compromise their ability to turn a profit, and could eventually lead to failure. A balance of attention, on the day-to-day pressures as well as on the need to manage, could well be a better strategy in terms of survival.

This research used a phased approach to iteratively develop understanding and support for SMEs wishing to embark on SMPI. Each step fed into those following, using a range of appropriate research methods: a literature review, resulting from a systematic mapping; GT-methods applied to 22 interviews in the industrial review; iterative design, development and refinement of the SMF4SMEs solution; and assessment of the framework based on 110 responses to a questionnaire-based survey. Figure **9-3** shows the key steps and outcomes of this research.

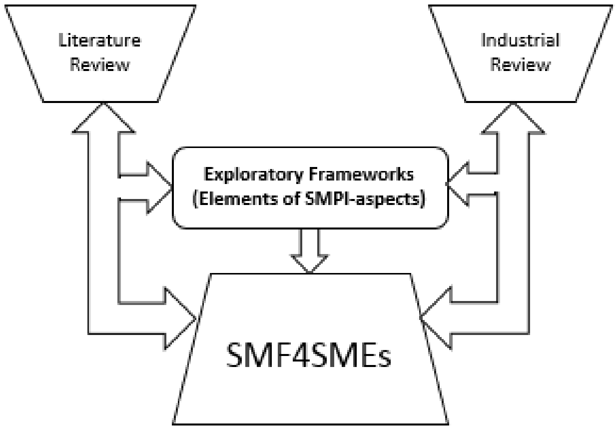

Figure 9-3 Research Outcomes

Chapter 10 Conclusion

This Chapter 10concludes this thesis and the research reported in it. It summarises the work undertaken, it states the key contributions made, and it acknowledges threats to the validity of the research. It also considers the implications of this research and future research prospects.

10.1. Summary

This research has investigated the implementation of software measurement programs in small- and medium-sized enterprises (SMPI in SMEs). The research was conducted in three phases following a design science research (DSR) methodology; problem identification, solution design and development, and evaluation. The study addressed two aims: first, to understand a range of aspects relevant to SMPI in this particular context, including challenges, obstacles, benefits and success factors, conducted primarily during the first research phase; and second, to propose, evaluate and refine a framework to support SMPI in SMEs, as performed during the second and third research phases. The key motivations for this research were the lack of available SMPI literature, the high failure rate of SMPI reported in the literature, the apparent reluctance of practitioners to adopt SMPs due to their limited resources, and the lack of sustainability of SMPs in industry.

The problem identification phase of the research was divided into two parts so that the state-of-the-art and the state-of-practice might be examined consecutively. The existing literature was reviewed to determine the state-of-the-art of SMPI in SMEs, in the form of a systematic mapping study. The results of the mapping study revealed that little research work had been conducted in the subject area, and hence, few solutions had been proposed to date. Further, a gap was found in the identification of challenges and success factors; it was considered that if these were explicitly identified this might inform the development of more suitable measurement programs and so enhance the success of SMPI in SMEs. This further motivated the particular focus of the review of the current state-of-practice. In addition, the systematic investigation of the current state-of-the-art contributed to a refinement of the primary research goal, that is, "*To provide a comprehensive understanding of how SMPs should be implemented, and to provide a light-weight framework to support SMP implementation in practice in SMEs*".

To investigate the second part of the problem identification phase, in order to determine the state-of-practice, an industrial review was conducted. The objectives of the industrial review were to examine the importance of SMPs in industry and to investigate the challenges practitioners face when seeking to implement SMPs, and what solutions they might adopt. During this research phase data was collected through face-to-face interviews with 22 practitioners. The interviews were conducted using open-ended questions so that as much information as possible might be collected from the practitioners to provide in-depth insight into the perceptions and practices of some of those currently working in SMEs. The data collected from interviewees was transcribed, analysed and synthesized using qualitative data analysis procedures leveraged from Grounded Theory (GT) techniques. GT techniques were used due to the rigor they bring to such analyses, via open, focused, selective coding and constant comparison. The outcomes of the industrial review, building on the outcomes of the literature review, were preliminary exploratory frameworks representing various aspects of SMPI. Each exploratory framework was comprised of multiple interconnected categories, subcategories, and their properties.

In summary, the first phase of the research revealed an ongoing need for solutions to initiate, define and manage the implementation of SMPs in SMEs. Challenges to the adoption of such solutions were their complexity, a lack of awareness among SMEs of the potential value of SMP, and, above all, limited resources in such organisations. Given this scenario, the objective of the second phase of the research centred on the development of a suitably lightweight software measurement framework (SMF) that would (more) effectively support SMEs in initiating, defining and implementing SMPs.

The second phase of the research was conducted through an iterative sequence of three field studies conducted in two SMEs: ABC, a medium-sized organization, and XYZ, a small-sized organization. The SMF4SMEs that emerged as a result of these field studies comprised of nine core activities supported by a range of other elements such as activities vs. checklists, lists of roles-and-responsibilities, precautions, implementation benefits, and success factors. The framework was initially designed through a first case in ABC, and it was then evaluated and refined through two further cases, one in ABC and another in XYZ. The SMF4SME was proposed by paying particular attention to the resource limitation issue (whether the resource be time, budget, and/or human expertise) that had seemed to be such an obstacle previously, as well as the process immaturity inherent in most SMEs. While these limitations could not be eliminated, their impact on SMPI could be mitigated through intelligent implementation.

The first-time user of SMF4SMEs is required to spend some extra time in its implementation, but no specialist expertise is required. Some activities are one-time only, and checklists are also provided as guidance, saving time and keeping users on track. As per the SMF4SME recommendations, if the user is new to implementing SMP, then he/she should follow pre-listed GQMs. It is important that the leading participants (such as PMs, SQM, TLs) in SMPI read the provided instructions/guidelines of SMF4SME, to know each step in detail. If this is simply not possible for all leading participants, then at least, the initiator or principal leading participant (such as PM(s), as encouraged by SMF4SME, to lead SMPI), must go through all of the provided guidelines first time.

The third and final phase of the study sought to validate the developed solution, the SMF4SME. To carry out this phase a survey instrument was prepared and piloted, and data was collected from 110 practitioners from a range of software development enterprises (SDEs). In particular the survey was intended to evaluate the perceived usefulness of the SMF4SMEs and its various elements. The findings of this particular phase of the research revealed that, among the available elements of the SMF4SME, the checklists and roles-and-responsibilities were seen as being the most useful. Respondents considered that the framework resolved identified challenges adequately, and they were found to be more interested in pre-defined GQMs and their link with business goals. Moreover, they noted a need to improve the implementation guidelines by shortening them and to improve the predefined GQMs with more tangible links to business goals.

10.2. Accomplishment of the Research Objectives

Mature Software Development Enterprises (SDEs) recognize SMPI as being an important part of their software project and organizational management. However, the initiation, definition, implementation and management of SMPs remains particularly challenging for SMEs, due to their limited resources and knowledge. Hence, the main objective of this research was to design a lightweight solution to support SMEs in implementing SMPs by more effectively taking into account SMPI challenges. To achieve this main objective, multiple sub-objectives were stated for each of the research phases, as follows.

Obj1: To study the current state-of-the-art of the context research area through an in-depth literature review.

Chapter 4: An extensive literature review was conducted in the form of a systematic mapping study to identify any existing SMPI methodologies. It was discovered that, in the context of SMPI in SMEs, just two methodologies had been proposed to date. Furthermore, for one of the two (GQM-Lightweight), no evaluation was available, and the other (MIS-PyME) suited mature organizations rather than non-mature SMEs. Additionally, none of the prior research had explicitly reported challenges and success factors. As a result, SMPI challenges and success factors were given particular attention in the literature review.

Obj2: To study the current state-of-practice through in-depth industrial review in SMEs.

Chapter 5: An industrial review was conducted to identify the challenges encountered by SMEs when they sought to implement SMPs in their setup, as well as any success factors and other mechanisms that enabled them to cope with or mitigate those challenges. In addition, SMPI obstacles and benefits were traversed. It was evident that SMEs still faced several significant challenges and obstacles when implementing SMPs such as limited resources and scant/variable awareness. Based on the findings of the industrial review four preliminary exploratory frameworks were designed for various aspects of SMPI, being challenges, obstacles, benefits and success factors.

Obj3: To compare the state-of-the-art and state-of-practice in order to identify the main challenges faced in the context of SMPI-in-SMEs.

Chapter 6: The findings regarding the current state of SMPI in SMEs, as determined through the literature and industrial reviews, were then compared. While it was noted in the literature review that SMPI was considered to be an important element of a company's management processes it was also evident that practitioners (particularly in SMEs) were reluctant to adopt SMPI, due in part to the lack of suitable frameworks. This led to the conclusion that there was a need for a lightweight SMF that would provide appropriate support to SMEs initiating, defining and managing SMPs in their setup.

Obj4: To develop a framework to enable SMEs to implement simple, sufficient and straight-forward SMPs.

Chapter 7: Three field studies were then conducted, in the medium-sized company ABC and in the small-sized company XYZ. The aim of the first case (in ABC) was to study the SMPI requirements in that organization and to design the structure and activities to support their implementation of SMP. The aim of case 2, also undertaken in ABC, was to evaluate and refine the initially defined activities and to further improve the implementation of their SMP. The third case was conducted in XYZ, the main aim being to validate and improve the framework so that it also worked effectively for a smaller organization. The product of these three cases was a new framework, the SMF4SME, comprising a set of nine activities that should be suitable for SMEs, as informed by the case organizations' requirements. Furthermore, the results of the field studies suggested that the SMF4SMEs would comply with the needs of SMEs and would be useful for initiating, defining and managing SMPI in SMEs.

Chapter 7 described in detail the SMF4SMEs in terms of its nine core activities as well as its supporting elements, such as checklists, roles-and-responsibilities, precautions, benefits and risk factors, each supported by detailed implementation and integration guidelines.

Obj5: To validate and evaluate the perceived utility of the SMF4SME.

Chapter 8: To independently assess the perceived usefulness of the SMF4SMEs a cross-sectional survey was designed. The survey questionnaire was distributed to numerous SDEs in multiple countries. The aim was to obtain feedback from practitioners working in the software development industries as to their perceptions of the suitability of SMF4SMEs. The responses received from 110 participants were analysed and the results appeared to be positive, indicating that the SMF4SMEs would likely fulfil the SMPI requirements of SMEs.

Based on the accomplishment of each of the research objectives just listed it is asserted here that the main research objective of the study was indeed achieved. The software measurement needs of SMEs were understood, and a framework suitable for use by SMEs was designed, refined and validated.

10.3. Research Contributions

The findings of the research reported in this thesis contribute to the body of knowledge on SMPI in SMEs as well as to software practice, as described in the succeeding paragraphs.

There are two primary contributions emanating from this research: the preliminary exploratory frameworks for various aspects of SMPI (addressing challenges, obstacles, benefits and success factors) as presented in Chapter 5, and the SMF4SMEs that should lend tangible and appropriate support or the implementation of SMPs in SMEs, as presented in Chapter 7. A secondary contribution is the systematic mapping regarding SMPI in SMEs. This contribution should be of value to researchers working in this topic area.

10.3.1. Preliminary Exploratory Frameworks

As constructed inductively from the literature and industrial reviews each exploratory framework comprised multiple interconnected categories, subcategories and their properties. The relationships depicted how the different categories were related and how they impacted SMPI failure and or success in SMEs. These frameworks provide the first comprehensive depiction in the research literature of the complex sets of issues and factors that manifest as challenges, obstacles, benefits and success factors in SMPI for SMEs.

In terms of a contribution to practice the identified benefits can be used to motivate SMPI stakeholders. In a similar vein the identified challenges and obstacle can be used as explicit 'warning signs' to look out for during SMPI through SMF4SME, just as the identified categories of the success factors and their relations can be translated into guidelines which could be used to increase the likelihood of a successful SMP implementation.

10.3.2. SMF4SME

The major contribution of this research is the SMF4SME, a nine-activity framework designed for and evaluated by software SMEs. Based on literature and industrial reviews and engineered through three field studies the SMF4SMEs includes detailed implementation guidelines for SMP initiation, definition, and management. Moreover, it provides other support elements corresponding to the nine activities, including checklists, roles-and-responsibilities definitions, and precautions. The SMF4SMEs activities and corresponding elements were validated *in situ* and were evaluated through a cross-sectional survey. This newly proposed SMF4SMEs contributes to the existing body of knowledge regarding SMPI in SMEs. This is the only known solution built specifically for SMP initiation, definition, implementation and management in SMEs.

In terms of practice it appears that SMEs need and can benefit from the type of support provided by the SMF4SMEs activities and their corresponding elements. SMEs face numerous constraints in regard to knowledge, resources, timelines and budgets. As such they cannot afford to adopt the complicated and/or time-consuming processes and frameworks that have been designed for their larger and more mature counterparts. The SMF4SMEs is a simple and available alternative comprising straightforward activities that emphasise process initiation and the provision of *sufficient knowledge* to process stakeholders so that they can cope with relevant challenges in regard to SMPI. It engages stakeholders as appropriate throughout the process by dividing their roles and responsibilities and sharing knowledge at each phase. Checklists are provided to support the performance of each key activity. The whole framework is designed to keep participants engaged, informed and motivated through the adoption of simple and straight-forward activities. These activities ensure it remains lightweight in execution.

The SMF4SMEs also contains an embedded communication model in each phase, in the form of daily-quick and weekly meetings. This means that it should be easily integrated into agile-based development methodologies, given their predominant use in industry (and as was evident to the researcher during this study). Additionally, the proposed solution provides guidelines to support the integration of SMF4SMEs with agile-based methodologies. Such support should further motivate traditionally reluctant SMEs to reconsider their past hesitance to implement a software measurement programme.

10.4. Threats to Validity

While Cronbach and Wainer state that readers are the best judges of the validity of a given study (Cronbach & Wainer, 1988) the following sections acknowledge and consider a range of threats that might cause readers to question the validity of the research..

10.4.1. Internal Validity

Internal validity is concerned with the effects of treatments, outcomes, and participants' backgrounds that may impact the validity of conclusions drawn based on findings (Day et al., 1979).

In the first phase a key step involved a literature review (in the form of a mapping study), where there is the possibility of bias in the references selected – or instance, the author might cite only studies that discuss positive perspectives regarding SMPI. To mitigate against this risk a systematic approach to study selection was taken, drawing from a well-known and widely used set of databases. The second part of the first phase of the research sought the views of relevant industry practitioners – as such the nature of the organizations and the practitioners' backgrounds can be influential. Although it was challenging to find relevant and willing SMES organizations and practitioners in the working area persistence and a systematic approach appeared to pay off. Companies' authorities were contacted through email and were provided with a participant information sheet and consent form which gave them an overview of the context area. These authorities then passed the opportunity on those who were most qualified and most relevant to take part. There may therefore be the possibility of some bias in the results because of this facilitated introduction process. Furthermore, the analysis approach of literature review was different to industrial review which may limit to perform comparative analysis. To avoid this limitation researcher mainly focus on presenting state-of-art in literature and state-of-practice.

The second phase of the research involved the design and development of a solution through field studies, where one medium-sized and one small-sized organization were selected. These participant organizations had contributed to the industrial review, so they had sufficient prior knowledge of the context area to make an informed decision regarding their further involvement. Furthermore, the researcher communicated extensively with the lead participants of both organizations before commencing the field studies. It was therefore clearly established that the organizations did not have a SMP in place, and that the lead participants were not measurement experts but had adequate knowledge of the process, which lessened any related threat: the unavailability of experts and SMPs in the case organizations meant the participant organizations and individuals were well-suited for the research.

The third phase of the study centred on the evaluation of the proposed solution through a cross-sectional questionnaire (a survey), where again participants' relevance matters. Finding and securing the involvement of practitioners working in context area of SMEs was a challenge, due in particular to their heavy workload and to their relative lack of knowledge regarding software measurement. Therefore, to mitigate any threat related to participants' backgrounds, the survey was distributed across several countries to relevant practitioners of SDEs without imposing any limitation on company size.

10.4.2. External Validity

Threats to external validity centre on the extent to which conclusions may or may not generalize to research and practice across settings and geographical regions (Cook et al., 1979) based on their possible relevance to other cases (Runeson & Höst, 2009). The participants in two primary research phases of this research (interviews and field studies) were indeed from the same geographical region, which could limit the external validity of the results obtained in these phases, given that cultural values and norms could vary from country to country. Mitigating this threat to some degree is the fact that the survey was distributed across a wide range of countries. The overall findings of this research work may therefore be valid *within this context*, of SMEs based in Asia but working globally, but still, there is the possibility that different results might accrue from other geographical regions where organizational culture, domains, methodologies, and above all perceptions, might vary from those recorded here.

10.4.3. Conclusion validity

Conclusion validity relates to the credibility and reliability of the conclusions drawn from the results (Campbell et al., 2002) of each phase of the research work. This form of validity relates to how confident one can be that the adopted empirical methods have been used appropriately (Wohlin et al., 2012). By taking an iterative approach to this research, conducting the work in multiple phases and using a variety of research methods, it is asserted here that threats to conclusion validity have been managed. By adopting a systematic mapping study the results can be considered to be as robust as the method allows; this directly informed the second step, the interview study. The use of GT methods in this step should have lent assurance to the outcomes. The iterative conduct of three field study cases across two relevant organisations should also have contributed positively to outcome reliability. Finally, the evaluation of the proposed solution through a cross-sectional survey provided a suitable degree of independent validation of the solution.

10.5. Implications and Future Work

Development and use of the outcomes of this research carry a range of implications for researchers and practitioners – a non-exhaustive list of future (possible) actions and directions is now presented.

10.5.1. General Questions

1. Does the attitude of enterprise owners and managers affect the likelihood of success of SMPI in SMEs?
2. Does/should SMPI vary for global software development, where factors related to geographical, temporal and cultural distance might need to be considered?
3. To what extent do technological (Java vs. .Net), domain (the web vs. desktop) or criticality (an ordinary business project vs. defence project) dimensions impact on SMPI?
4. Do mature SMEs use SMP more effectively than less mature SMEs?

10.5.2. Exploratory Frameworks Improvements

5. The exploratory frameworks could be further extended and validated by other researchers performing quantitative investigations of the effects and relationships shown.
6. Interviews could be conducted in other countries to further evaluate the exploratory frameworks in terms of any cultural effects.
7. The applicability (or otherwise) of the frameworks could be assessed in relation to larger software enterprises – perhaps there are factors that are relevant to these organisations that have been overlooked in other SMPI guidance.

10.5.3. SMF4SMEs Improvements

8. Survey respondents noted the need to better align business goals with GQMs.
9. Automation of (parts of) the SMF4SME, perhaps in the form of a web-based solution, could streamline its use in practice. This could extend to the calculation and analysis of the values recorded for various metrics.
10. The SMF4SMEs should be applied and evaluated in a wide range of other SMEs.

11. Large companies might like to consider using (elements of) the SMF4SMEs to improve their existing approaches to measurement.

10.6. Final statement

The research reported in this thesis has addressed the general topic of software measurement, establishing that this is an important but neglected area of research and practice. It is hoped that the contributions delivered through this research will underpin more effective planning and management of measurement programs, activities that remain a challenge for many software organizations. In particular, their use should explicitly address the need to plan and establish cost-effective, lean and sustainable measurement programs in SMEs.

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Appendices

Appendix 4.1 : List of Selected Journals and Conference Proceedings

The following Journal and conferences were explored for mapping study.

Journal	Acronym
ACM Transactions on Software Engineering and Methodology	TOSEM
Empirical Software Engineering Journal	ESEJ
IEEE Software	IEE Soft.
IEEE Transactions on Software Engineering	TSE
IET Software	IET Soft.
Information and Software Technology	IST
Journal of Software: Evolution and Process	
Journal of Systems and Software	JSS
Software Quality Journal	SQJ
Software: Practice and Experience	SPE
International Journal of Software Engineering and Knowledge Engineering	IJSEKE
Journal of Software	JSW
Advances in Engineering Software	AES
Conference Proceedings	
Asia-Pacific Software Engineering Conference	APSEC
Australian Software Engineering Conference	ASWEC
European Conference on Software Process Improvement	EuroSPI
European Software Engineering Conference and the Symposium on the Foundations of Software Engineering	ESEC/FSE
International Conference on Evaluation and Assessment in Software Engineering	EASE
International Conference on Evaluation of Novel Approaches to Software Engineering	ENASE
International Conference on Software and System Process	ICSSP
International Conference on Software Engineering	ICSE
International Conference on Software Engineering and Knowledge Engineering	SEKE
International Symposium on Empirical Software Engineering and Measurement	ESEM
International Conference on Software Process and Product Measurement	IWSM
International Conference on Software Engineering Advances	ICSEA

Appendix 4.2 : Data extraction quality check results

The following table presents the consensus of the researcher, supervisor and another senior researcher in terms of quality check of extracted data from the selected articles of mapping study.

Data Item/Category	Values	Results				
Research Methodology		Ref	**Researcher**	Supervisor	Senior Researcher	Results
Empirical	yes, no, unclear	3	Yes	Yes	Yes	Yes
		5	Yes	Yes	Yes	Yes
		6	Yes	Yes	Yes	Yes
		8	No	No	Yes	No
		15	Yes	Yes	Yes	Yes
		17	Yes	Yes	Yes	Yes
		24	Yes	Yes	Yes	Yes
		27	Yes	Yes	Yes	Yes
		39	Yes	Yes	Yes	Yes
Research type	evaluation, validation, solution proposal, philosophical, personal experience, personal opinion	3	Evaluation	Evaluation	Evaluation	Evaluation
		5	Evaluation	Evaluation	solution proposal, Evaluation	Evaluation
		6	Experience	Evaluation	Validation	Tie
		8	Solution proposal	Solution proposal	Solution proposal	Solution proposal
		15	Evaluation	solution proposal, Evaluation	Evaluation	Evaluation
		17	Evaluation	Evaluation	Evaluation	Evaluation
		24	Solution proposal	Solution proposal	Solution proposal	Solution proposal
		27	Personal experience	Personal experience	Personal experience	Personal experience
		39	Evaluation	Evaluation	Evaluation	Evaluation
Research method:	qualitative, quantitative, mixed	3	Qualitative	Qualitative	Qualitative	Qualitative
		5	Qualitative	Qualitative	Qualitative	Qualitative
		6	Qualitative	Qualitative	Qualitative	Qualitative
		8	Qualitative	Unclear	Qualitative	Qualitative
		15	Quantitative	Quantitative	Quantitative	quantitative
		17	Mixed	Qualitative	Qualitative	Qualitative

		24	Qualitative	Unclear	Qualitative	Qualitative
		27	Qualitative	Mixed	Mixed	mixed
		39	Qualitative	Mixed	Qualitative	Qualitative
Means of data collection	survey, questionnaire, interview, literature, case study, unclear	3	Case Study	Case Study	Case Study, Interview	Case Study
		5	Case study	Action research, case study, interviews	Case study, interview	Case study, interview
		6	Case study	Case study	interview , Case study	Case study
		8	Literature	Unclear	Data collection, but data collection is not very clear.	Unclear
		15	Questionnaire, Interview	Questionnaire, literature, interview	Questionnaire, interview	Questionnaire, interview
		17	Interview	Interview, literature	Interview	Interview
		24	Literature	Unclear	Literature	Literature
		27	Case study	Case study	Survey, interviews	Case study
		39	Case study, interview	Case study	Interview	Case study interview
Tool/Technique/Method/Framework/Model						
Introduced	Year, Unclear	3	2006	2006	2008	2006
		5	2007	2007	2008	2007
		6	2007	Unclear	2008	Tie
		8	2012	Unclear	2012	2012
		15	Unclear	Unclear	No Answer	Unclear
		17	Unclear	Unclear	No Answer	Unclear
		24	2011	Unclear	2011	2011
		27	1999	Unclear	1999	1999
		39	2013	Unclear	2013	2013
Use in/for	SME, SSE, CME, LSE, medium, small, Unclear	3	SME	SME (39 in group)	SME	SME
		5	SME	SME	SME	SME
		6	Medium	SME	SME	SME
		8	Small	Small	Small	Small
		15	Small	Small	No Answer	Small
		17	SME	SME	No Answer	SME
		24	Small	Small	Small	Small
		27	Small	Small	Small	Small

		39	Unclear	Unclear	Unclear	Unclear
Focus	SPI, SM , MMM, unclear	3	SM, SPI	SM, SPI, MM Framework	MM	SM, SPI, MM
		5	SPI, SM	SPI, SM, MM	MM	SPI, SM, MM
		6	SM, SPI	SM →MM → SPI	MM	SM, MM, SPI
		8	SM	SM → SPI	SM	SM
		15	SM	Web Development, SM	No Answer	SM
		17	SM	SM	No Answer	SM
		24	SM	SM → SPI	SM	SM
		27	SM	SM → SPI	SM → SPI	SM → SPI
		39	SM	SM	SM	SM
Goal Based	Yes, No	3	Yes	Yes (GQ(I)M)	Yes	Yes
		5	Yes	Yes	Yes	Yes
		6	Yes	Yes	Yes	Yes
		8	Yes	No	Yes	Yes
		15	No	No	No Answer	No
		17	NO	NO	No Answer	NO
		24	Yes	No	Yes	Yes
		27	Unclear	No Answer	Unclear	Unclear
		39	Yes	Yes	Yes	Yes
Reported/Perceived Performance	Evaluated, Clearly stated, EUM, EFL, COM, INF, INTP, MMM, Unclear	3	Clearly Stated	No Answer	Clearly stated	Clearly stated
		5	Clearly Stated	No Answer	EUM, Clearly Stated	Clearly stated
		6	EUM, INF, INTP	No Answer	Clearly Stated, EUM	EUM
		8	Unclear, EUM	No Answer	Unclear	Unclear
		15	Unclear	No Answer	No Answer	Unclear
		17	Unclear	No Answer	No Answer	Unclear
		24	Evaluated, EUM	No Answer	Unclear	Tie
		27	EUM	No Answer	EUM	EUM
		39	EUM, EFL, INF	No Answer	EFL, INF	EFL, INF
Results						
Contributions:	problem report, recommendations,	3	Framework, Recommendation	Framework, lesson learned, success factors, recommendations	Framework, Problem report, lessons learned, recommendation	Framework, lesson learned, Recommendations

	lessons learned, tools, framework, model	5	Framework	Model, recommendations, lesson learned	Framework, lesson learned	Framework, lesson learned
		6	Framework	Framework, lesson learned	Method, framework, lesson learned	Framework, lesson learned
		8	Framework, Recommendations	Framework, challenges recommendations	Framework, recommendations	Framework, recommendations
		15	Problem report	current snapshot, Problem report	No Answer	Problem report
		17	Recommendations, problem report	Recommendation, snapshot, problem report	No Answer	Recommendation, problem report
		24	Framework, recommendations	Framework, challenges, recommendations	Framework	Framework, recommendations
		27	Lesson learned	Lesson learned, recommendations	Lesson learned, recommendations	Lesson learned, recommendations
		39	Framework, tool, recommendations	Framework, tool	Framework, recommendations	Framework, tool, recommendations
% based on 2/3			92.22%	76.66%	75.55%	Average: 83.81

Appendix 5.1 SMPI-Aspects and their categories

The following table shows the number of participants against each identified sub category of SMPI core categories.

Category	# of Interviewee
Challenges	
Multiple roles	15
Lack of knowledge/awareness	12
Cultural reluctance	9
Solution/process complexities	16
Resource limitations	18
Problem/Obstacles	
Reliance on expert judgment	11
Top management	
Implementation overhead	6
Process impact on SMPI	17
Other factors	13
Success Factors	
Project success	7
Measurement goals identification	5
Tool automation	14
Managed implementation	12
Top management	8
Client support	4
Communication	3
Awareness	9
Expert	5
Roles and responsibilities definition	15
SM Benefits	
Top Management	13
Development/Performance/Productivity	5
Efficient project management	17
Processes improvements	15
Quality improvements	17

Appendix 5.2 Participants Companies

Seven practitioners participate from 5 different Software development companies of UAE and fifteen practitioners participate from 12 different software development companies of Pakistan.

Company	# of Interviewee
C1	2
C2	1
C3	1
C4	2
C5	1
C6	1
C7	1

C8	1
C9	3
C10	1
C11	1
C12	2
C13	1
C14	1
C15	1
C16	1
C17	1

Appendix 5.3 .Relationships of identified categories of SMPI-aspects

The following table shows the relationship among identified sub categories of SMPI core categories.

Category From	Relation ship	Direction	Category To
Interviews\Challenges\GSE	Tot Up	→	Interviews\Challenges
Interviews\Challenges\GSE	Cause	↔	Interviews\SM Obstacles
Interviews\Challenges\Knowledge or Awareness issues	Tot Up	→	Interviews\Challenges
Interviews\Challenges\Knowledge or Awareness issues	Results in	→	Interviews\Challenges\Reluctance
Interviews\Challenges\Knowledge or Awareness issues	Assume	→	Interviews\Challenges\Knowledge or Awareness issues\overhead
Interviews\Challenges\Knowledge or Awareness issues	Assume	→	Interviews\Challenges\Knowledge or Awareness issues\Just a Label
Interviews\Challenges\Knowledge or Awareness issues	Associated	—	Interviews\Challenges\Knowledge or Awareness issues\Misconceptions
Interviews\Challenges\Knowledge or Awareness issues\Misconceptions	Associated	—	Interviews\Challenges\Knowledge or Awareness issues\Just a Label
Interviews\Challenges\Multiple Roles	Cause	↔	Interviews\Challenges
Interviews\Challenges\Multiple Roles	Cause	↔	Interviews\SM Obstacles
Interviews\Challenges\Multiple Roles	Results in	→	Interviews\Challenges\Knowledge or Awareness issues
Interviews\Challenges\Multiple Roles	Cause	↔	Interviews\Challenges\Multiple Roles\overloaded
Interviews\Challenges\Multiple Roles	Cause	↔	Interviews\Challenges\Multiple Roles\Reduce Performance
Interviews\Challenges\Multiple Roles\overloaded	Cause	↔	Interviews\Challenges\Multiple Roles\Reduce Performance
Interviews\Challenges\Reluctance	Vieled	→	Interviews\Challenges
Interviews\Challenges\Resources Limitation issues	Root Cause	→	Interviews\Challenges
Interviews\Challenges\Resources Limitation issues	Impact	—	Interviews\Challenges\GSE
Interviews\Challenges\Resources Limitation issues	Associated	—	Interviews\Challenges\Resources Limitation issues\budget
Interviews\Challenges\Resources Limitation issues	Associated	—	Interviews\Challenges\Resources Limitation issues\Experts
Interviews\Challenges\Resources Limitation issues	Associated	—	Interviews\Challenges\Resources Limitation issues\people
Interviews\Challenges\Resources Limitation issues	Associated	—	Interviews\Challenges\Resources Limitation issues\time
Interviews\Challenges\Resources Limitation issues\budget	Associated	—	Interviews\Challenges\Resources Limitation issues\people
Interviews\Challenges\Resources Limitation issues\Experts	Associated	—	Interviews\Challenges\Resources Limitation issues\time

Interviews\Challenges\Resources Limitation issues\people	Associated	—	Interviews\Challenges\Resources Limitation issues\Experts
Interviews\Challenges\Resources Limitation issues\time	Discourage	→	Interviews\Challenges\Resources Limitation issues\time\time to train resources
Interviews\Challenges\Resources Limitation issues\time\Time to deliever	Rushed	→	Interviews\Challenges\Resources Limitation issues\time
Interviews\Challenges\Resources Limitation issues\time\Time to deliver	Associated	—	Interviews\Challenges\Resources Limitation issues\time\Time to market
Interviews\Challenges\Resources Limitation issues\time\Time to deliver	Impact	—	Interviews\Challenges\Resources Limitation issues\time\time to train resources
Interviews\Challenges\Resources Limitation issues\time\Time to market	Rushed	→	Interviews\Challenges\Resources Limitation issues\time
Interviews\Challenges\Resources Limitation issues\time\Time to market	Impact	—	Interviews\Challenges\Resources Limitation issues\time\time to train resources
Interviews\Challenges\Solutions or Process Complexities	Accelerates	→	Interviews\Challenges
Interviews\Challenges\Solutions or Process Complexities	Results in	→	Interviews\Challenges\Reluctance
Interviews\Challenges\Solutions or Process Complexities	Tot Up	→	Interviews\Challenges\Resources Limitation issues
Interviews\Challenges\Solutions or Process Complexities	Have	→	Interviews\Challenges\Solutions or Process Complexities\Learning Curve
Interviews\Challenges\Solutions or Process Complexities	Associated	—	Interviews\Challenges\Solutions or Process Complexities\Standards Problems
Interviews\Challenges\Solutions or Process Complexities	Required	→	Interviews\Challenges\Solutions or Process Complexities\effort
Interviews\Challenges\Solutions or Process Complexities\effort	Associated	—	Interviews\Challenges\Solutions or Process Complexities\Learning Curve
Interviews\Challenges\Solutions or Process Complexities\effort	Associated	—	Interviews\Challenges\Solutions or Process Complexities\Standards Problems
Interviews\Challenges\Solutions or Process Complexities\Standards Problems	Associated	—	Interviews\Challenges\Solutions or Process Complexities\suitability
Interviews\Challenges\Solutions or Process Complexities\suitability	Associated	—	Interviews\Challenges\Solutions or Process Complexities
Interviews\SM Benefits	Improve	→	Interviews\SM Benefits\Quality
Interviews\SM Benefits	Monitoring	→	Interviews\SM Benefits\Project Management
Interviews\SM Benefits	Provide	→	Interviews\SM Benefits\accuracy
Interviews\SM Benefits	Increase	→	Interviews\SM Benefits\performance
Interviews\SM Benefits	Facilitates	→	Interviews\SM Benefits\Risk Management
Interviews\SM Benefits	Backbone for	→	Interviews\SM Benefits\SDLC

Interviews\SM Benefits	Improve	→	Interviews\SM Benefits\Development
Interviews\SM Benefits	Increase	→	Interviews\SM Benefits\Productivity
Interviews\SM Benefits	Help in	→	Interviews\SM Benefits\predictability
Interviews\SM Benefits	Provide	→	Interviews\SM Benefits\estimation accuracy
Interviews\SM Benefits	Support in	→	Interviews\SM Benefits\Monitoring and Scheduling
Interviews\SM Benefits	Increase Satisfaction Level	→	Interviews\SM Benefits\Top Management
Interviews\SM Benefits	Build	→	Interviews\SM Benefits\Trust
Interviews\SM Benefits	Play key role in	→	Interviews\SM Benefits\Processes Improvements
Interviews\SM Benefits\accuracy	Associated	—	Interviews\SM Benefits\performance
Interviews\SM Benefits\estimation accuracy	Associated	—	Interviews\SM Benefits\predictability
Interviews\SM Benefits\Monitoring and Scheduling	Assist in decision-making	→	Interviews\SM Benefits\Top Management
Interviews\SM Benefits\Project Management	Associated	—	Interviews\SM Benefits\Risk Management
Interviews\SM Benefits\Quality	Help in	→	Interviews\SM Benefits\Monitoring and Scheduling
Interviews\SM Benefits\Trust	Associated	—	Interviews\SM Benefits\Top Management
Interviews\SM Obstacles	Associated	—	Interviews\Challenges
Interviews\SM Obstacles	Associated	—	Interviews\SM Obstacles\Impact Processes
Interviews\SM Obstacles	Cause	↔	Interviews\SM Obstacles\Top Management
Interviews\SM Obstacles	Associated	—	Interviews\SM Obstacles\Other Impact factors
Interviews\SM Obstacles\expert judgments	Results in	→	Interviews\SM Obstacles
Interviews\SM Obstacles\Impact Processes	Associated	—	Interviews\SM Obstacles\Other Impact factors
Interviews\SM Obstacles\Impact Processes\Analysis	Impact	—	Interviews\SM Obstacles\Impact Processes
Interviews\SM Obstacles\Impact Processes\change management	Cause	↔	Interviews\SM Obstacles\Impact Processes
Interviews\SM Obstacles\Impact Processes\design	Results in	→	Interviews\SM Obstacles\Impact Processes
Interviews\SM Obstacles\Impact Processes\Estimation	Results in	→	Interviews\SM Obstacles\Impact Processes
Interviews\SM Obstacles\Impact Processes\Planning	Impact	—	Interviews\SM Obstacles\Impact Processes
Interviews\SM Obstacles\Impact Processes\requirements	Impact	—	Interviews\SM Obstacles\Impact Processes
Interviews\SM Obstacles\Impact Processes\Risk Management	Cause	↔	Interviews\SM Obstacles\Impact Processes
Interviews\SM Obstacles\Implementation	Associated	—	Interviews\SM Obstacles
Interviews\SM Obstacles\Metrics Selection	Results in	→	Interviews\SM Obstacles
Interviews\SM Obstacles\Metrics Selection	Associated	—	Interviews\SM Obstacles\Implementation

Interviews\SM Obstacles\Other Impact factors\Domain Critics or Variation	Associated	—	Interviews\SM Obstacles\Other Impact factors
Interviews\SM Obstacles\Other Impact factors\Politics	Tot Up	→	Interviews\SM Obstacles\Other Impact factors
Interviews\SM Obstacles\Other Impact factors\resources Management	Results in	→	Interviews\SM Obstacles\Other Impact factors
Interviews\SM Obstacles\Other Impact factors\resources Management	Associated	—	Interviews\SM Obstacles\Other Impact factors\Scheduling
Interviews\SM Obstacles\Other Impact factors\resources utilization	Results in	→	Interviews\SM Obstacles\Other Impact factors
Interviews\SM Obstacles\Other Impact factors\resources utilization	Associated	—	Interviews\SM Obstacles\Other Impact factors\resources Management
Interviews\SM Obstacles\Other Impact factors\Scheduling	Cause	↔	Interviews\SM Obstacles\Other Impact factors
Interviews\SM Obstacles\Other Impact factors\Technology Limitation	Cause	↔	Interviews\SM Obstacles\Other Impact factors
Interviews\SM Obstacles\Top Management	Associated	—	Interviews\SM Obstacles\Work Load
Interviews\SM Obstacles\Work Load	Results in	→	Interviews\SM Obstacles
Interviews\SM Success	Results in	→	Interviews\SM Success\Project or Product Success
Interviews\SM Success\Appropriate Solutions Selection	Guarantee	→	Interviews\SM Success
Interviews\SM Success\Awareness	Results in	→	Interviews\SM Success
Interviews\SM Success\Client	Facilitates	→	Interviews\SM Success
Interviews\SM Success\Client	Results in	→	Interviews\SM Success\Project or Product Success
Interviews\SM Success\Communication	Facilitates	→	Interviews\SM Success
Interviews\SM Success\Company Goals	Associated	—	Interviews\SM Success
Interviews\SM Success\Dynamic Changes Consideration	Are Essential	→	Interviews\SM Success
Interviews\SM Success\Experts	Are Essential	→	Interviews\SM Success
Interviews\SM Success\Experts	Associated	—	Interviews\SM Success\Proper Implementation
Interviews\SM Success\In House Training	Drives	→	Interviews\SM Success
Interviews\SM Success\In House Training	Associated	—	Interviews\SM Success\Awareness
Interviews\SM Success\Light Weight Framework	Facilitates	→	Interviews\SM Success
Interviews\SM Success\Light Weight Framework	Associated	—	Interviews\SM Success\Appropriate Solutions Selection
Interviews\SM Success\Measurement Goals Identification and Definition	Results in	→	Interviews\SM Success
Interviews\SM Success\Measurement Goals Identification and Definition	Associated	—	Interviews\SM Success\Metrics Dashboard

Interviews\SM Success\Measurement Goals Identification and Definition	Associated	—	Interviews\SM Success\Company Goals
Interviews\SM Success\Metrics Dashboard	Drives	→	Interviews\SM Success
Interviews\SM Success\Project Management	Facilitates	→	Interviews\SM Success
Interviews\SM Success\Project Management	Associated	—	Interviews\SM Success\Risk Management
Interviews\SM Success\Project Management	Associated	—	Interviews\SM Success\Roles and Responsibilities
Interviews\SM Success\Proper Implementation	Guarantee	→	Interviews\SM Success
Interviews\SM Success\Quality Assurance or Testing	Quantify	→	Interviews\SM Success
Interviews\SM Success\Quality Assurance or Testing	Associated	—	Interviews\SM Success\Standards implementation
Interviews\SM Success\Reuseability	Results in long run	→	Interviews\SM Success
Interviews\SM Success\Risk Management	Contributes Towards	→	Interviews\SM Success
Interviews\SM Success\Roles and Responsibilities	Drives	→	Interviews\SM Success
Interviews\SM Success\Scheduling	Facilitates	→	Interviews\SM Success
Interviews\SM Success\Scheduling	Associated	—	Interviews\SM Success\Project Management
Interviews\SM Success\Standards implementation	Tot Up	→	Interviews\SM Success
Interviews\SM Success\Tools Automation	Accelerates	→	Interviews\SM Success
Interviews\SM Success\Tools Automation	Associated	—	Interviews\SM Success\Reusability
Interviews\SM Success\Top Management	Play key role in	→	Interviews\SM Success
Interviews\SM Success\Top Management	Identify	→	Interviews\SM Success\Company Goals
Interviews\SM Success\Visualization	Triggers	→	Interviews\SM Success
Interviews\SM Success\Visualization	Motivates	→	Interviews\SM Success\Top Management

Appendix 5.4 Interview Questionnaire

The following open ended questionnaire was prepared to conduct professionals' interviews. The questionnaire was mainly adopted from (Pusatli, 2011).

S.NO	Question	Context
1.	Country	
2.	What is the title of your current position?	
3.	How would you describe your current occupation to others?	
4.	How long (years, months) have you been involved in this occupation?	Average experience of software professional
5.	Please describe your top three areas of professional expertise.	
6.	What is the highest degree you earned?	
7.	How much IT staff do you have in total?	
8.	You are currently involved in the development of a software project/product development. Please describe your role in this development, and your responsibilities in it.	
9.	What motivated you to become involved in this development?	
10.	Do you think that developing successful software applications involves efficient software processes? Please describe what process(es) you think are most important, and how does each process may become a viable for project/product.	Software processes usage and importance in SMEs
11.	What kind of projects/products your company developed mainly e.g. Web, Desktop, mobile, built-in/embedded, game etc.?	
12.	Your project/product involved global development?	
13.	Which processes of the software product /project development you are involved?	
14.	Which process of the software product /project process could be most effective for success completion?	
15.	What do you think would be the main obstacles in successful completion of this software project/product development you are involved with?	
16.	Describe what problems are you experiencing in the software project/product development you are involved with?	challenges identification
17.	How many core team members are aware about the usefulness and importance of software measurements to achieve quality objectives?	Experience and awareness of team members for measurements in software industry
18.	Which tools and methods are you applying for achieving quality objectives?	Knowledge of tools for quality measurements
19.	Does the company use software measurement as tool in the business?	Applicability of measurement tools for quality measurements

20.	Have you got any measurement guidelines/framework for controlling/assessing your products' quality?	Awareness and availability of measurement tools
21.	In terms of software development, are you using any internationally recognized standards for achieving quality objectives and to improve your business? For example, ISO, IEC, CMMI.	Availability and applicability of international standards
22.	If you already have any of those standards, did they help you to improve your company up to your expectations? If so, in what aspects?	Effect and results of using international standards
23.	Do you think CMMI is a criterion to assess a company's quality and reputation?	Aim of adopting highest standard for a company
24.	Which type of measurements are you using? Could you please name few of them e.g. resource management of computer, number of: line of code, loops, modules, errors etc.	Specific metric for measurements
25.	Has the company got expert team or members who are software quality engineer or experienced in software measurement; if so, how many? Do you hire any person outside for this activity, alternatively?	Availability of software quality engineers
26.	In the full software development cycle (from requirements, through design, development, testing, to deployment) are you using any kind of measurement?	Use of measurement Techniques in software life cycle
27.	Do you give more importance to inspection or testing your products? In other words, do you do assessment while inspecting or testing?	Software review/inspection
28.	Where else are you using measurements; e.g. maintenance or support to you clients?	Further use of measurement
29.	Are you following quality guidelines/frameworks/ measurements while doing business with your partners?	Use/effect of measurement in business
30.	Who is performing measurement related activities, irrespective of following an ad-hoc or formalized measurement process? (E.g. Scheduling, predicting/measuring reliability, quality etc.).	Identification of Roles and responsibility
31.	Do you think that software measurement can improve the quality of your products? Please provide an example while answering.	Actual Knowledge and awareness of quality objectives
32.	Do you think there are additional/alternative tools/methods than software measurements in order to improve your business in software development?	Awareness of other tools for improving quality and level of company

Appendix 5.5 Participant Information Sheet

Participant Information Sheet

Date Information Sheet Produced:

26 July 2013

Project Title

Software Measurement Programs Implementation in Small and Medium Enterprises (SMPI-in-SMEs)

An Invitation

My name is Aftab Ahmad Mughal. I am a Ph.D. Researcher at the School of Computing and Mathematical Sciences, working on the implementation of software measurement programs more efficiently into Small and Medium Enterprises (SMEs). I am conducting the interviews by personnel involved into measurement process (mostly Measurement Experts, Project Managers, Quality Assurance Managers, Team Leads), around the globe into SMEs. I would like to invite you to participate in my research and take part in the in-depth interview(s) on the topic of "**How Successfully Implement Software Measurement Programs?**" Your agreement to participate will be highly appreciated and would be beneficial for your industry at the end. Your knowledge, experience and expertise will help evaluate and improve the framework I am building for SMPI-in-SMEs. Please note that your participation is entirely voluntary, and you may withdraw at any time without any adverse consequences.

What is the purpose of this research?

The research is concerned with the investigation of the software measurement program and the challenges/obstacle faced by SMEs to implement it. Its main purpose is to create and validate a light-weight framework for SMEs to successfully implement software measurement programs. The results of the research will be included in my Ph.D. research and may also be published in scholarly outlets such as international peer-reviewed academic journals.

How was I chosen for this invitation?

You were chosen as an expert on software development applications and software process improvement in one or more of the following software development processes: requirements engineering, design & architecture, development & coding, quality assurance & testing, implementation, maintenance & support.

What will happen in this research?

The project involves gathering data and analyzing it with respect to the improvement and validity of the findings as part of my research for simple and straight-forward SMPI-inSMEs. The interviews will be recorded using a digital recorder and later transcribed by my personally.

What are the discomforts and risks?

No risks and discomforts are envisaged. However, in your particular organization, you may need to obtain the agreement of your senior manager to participate in the research.

How will these discomforts and risks be alleviated?

If the agreement of your senior manager is required, I will provide any additional information he or she may ask for in order to consider the invitation.

What are the benefits?

The research contributes academically to the body of knowledge by building a theory of software measurement process improvement and by proposing and validating a framework for lean and sustainable software measurement programs implementation. From an industry perspective, successful measurement program implementation will help in understanding, controlling, monitoring, predicting, and evaluating software development and maintenance projects and also a necessary part of any software process improvement or change program.

How will my privacy be protected?

The identities of the participants will be known to the researchers however the data gathered from participants will not contain any personal details. Furthermore, the data will be used in such a way that the identities of the participants and their respective organizations or companies will be protected from disclosure. The individual participants will not know who else is participating in the project. The digital records and the transcriptions will be accessible only to the researcher.

What are the costs of participating in this research?

The in-depth interview will take between 60 and 90 minutes overall but not more than 2 hours.

What opportunity do I have to consider this invitation?

Please respond to my invitation within one week of receiving it. Please also let me know whether further information about the research and the project is needed.

How do I agree to participate in this research?

To indicate that you agree to take part in the research, please complete the attached Consent form and email it to me as an attachment.

Will I receive feedback on the results of this research?

Once the Ph.D. thesis is successfully completed, I will let all participants know and will send them the link where it will be accessible on the Web.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Professor Steve MacDonell, smacdone@aut.ac.nz, 09-921-9073.

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, madeline.banda@aut.ac.nz, 921 9999 ext 8044.

Whom do I contact for further information about this research?

Researcher Contact Details:

Aftab Ahmad Mughal, Ph.D. Researcher, School of Computing and Mathematical Sciences, AUT University.

Email: amughal@aut.ac.nz

Phone: +64 9 921 9999 ext 5852.

Project Supervisor Contact Details:

Assoc. Prof. Stephen MacDonell, School of Computing and Mathematical Sciences, AUT University

Email: Stephen.macdonell@aut.ac.nz]

64 9 921 9999 ext 5329

Approved by the Auckland University of Technology Ethics Committee on the *10/21/2013*, AUTEC Reference number *13/273*.

Appendix 5.6 Consent Form

Consent Form

Project title: ***Software Measurement Programs Implementation in Small and Medium Enterprises (SMPI in SMEs)***

Project Supervisor: ***Professor Stephen MacDonell***

Researcher: *Aftab Ahmad Mughal*

- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that notes will be taken during the interviews and that they will also be audio-taped and transcribed.
- ○ I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- ○ If I withdraw, I understand that all relevant information including tapes and transcripts, or parts thereof, will be destroyed.
- ○ I agree to take part in this research.
- ○ I wish to receive a copy of the report from the research (please tick one): Yes○ No○

Participant's signature: ....

Participant's name: ....

Participant's Contact Details (if appropriate):

....

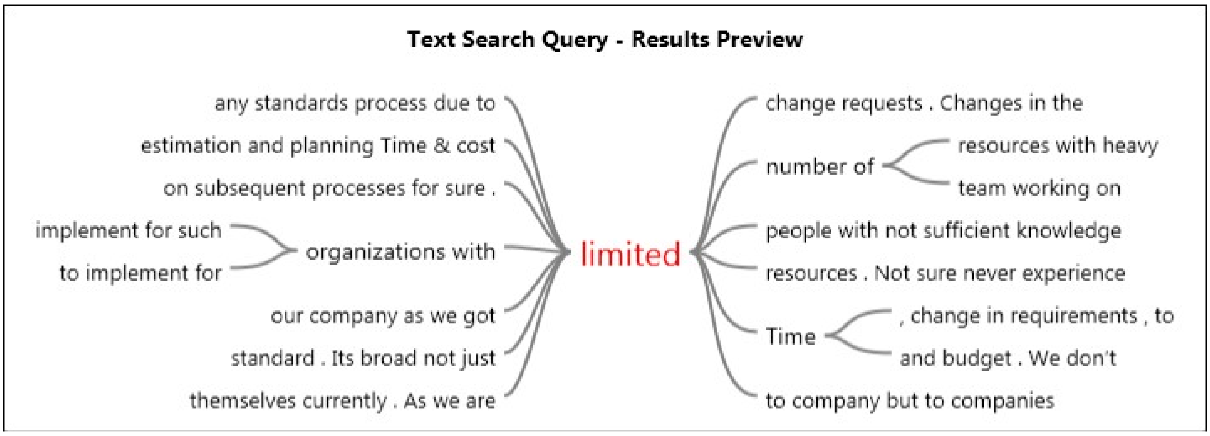
....

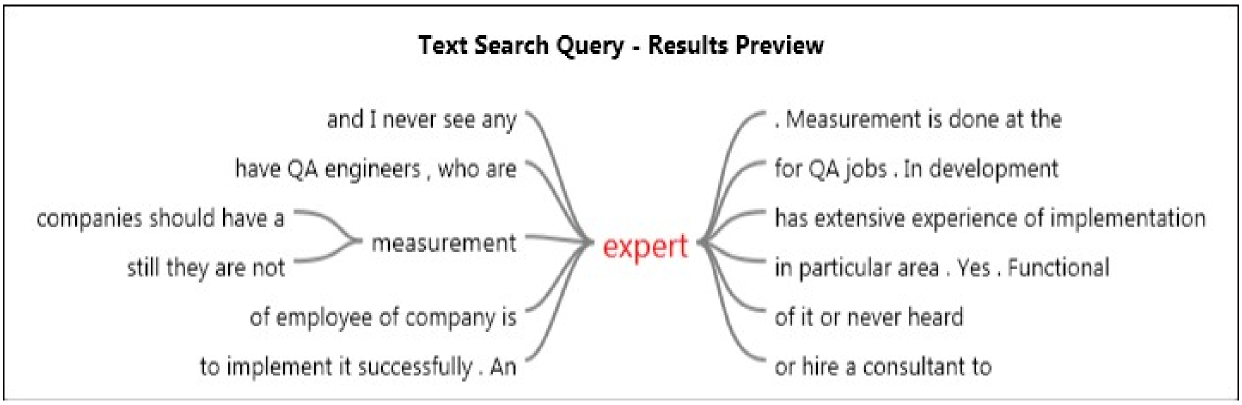
Date: dd/mm/yyyy

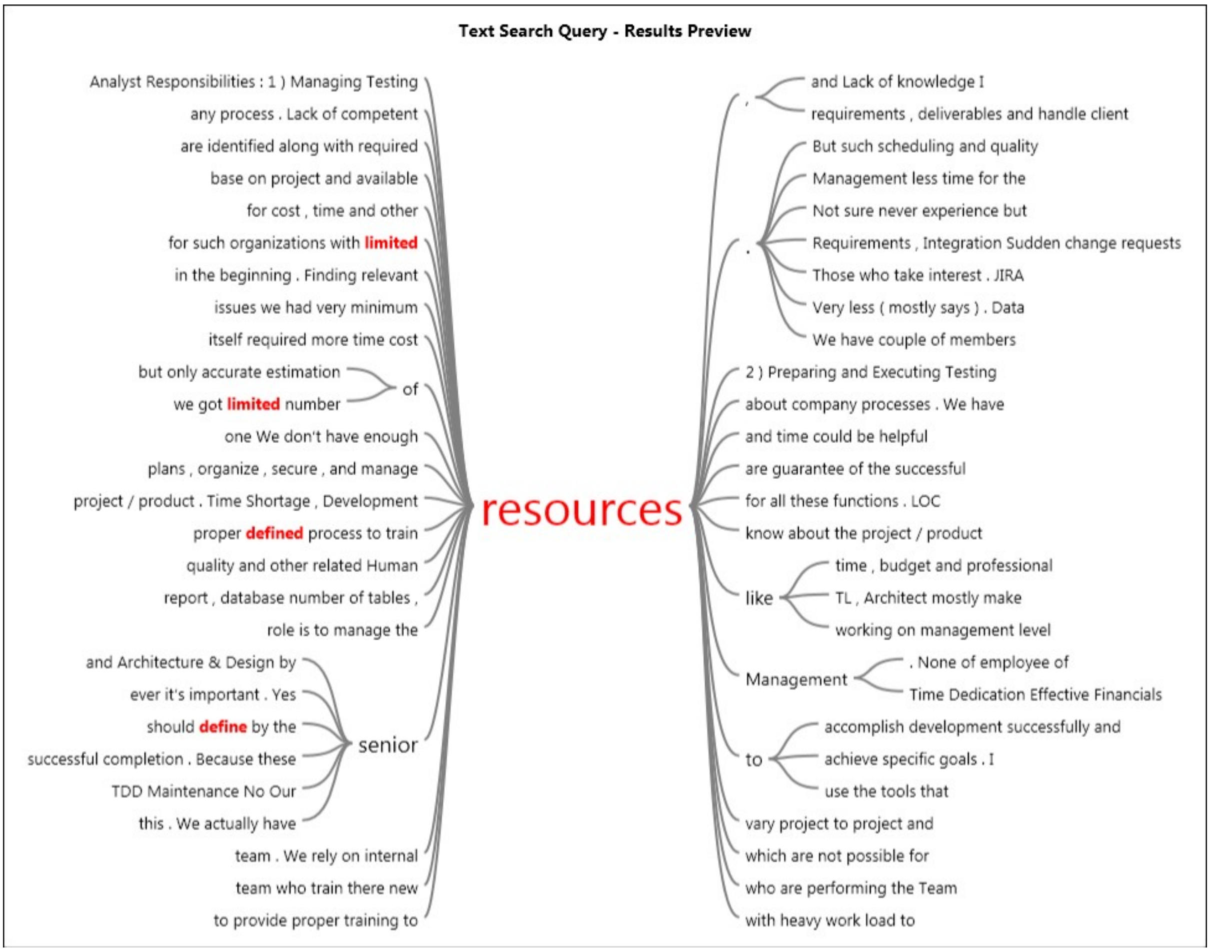
Approved by the Auckland University of Technology Ethics Committee on dd/mm/yyyy
AUTEC Reference number ....

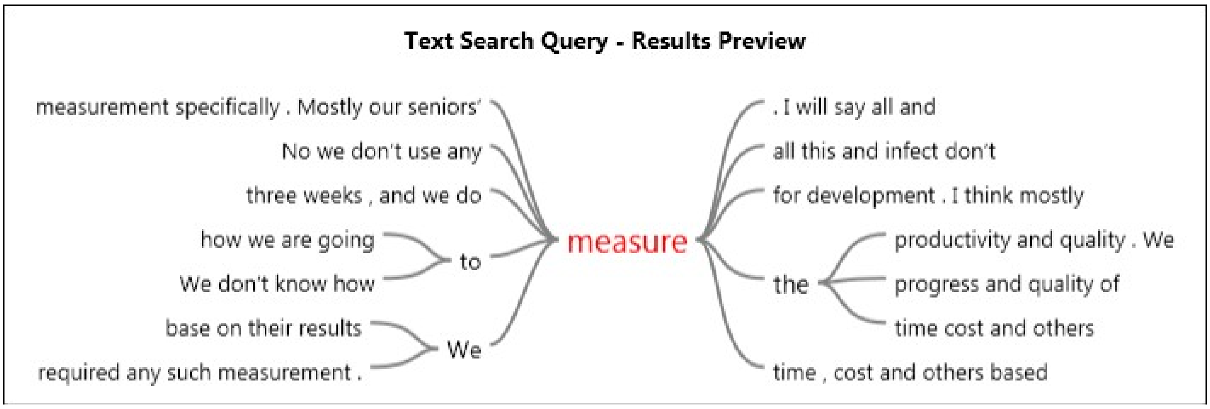
Appendix 5.7 Word Trees

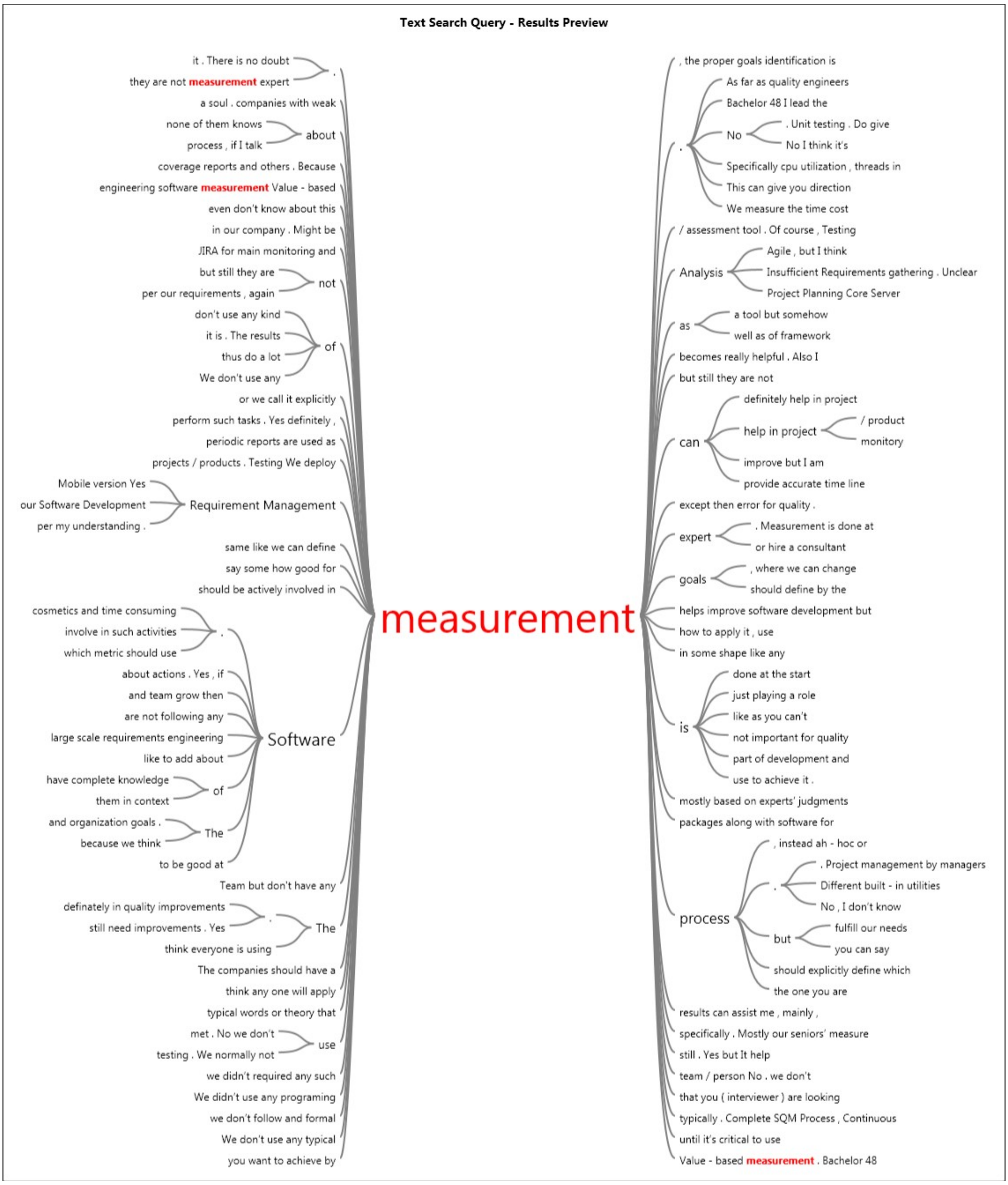
The following word trees are drawn through Nvivo based from interviewees data based on some random key words. These word trees shows the excerpts of their statements about particular key words.






Text Search Query - Results Preview
Analyst Responsibilities : 1) Managing Testing
any process . Lack of competent
are identified along with required
base on project and available
for cost , time and other
for such organizations with limited
in the beginning . Finding relevant
issues we had very minimum
itself required more time cost
but only accurate estimation
we got limited number
of
one We don't have enough
plans , organize , secure , and manage
project / product . Time Shortage , Development
proper defined process to train
quality and other related Human
report , database number of tables ,
role is to manage the
and Architecture & Design by
ever it's important . Yes
should define by the
successful completion . Because these
TDD Maintenance No Our
this . We actually have
senior
team . We rely on internal
team who train there new
to provide proper training to
resources
and Lack of knowledge I
requirements , deliverables and handle client
But such scheduling and quality
Management less time for the
Not sure never experience but
Requirements , Integration Sudden change requests
Those who take interest . JIRA
Very less (mostly says) . Data
We have couple of members
2) Preparing and Executing Testing
about company processes . We have
and time could be helpful
are guarantee of the successful
for all these functions . LOC
know about the project / product
like
time , budget and professional
TL , Architect mostly make
working on management level
Management
. None of employee of
Time Dedication Effective Financials
to
accomplish development successfully and
achieve specific goals . I
use the tools that
vary project to project and
which are not possible for
who are performing the Team
with heavy work load to


Text Search Query - Results Preview
measurement specifically . Mostly our seniors'
No we don't use any
three weeks , and we do
how we are going
We don't know how
to
base on their results
required any such measurement .
We
measure
. I will say all and
all this and infect don't
for development . I think mostly
the
productivity and quality . We
progress and quality of
time cost and others
time , cost and others based


Text Search Query - Results Preview
it . There is no doubt
they are not measurement expert
.
a soul . companies with weak
none of them knows
process , if I talk
about
coverage reports and others . Because
engineering software measurement Value - based
even don't know about this
in our company . Might be
JIRA for main monitoring and
but still they are
per our requirements , again
not
don't use any kind
it is . The results
thus do a lot
We don't use any
of
or we call it explicitly
perform such tasks . Yes definitely ,
periodic reports are used as
projects / products . Testing We deploy
Mobile version Yes
our Software Development
per my understanding .
Requirement Management
same like we can define
say some how good for
should be actively involved in
cosmetics and time consuming
involve in such activities
which metric should use
.
about actions . Yes , if
and team grow then
are not following any
large scale requirements engineering
like to add about
have complete knowledge
them in context
of
and organization goals .
because we think
The
to be good at
Software
Team but don't have any
definately in quality improvements
still need improvements . Yes
.
think everyone is using
The
The companies should have a
think any one will apply
typical words or theory that
met . No we don't
testing . We normally not
use
we didn't required any such
We didn't use any programing
we don't follow and formal
We don't use any typical
you want to achieve by
measurement
, the proper goals identification is
.
As far as quality engineers
Bachelor 48 I lead the
No
. Unit testing . Do give
No I think it's
Specifically cpu utilization , threads in
This can give you direction
We measure the time cost
/ assessment tool . Of course , Testing
Analysis
Agile , but I think
Insufficient Requirements gathering . Unclear
Project Planning Core Server
as
a tool but somehow
well as of framework
becomes really helpful . Also I
but still they are not
can
definitely help in project
help in project
/ product
monitory
improve but I am
provide accurate time line
except then error for quality .
expert
. Measurement is done at
or hire a consultant
goals
, where we can change
should define by the
helps improve software development but
how to apply it , use
in some shape like any
is
done at the start
just playing a role
like as you can't
not important for quality
part of development and
use to achieve it .
mostly based on experts' judgments
packages along with software for
process
, instead ah - hoc or
.
. Project management by managers
Different built - in utilities
No , I don't know
but
fulfill our needs
you can say
should explicitly define which
the one you are
results can assist me , mainly ,
specifically . Mostly our seniors' measure
still . Yes but It help
team / person No . we don't
that you (interviewer) are looking
typically . Complete SQM Process , Continuous
until it's critical to use
Value - based measurement . Bachelor 48

Appendix 5.8 Ethical Approval

For AUTEC Secretariat Use only

/

AUCKLAND UNIVERSITY OF TECHNOLOGY ETHICS COMMITTEE (AUTEC)

EA1

APPLICATION FOR ETHICS APPROVAL BY AUTEC

Once this application has been completed and signed, please read the notes at the end of the form for information about submission of the application for review.

NOTES ABOUT COMPLETION

- Ethics review is a community review of the ethical aspects of a research proposal. Responses should use clear everyday language with appropriate definitions being provided should the use of technical or academic jargon be necessary.
- The AUTEC Secretariat and your AUTEC Faculty Representative are able to provide you with assistance and guidance with the completion of this application which may help expedite the granting of ethics approval.
- The information in this application needs to be clearly stated and to contain sufficient details to enable AUTEC to make an informed decision about the ethical quality of the research. Responses that do not provide sufficient information may delay approval because further information will be sought. Overly long responses may also delay approval when unnecessary information hinders clarity. In general each response should not exceed 100 words.
- AUTEC reserves the right not to consider applications that are incomplete or inadequate.
- The information provided in this application will be used for the purposes of granting ethics approval. It may also be provided to the University Postgraduate Centre, the University Research Office, or the University's insurers for purposes relating to AUT's interests.
- The Form is focussed around AUTEC's ethical principles, which are in accordance with the Operational Standards for Ethics Committees in New Zealand.

To respond to a question, please place your cursor in the space following the question and its notes and begin typing.

A. Project Information

A.1. What is the title of the research?

Establishing Lean and Sustainable Software Measurement Programs

A.2. Who is the applicant?

Assoc. Prof. Tony Clear

A.3. Further information about the applicant

A.3.1. In which faculty, directorate, or research centre is the applicant located?

School of Computing & Mathematical Sciences,

Associate Dean Research, Faculty of Design & Creative Technologies

A.3.2. What are the applicant's qualifications?

2008 Doctor of Philosophy (Computer and Information Sciences): "Supporting the work of global virtual teams: the role of technology-use mediation" (AUT University) [Graduation August 2009]

2001 Master of Philosophy (Information Systems), University of Auckland

1975 Master of Arts (Hons) (Latin and English), Victoria University

A.3.3. What is the applicant's email address?

tony.clear@aut.ac.nz

A.3.4. At which telephone numbers can the applicant be contacted during the day?

64 9 921 9999 xtn 5329

B. The Ethical Principle of Research Adequacy

AUTEC recognises that different research paradigms may inform the conception and design of projects. It adopts the following minimal criteria of adequacy: the project must have clear research goals; its design must make it possible to meet those goals; and the project should not be trivial but should potentially contribute to the advancement of knowledge to an extent that warrants any cost or risk to participants.

B.1. What is the aim of this research?

The aim of this research is to understand and then contribute to the more effective planning, deployment, operation and management of measurement programs particularly in the context of small to medium sized enterprises (SMEs). The intent is to support the delivery of more relevant and actionable measurement outcomes by ensuring that metrics are collected based on the goals of potentially multiple stakeholders in these organizations. More specifically, it will address the need to plan and establish cost-effective, lean and sustainable measurement programs in dynamic environments, where information needs, their priorities, and the constraints of the organization, all change perhaps quite rapidly. In particular, small to medium sized software enterprises (SSEs) will be targeted in this research and so stand to gain most substantially from it. From a research standpoint, these types of organisations have received relatively less attention, in spite of the fact that many economies are heavily reliant on such smaller entities.

In brief, the research is being conducted to answer following research questions:

Q1. How can SSEs best collect valid and sound software metrics using appropriate and efficient measurement models?

Q2. How can SSEs collect all metrics, and only those metrics, consistent with achieving users' goals?

B.2. Is the applicant the person doing most of the research (the primary researcher)?
☐ **Yes** ☒ **No**

B.2.1. What is the name of the primary researcher if it is someone other than the applicant?

AFTAB AHMAD MUGHAL

B.2.2. What are the primary researcher's completed qualifications?

2010 Master in Software Engineering Blekinge Institute of Technology, School of Engineering, Sweden

2007 Master of Computer Science, University of Arid Agriculture Rawalpindi, Pakistan

2002 Bachelor of Information Technology, AL-Khair University (AJK), Pakistan

B.2.3. What is the primary researcher's email address?

amughal@aut.ac.nz

B.2.4. At which telephone numbers can the primary researcher be contacted during the day?

64 9 921 9999 ext 5852

B.3. Is the primary researcher ☐ an AUT staff member ☒ an AUT student

If the primary researcher is an AUT staff member, please answer B.3.1 and the following sections, otherwise please answer B.4 and continue from there.

B.3.1. In which Research Institute or Faculty and school or department is the primary researcher employed?

B.4. If the primary researcher is a student:

B.4.1. What is their Student ID Number?

1241523

B.4.2. In which faculty school, department, or Research Centre are they enrolled?

Department: School of Computing and Mathematical Sciences, Research

Centre: Software Engineering Research Lab (SERL)

B.5. What is the primary researcher's experience or expertise in this area of research?

Where the primary researcher is a student at AUT, please identify the applicant's experience or expertise in this area of research as well.

The primary researcher investigated software measurement process improvement in his Master's thesis, conducting a case study into a reasonably mature multinational software development organization. A framework was proposed to enable lean and sustainable software measurement. The main goal of the study was to select a valid optimum set of metrics consistent with goal achievement. In that study organizational size was not an issue under consideration, whereas in the proposed research SMEs will be a specific target. SMEs have specific characteristics that present additional challenges to the research undertaken previously. The Master's work formed the basis of a journal article that has been recently accepted for publication in the Journal of Systems and Software.

B.6. Who is in charge of data collection? The primary researcher

B.7. Who will interact with the participants?

The primary researcher and potentially the applicant

B.8. Is this research being undertaken as part of a qualification? **Yes** ☒ **No** ☐ ***If the answer is 'Yes' please answer B.8.1 and the following sections, otherwise please answer B.9 and continue from there.***

B.8.1. What is the name of the qualification?

PhD

B.8.2. In which institution will the qualification be undertaken?

Auckland University of Technology

B.9. Details of Other Researchers or Investigators

B.9.1. Will any other people be involved as researchers or co- investigators? ☒ **Yes** ☐ **No** ***If the answer is 'Yes' please answer B.9.1.1 and the following sections, otherwise please answer B.9.2 and continue from there.***

B.9.1.1 What are the names of any other people involved as researchers or investigators?

Professor Stephen MacDonell

B.9.1.2 Where do they work?

Department of Information Science, University of Otago

B.9.1.3 What will their roles be in the research?

Co-supervisor of the primary researcher

B.9.1.4 What are their completed qualifications?

1993, PhD, University of Cambridge, United Kingdom

1990, MCom, University of Otago, New Zealand

1988, BCom(Hons), University of Otago, New Zealand

B.9.2. Will any research organisation or other organisation be involved in the research?

☒ **Yes** ☐ **No**

If the answer is 'Yes' please answer B.9.2.1 and the following sections, otherwise please answer B.10 and continue from there.

B.9.2.1 What are the names of the organisations?

To be determined as part of the research process.

B.9.2.2 Where are they located?

Likely to be Pakistan, UAE and New Zealand.

B.9.2.3 What will their roles be in the research?

They will be participants in the research. They will provide access to staff, electronic systems and artefacts for evaluation, some staff members will be interviewed in relation to software measurement processes, practices and needs.

B.10. Why are you doing this research and what is the background?

Please provide an academic rationale with sufficient information, including relevant references, to place the project in perspective and to allow the project's significance to be assessed.

Background

For around two decades software organizations have been initiating (sometimes systematic) measurement programs as part of their software process improvement practices, directed towards increasing the quality of their software products and services [1]. Soundly designed measurement practices help users to understand, control and improve both processes and products [2]. They can help organizations to maximize project estimation accuracy, leading to better project plans for the development team, and enabling them to make best use of resources [3]. In short, good software measurement can play a vital role in controlling the cost and quality of software development [4]; however, the software measurement process itself is costly [5]. It can also require significant effort to develop and sustain.

The ISO/IEC 15939 standard [6] identifies a set of recommended activities and tasks to identify, define, select, apply and improve software measurement. In keeping with an industry standard, however, it is inherently generic and high-level in nature. Several goalbased measurement/metric selection models have therefore been introduced to aid organizations in developing more specific or tailored approaches, and the Goal Question Metric (GQM) framework is one of the most well-known and widely adopted [2]. The main idea underpinning such approaches is that measures should be chosen and collected based on the goals of the organization. Over time, software engineers have generally accepted that measurement should indeed be goal oriented [7]. There is a question for some, however, over the efficacy of GQM – for instance, it has been noted [8] that the measures identified by GQM for collection and analysis are often more than are actually needed. Furthermore, although GQM and other GQM-based frameworks have resolved a number of measurement issues, they have some limitations: defined goals can be subject to inconsistent interpretations [9]; for instance, the department manager or project manager may have different perspectives on the same goals, or may in fact have different, potentially conflicting, goals. In addition, the approaches may not facilitate rapid change in measurement as might be needed in highly geared organisations.

Opportunities for efficiency gains in software provision are sorely needed. The sector continues to grow at a rapid rate and yet the software industry suffers from significant labour shortage [10]. This raises questions in organizations such as “How to manage more work with less effort?” This applies doubly to software measurement – measurements are needed to answer such a question, and the measurement process itself must be efficient. Implementing software measurement is not a straightforward task, however [11], and sometimes fails because the required information is not in fact provided or the necessary data is difficult and/or costly to obtain. In fact, it has been reported that about 80% of measurement programs fail due to indecisive power [12, 13]. There are several grounds behind that failure: measurement programs usually start measuring what is easy to measure [9], and so may not focus sufficiently on what is needed. In a more general sense there are three key problems [8]: first, organizations face difficulties in deciding what should be measured; second, they make improper use of measurement data which in fact debilitates organizational success and progress; and third, many managers are unaware of the fundamental concepts and limitations of measurement.

The results of the literature review undertaken to date for this research show that the approaches being used currently would still benefit from being more structured and integrated in order to enable effective software measurement [4,11]. 'Structured' means the goals, questions and measures as well as their vertical and horizontal relations are well-defined. A structured measurement process can be 'integrated' into the organization via establishing links between business and organizational goals and the measurement process. The whole process becomes more 'effective' as these goals and measures become traceable, and hence the mechanisms to prioritize and select the optimum set of measures can be established. In addition, it is contended here that measurement programs need to be dynamic and that they need to be tailored according to organisational characteristics.

One of the organisational characteristics that warrant attention is size. It has been estimated that around 70% of software development is carried out by small and medium sized enterprises (although how these terms are defined is an additional, relevant question). In Europe, for instance [14], "85% of the Information Technology (IT) sector has between 1 and 10 employees. In the Montreal area 80% of IT companies have between 1 and 25 employees, in Brazil, small IT companies represent about 70% of the total number of companies and finally, in Northern Ireland 66% of IT organizations employ fewer than 20 employees".

Motivation for This Research

In previous research undertaken by the primary researcher several goal-based models were evaluated, and this led to the development of a proposed framework for a more effective measurement process, called GQM-Lean. It provides an integrated measurement process, starting from the goals and question definitions with all the links between sub-goals and questions (in terms of software entities and attributes) as well as between the selected measures. The proposed framework was validated in only one case organization and for two case projects. Moreover, just two main goals were selected and the measurement stakeholders were the same for both projects.

Given the predominance of SMEs in the New Zealand ICT sector, and their relative prevalence internationally, the proposed research will be focused on organisations of this scale. Software measurement implementation is not an easy task for any organisation but it becomes even more challenging when the targeted organisations are SMEs [15]. They are generally not mature in terms of process and their work is highly time-sensitive. Also they do not have the scale or depth of experience to adopt extensive – and expensive – measurement programmes. Furthermore, existing frameworks to implement software measurement programs do not fully address the needs of SMEs [15]. The proposed research will therefore focus on the provision of lean and sustainable software measurement in SMEs that undertake software systems development – small software enterprises (SSEs) who provide software intensive solutions. To achieve lean and sustainable measurement we will focus of the selection of a valid and optimum set of metrics that is dynamically consistent with goal achievement, taking into account a range of considerations including organisation maturity. Companies' maturity has not been taken into account during prior efforts at measurement definition [16], one of the reasons for the failure of measurement program implementations.

B.11. What are the potential benefits of this research to the participants, the researcher, and the wider community?

This research will contribute to more effective planning and management of measurement programs which still remains a challenge for many software organizations, and particularly SMEs. It will make measurement more successful by ensuring that metrics are collected based on the goals of multiple stakeholders in organizations. It will explicitly address the need to plan and establish cost-effective, lean and sustainable measurement programs in dynamic environments, where the information needs, their priorities and the constraints of the organization change. In particular, the SSE sector will be targeted in this research and so stands to gain most substantially from it. There will also be multiple research outcomes that will form the basis of refereed conference and journal publications, of benefit to the research community and to the researcher and applicant. Finally, the work will benefit the researcher in terms of contributing to the completion of his PhD.

B.12. What are the theoretical frameworks or methodological approaches being used?

The proposed research will combine elements of observation, design, intervention and evaluation under the umbrella of a design science methodology. We intend to conduct a sequence of field studies to assess and refine variants of GQM-Lean that will work specifically within the SSE context. The field studies will utilise observation, interviews and document analysis in order to inform measurement program development. Validation of the approach will comprise the in-principle evaluation of the proposed framework as well as further on-site observation and interviews with key personnel in relevant SSEs. A mix of quantitative and qualitative analysis methods will be used as appropriate.

B.13. How will data be gathered and processed?

For this study several different sources of information will be used to gather data in order to limit the effects of constrained interpretation due to the availability of a single data source. Data will be collected from various artefacts (both electronic and non-electronic), participant interviews and discussions, which then will be collectively used for analysis. The main source of study data will be derived from organisations' actual and desired measurement processes.

The techniques used for data collection in this study fall under the three broad categories defined by [17]. Techniques include I) direct methods, real time data collected directly from the subjects through interviews, meetings and the like; II) indirect methods, which involve collection of raw data without actually interacting with the subjects during the data collection such as available via software tools, source code, CVS data; and also by III) examining already available compiled or un-compiled data (such as documented records of measurement and failure reports, archival data, repositories, logs).

B.14. How will the data be analysed?

Please provide the statistical (for quantitative research) or methodological (for qualitative or other research) justification for analysing the data in this way. This research will adopt primarily qualitative analysis methods owing to the non-numeric nature of most of the empirical evidence that will be collected (and as recommended [18] for such a study). The investigation will study software measurement processes, the people involved in these processes as well as the adoption of process-related technologies in real life contexts. It is likely that technology adoption or a similarly appropriate theory might also be considered to underpin the constructs investigated. The purpose of the analysis is to gain a deeper understanding of the phenomenon of interest and to identify the challenges faced by practitioners while implementing software measurement programs.

Content analysis will be used to develop an understanding of programs' implementation needs and challenges as well as related issues such as organizational policy, customer expectations, domain understanding and process awareness. Qualitative methods will also be employed to analyse the data collected in relation to the use and evaluation of the proposed software measurement framework.

The proposed data analysis methodology is shown in Figure. 1. The process will be informed by a review of existing measurement processes and programs (MP) and conducting interviews with SMEs.

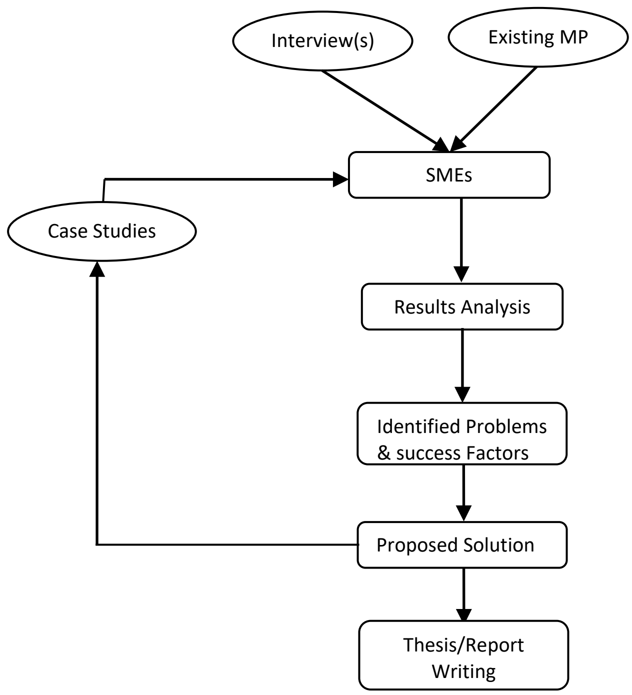


Fig1. Data Collection and Analysis

The researcher will ask participating organisations to provide information regarding any existing measurement processes, including documentation if available, which will be screened and analysed to obtain an understanding of its strengths/weaknesses. These results will be cross-checked with other related available artefacts. The analysis process will also involve interviews with key figures in the organisation (self-identified as well as nominated) to capture a first-hand understanding of the challenges faced by practitioners during the design and implementation of software measurement programs. The interviewees will be provided with an open-ended questionnaire to provide this information, which will be further examined as part of the analysis process. The purpose of such an activity is to confirm our evaluation and triangulate our initial findings. The results obtained will further inform the construction and refinement of the proposed framework.

If possible, the proposed framework solution will be implemented in selected organisations and opinions on its efficacy collected and analysed. If this is not possible a further round of interviews will be conducted to ascertain its perceived utility in the context of SSE.

Has any peer review taken place (e.g. approval of a PG1, D1, or D9)? ☒ Yes ☐ No

If your answer is 'Yes', please specify and provide evidence.

C. General Project Details

C.1. Likely Research Output

C.1.1. Will the research result in one or more of the following

☒ a thesis ☐ a dissertation ☐ a research paper ☒ a journal article ☐ a book ☒ a conference paper ☐ other academic publications or presentations ☐ an exhibition ☐ a film ☐ a documentary ☐ some other artwork ☐ Some other output, please specify

C.2. Research Location and Duration

C.2.1. In which countries and cities/localities will the data collection occur?

Auckland University of Technology (AUT),

New Zealand: potentially Auckland, Wellington, Christchurch, Dunedin

Pakistan: Islamabad, Lahore, Karachi

UAE: Dubai

Very few studies focus on the cultural or human side of measurement programme implementation; instead most focus only on the technical aspects of measurement [19]. As a result, in the absence of any other evidence, we must initially assume that the software measurement process and its effectiveness are country-neutral. Given that the software industry is a global one with many projects occurring across international borders, as well as the extensive influence that west-to-east outsourcing has had on IT globalisation, we therefore treat all the organisations as part of a single sample. While most software professionals agree that there is a need for measurement many implementations are challenged. While this challenge may arise due to a required cultural change in the organisation [20] this reflects an attitudinal culture rather than a national one.

As we had good access to organisations in three countries, approaching and engaging them in the research would hopefully provide a larger and richer source of information. That said, some research in the wider field of
SPI [21] has found evidence of regional differences in organisations' transitions from one maturity level to another, and the implementation of Software Quality management systems has also been found to be influenced by a range of issues of culture [22]. We will therefore be mindful to consider this factor as necessary when we come to analyse our data.

C.2.2. In which countries and cities/localities will the data analysis occur?

New Zealand: Auckland

C.2.3. When is the data collection scheduled to commence?

November 2013

C.3. Research Participants

C.3.1. Who are the participants?

Personnel involved in the design, development, implementation and operation of software measurement programs (likely to be managers and quality assurance staff) in SSEs.

C.3.2. How many participants are being recruited for this research?

It is difficult to predict how many participants will be interviewed from the participating organizations. The number will depend on the number and diversity of personnel involved in measurement program implementation in each organization and also the availability of personnel to participate. It is expected that 1 to 4 people will be involved in interviews in each case organization.

C.3.3. What criteria will be used to choose who to invite as participants?

Recruitment will be conducted on the basis of participants' overall experience, which should be not less than 5 years as a practitioner/expert in project management, software development, and quality assurance in general.

C.3.3.1 How will you select participants from those recruited if more people than you need for the study agree to participate?

We do not foresee this as being a problem! However, if there are more people willing to participate than expected then preference will be given to those with more experience (in terms of years worked) in software measurement among those who agree to participate.

C.3.4. Will any people be excluded from participating in the study? ☐ Yes ☒ No

If the answer is 'Yes' please answer C.3.4.1 and the following sections, otherwise please answer C.3.5 and continue from there.

C.3.4.1 What criteria will be used to exclude people from the study?

N/A

C.3.4.2 Why is this exclusion necessary for this study?

N/A

C.3.5. How will participants be recruited?

Please describe in detail the recruitment processes that will be used. If you will be recruiting by advertisement or email, please attach a copy to this Application Form

Candidate software organisations that fall into the SME category will be identified (from public sources such as http://www.indexnz.com/Top/Computersand-Internet/Software/Software-Firms/). The CIO (or equivalent) of these organisations will be contacted initially by the applicant and primary researcher via email. The message will describe the nature and purpose of research, the role of the researcher and our expectations of participating organisations. Organisations that have been undertaking software development for at least two years will be eligible to take part, as this is considered to be a required minimum experience level to enable informed comment on development and measurement practices, needs and expectations. The organisation will be asked for written consent and confirmation of their participation in the research. If consent is given the primary researcher will proceed. The primary researcher will ask the first contact of the targeted organisations to forward an email invitation to suitable participants who will then be asked to contact the researcher directly. In some cases the researcher may need to contact candidate organisations or research participants through phone calls or by face to face meetings.

C.4. Research Instruments

C.4.1. Which of the following does the research use:

☐ ***a written or electronic questionnaire or survey*** ☐ ***focus groups*** ☒ ***interviews***
☒ ***observation*** ☐ ***participant observation*** ☐ ***ethnography*** ☐ ***photographs***
☐ ***videos*** ☐ ***other visual recordings*** ☐ ***a creative, artistic, or design process***
☐ ***performance tests***
☐ ***some other research instrument (please specify)***

Please attach to this application form all the relevant research protocols. These may include: Indicative questions (for interviews or focus groups); a copy of the finalised questionnaire or survey in the format that it will be presented to participants (for a written or electronic questionnaire or survey); a protocol indicating how the data will be recorded (e.g. audiotape, videotape, note-taking) for focus groups or interviews (Note: when focus groups are being recorded, you will need to make sure there is provision for explicit consent on the Consent Form and attach to this Application Form examples of indicative questions or the full focus group schedule. Please note that there are specific confidentiality issues associated with focus groups that need to be addressed); a copy of the observation *protocol that will be used (for observations); full information about the use of visual recordings of any sort, including appropriate protocols and consent processes; protocols for any creative, artistic, or design process; a copy of the protocols for the instruments and the instruments that will be used to record results if you will use some other research instrument.*

C.4.2. Who will be transcribing or recording the data?

The primary researcher.

D. Partnership, Participation and Protection

D.1. How does the design and practice of this research implement the principle of Partnership in the interaction between the researcher and other participants?

How will your research design and practice encourage a mutual respect and benefit and participant autonomy and ownership?

The research methodology (Fig.2 Data Collection and Analysis) relies on the input of intended users and/or domain experts (the project and quality managers and team leads), and so explicitly considers their needs and expectations.

The intent is that different people in various roles will both contribute to and benefit from this research. The project managers, quality managers and team leads that play key roles in the software measurement processes of small organisations will be aware of the challenges they face, and possible solutions to improve the process. On other hand the researchers will bring in depth understanding of a range of measurement process solutions which should enable them to provide effective solutions.

How will you ensure that participants and researchers will act honourably and with good faith towards each other?

The methodology and research methods incorporate activities that should ensure that the participants are fully informed of this research, its benefits, potential risks, and outcomes, which should help to secure mutual understanding and acceptance of the roles and responsibilities of all parties involved. The success of the data collection activities depends entirely on the good faith of the participants. Therefore, the researchers will show respect towards the participants – for instance, interviews will be scheduled at the participants' convenience. The researchers have prior experience in similar projects so they are familiar with the challenges inherent to such research.

Are the outcomes designed to specifically benefit the participants and/or their social or cultural group?

As stated above, the design of the research will benefit the participant organisations indirectly through the support provided to project manager, quality managers, team leads and developers involved.

How will the information and knowledge provided by the participants be acknowledged?

The thesis will acknowledge the input of those taking part, generally in the Acknowledgements page and more specifically in informing the design and content of the framework.

D.2. How does the design and practice of this research implement the principle of Participation in the interaction between the researcher and other participants? *What is the actual role of participants in your research project?*

The project managers, quality managers and others will be active participants, in that their input will inform our assessment of the current state of measurement processes in SMEs as well as the proposed framework(s).

Will participants be asked to inform or influence the nature of the research, its aims, or its methodology?

The participants will certainly influence the nature of the research, and they may impact the methodology in terms of the number of design cycles that will be needed in order to build, test and refine the framework.

Will participants be involved in conducting the research or is their principal involvement one of sharing information or data?

The principal role of participants is one of sharing information – they will be expected to help in identifying strengths and weakness of measurement processes, and to share their experiences on how to implement such processes in order to be more effective.

Do participants have a formal role as stakeholders e.g. as the funders and/or beneficiaries of the research?

No – as stated, they will benefit indirectly from the research outcomes.

What role will participants have in the research outputs (e.g. will they be asked to approve transcripts or drafts)?

Participants will have no role in the research outputs, although (in keeping with the Fig.2 design methodology) they will be informed of the availability of the thesis when it is completed.

D.3. How does the design and practice of this research implement the principle of Protection in the interaction between the researcher and other participants? *How will you actively protect participants from deceit, harm and coercion through the design and practice of your research? How will the privacy of participants and researchers be protected? How will any power imbalances inherent in the relationships between the participants and researchers be managed? How will any cultural or other diversity be respected?*

How will you actively protect participants from deceit, harm and coercion through the design and practice of your research?

The nature of the research will be communicated in full to the participants prior to their involvement, and will be reiterated to them at interview. The participants will be fully informed of their role in the research, and their consent will be sought prior to any interviews. The researchers acknowledge and respect the role of the participants as being crucial to robust and useful outcomes – deceit, harm and coercion work entirely against this acknowledgement.

How will the privacy of participants and researchers be protected?

The identities of participants will be known to the researcher only. In the published reports of this research, participants' identities will not be revealed. No sensitive data will be published in the reports. The data and consent forms will be kept securely and separately for six years before being destroyed.

How will any power imbalances inherent in the relationships between the participants and researchers be managed?

Participation by managers and others is voluntary, and the participants will determine the time and place of the interviews. Only the primary researcher will attend the interview so it will be conducted one-to-one, and the open-ended nature of the interview should ensure that participants understand what is being asked of them but at the same time will not constrain their responses. Participants may decline to answer questions they find sensitive.

How will any cultural or other diversity be respected?

Prior to interview the researcher will contact each participant to ask if they have any particular preferences in regard to the conduct of the interview e.g. accessible location. The researcher will respect any such requests wherever feasible.

E. Social and Cultural Sensitivity (including the obligations of the Treaty of Waitangi)

E.1. What familiarity does the researcher have with the social and cultural context of the participants?

The primary researcher is familiar with the intended cultural contexts of this study, namely Pakistan, UAE, and New Zealand. The primary researcher, having lived in Pakistan and New Zealand and having studied and worked in the IT industry in each location, has social and cultural roots that are likely to coincide with those of the organisations involved in this research. It is believed that this professional and cultural familiarity will enable the primary researcher to conduct the research in an appropriate manner.

If you respond 'yes' to one or more of the following three questions please then answer E.5 and the following sections, otherwise please then answer E.6 and continue from there.

E.2. Does this research target Maori participants? ☐ **Yes** ☒ **No**

All researchers are encouraged to make themselves familiar with <u>Te Ara Tika: Guidelines for Maori Research Ethics: A framework for researchers and ethics committee members</u>

E.3. Does this research target participants of particular cultures or social groups?

☐ **Yes** ☒ **No**

AUTEC defines the phrase 'specific cultures or social groups' broadly. In section 2.5 of *Applying for Ethics Approval: Guidelines and Procedures* it uses the examples of Chinese mothers and paraplegics. This is to identify their distinctiveness, the first as a cultural group, the second as a social group. Other examples of cultural groups may be Korean students, Samoan husbands, Cook Islanders etc., while other examples of social groups may be nurse aides, accountants, rugby players, rough sleepers (homeless people who sleep in public places) etc. *Please refer to Section 2.5 of AUTEC's Applying for Ethics Approval: Guidelines and Procedures (accessible in the Ethics Knowledge Base online via http://www.aut.ac.nz/about/ethics) and to the relevant Frequently Asked Questions section in the Ethics Knowledge Base.*

E.4. Does this research focus on an area of research that involves Treaty obligations?

☐ **Yes** ☒ **No**

All researchers are encouraged to make themselves familiar with <u>Te Ara Tika: Guidelines for Maori Research Ethics: A framework for researchers and ethics committee members</u>.

E.5. What consultation has occurred?

Research procedures should be appropriate to the participants. Researchers have a responsibility to inform themselves of, and take the steps necessary to respect, the values, practices and beliefs of the cultures and social groups of all participants. Where a research project targets persons from another cultural, social or language group, consideration must be given to the preferences of the potential participants as far as consultation, language and documentation are concerned. Researchers should also be cognisant of potential implications or interest that the process and outcomes of the research might have for other cultures or groups. The purpose of any consultation is to ensure that research practices are appropriate and acceptable. Consultation should begin as early as possible in the project and should continue throughout its duration (the Ethics Knowledge Base (<u>http://www.aut.ac.nz/research/research-ethics/ethics</u>). All researchers are encouraged to make themselves familiar with <u>Te Ara Tika: Guidelines for Maori Research Ethics: A framework for researchers and ethics committee members</u> (This is able to be accessed through the Ethics Knowledge Base). Researchers may also find <u>Te Kahui Mangai</u> a directory of Iwi and Maori organisations to be helpful. This may be accessed via the Te Puna Kokiri website (http://www.tkm.govt.nz/). N/A

E.5.1. With whom has the consultation occurred?

Please provide written evidence that the consultation has occurred. N/A

E.5.2. How has this consultation affected the design and practice of this research?

N/A

E.6. Will the findings of this study be of particular interest to specific cultures or social groups? ☐ **Yes** ☒ **No**

If the answer is 'Yes' please answer E.5.1 and the following sections, otherwise please answer F.1 and continue from there.

E.6.1. To which iwi, hapu, culture or social groups will the findings be of interest?

N/A

E.6.2. How will the findings be made available to these groups?

N/A

F. Respect for the Vulnerability of Some Participants

F.1. Will your research involve any of the following groups of participants? Yes ☐ No ☒ *If your research involves any of these groups of participants, please clearly indicate which ones and then answer F.2 and the following sections, otherwise please answer G.1 and continue from there.*

☐ unable to give informed consent? ☐ your (or your supervisor's) own students?
☐ preschool children? ☐ children aged between five and sixteen years?
☐ legal minors aged between sixteen and twenty years ☐ aged over seventy years? ☐ in a dependent situation, such as people with a disability, or residents of a hospital, nursing home or prison or patients highly dependent on medical care?
☐ vulnerable for some other reason (e.g. the elderly, prisoners, persons who have suffered abuse, persons who are not competent in English, new immigrants) – please specify

F.2. How is respect for the vulnerability of these participants reflected in the design and practice of your research? N/A

F.3. What consultation has occurred to ensure that this will be effective?

Please provide evidence of the consultation that has occurred. N/A

G. Informed and Voluntary Consent

G.1. How will information about the project be given to potential participants?

A copy of all information that will be given to prospective participants is to be attached to this Application Form. If written information is to be provided to participants, you are advised to use the Information Sheet exemplar. The language in which the information is provided is to be appropriate to the potential participants and translations need to be provided when necessary.

All participants will be provided with a copy of the Information Sheet associated with the research. This will set out the goals of the research as well as the intended data collection methods. Roles and expectations of those involved will also be described. **G.2. How will consent of participants be obtained and evidenced?**

AUTEC requires consent to be obtained and usually evidenced in writing. A copy of the Consent Form which will be used is to be attached to this application. If this will not be the case, please provide a justification for the alternative approach and details of the alternative consent process. Please note that consent must be obtained from any participant aged 16 years or older. Participants under 16 years of age are unable to give consent, which needs to be given by their parent or legal guardian. AUTEC requires that participants under the age of 16 assent to their participation. When the nature of the research requires it, AUTEC may also require that consent be sought from parents or legal guardians for participants aged between 16 and twenty years. For further information please refer to AUTEC's Applying for Ethics Approval: Guidelines and Procedures.

Participants will be asked to complete an AUTEC-approved Consent Form prior to the commencement of the research. These forms will be collected and stored (with the data storage privacy protocols as discussed in section H.1. and H.9. below) at AUT in a secure location.

G.3. Will any of the participants have difficulty giving informed consent on their own behalf? ☐ **Yes** ☒ **No**

Please consider physical or mental condition, age, language, legal status, or other barriers.

If the answer is 'Yes' please answer G.3.1 and the following sections, otherwise please answer G.4 and continue from there.

G.3.1. If participants are not competent to give fully informed consent, who will consent on their behalf?

N/A

G.3.2. Will these participants be asked to provide assent to participation?

N/A

G.4. Is there a need for translation or interpreting? ☐ **Yes** ☒ **No**

If your answer is 'Yes', please provide copies of any translations with this application and any Confidentiality Agreement required for translators or interpreters.

H. Respect for Rights of Privacy and Confidentiality

H.1. How will the privacy and confidentiality of participants be protected?

Please note that anonymity and confidentiality are different. For AUTEC's purposes, 'Anonymity' means that the researcher is unable to identify who the participant is in any given case. If the participants will be anonymous, please state how, otherwise, if the researcher will know who the participants are, please describe how participant privacy issues and confidentiality of information will be managed.

Privacy and confidentiality will be respected and protected with diligence and by all available means. The following are the measures that will be taken to protect the identity of participants during the research.

- Coding of data and removal of identifying material from documentation
- Referring to participants by their roles rather than their names when collecting and storing information
- Not sharing or discussing the obtained information with others
- Removing field notes from the field study sites and keeping them at a different place to avoid any accidental misuse of the information that may reveal participants' identities
- Providing the participants with transcripts for review and confirmation to avoid conflicts of interest and to provide added assurance that the transcripts do not include content that might reveal participants' identities.

All information (including the identity of participants) will be kept confidential and secure from interception or appropriation by unauthorised persons, or for purposes other than the approved research. The confidentiality of information obtained incidentally during research will also be respected except where disclosure is necessary to avoid harm. The researcher is aware that, as the participants will be known by him, anonymity cannot be granted. The primary researcher and the applicant are aware of their responsibility for the safekeeping and confidentiality of signed consent forms and these will be stored separately from the data. Participants will have an on-going right to access any and all personal information regarding them that is held by the researchers. Information will be used only for the purpose for which it was gathered as per the principles established in the Privacy Act 1993.

In summary, the researchers are aware of the possibility of inadvertent disclosure of identities and will remain vigilant in avoiding any such incidents, for example, when reflecting on research experiences and outcomes in any form of written or verbal discussion.

H.2. How will individuals or groups be identified in the final report?

If participants or groups will be identified, please state how this will happen, why, and how the participants will give consent.

In order to retain confidentiality, the names of research participants and their organisations will not be used or referred to in research outputs. Organisations will likely be labelled with letters (e.g., Organisation A, B etc.). Given the small size of the targeted organisations individual participants will be referred to using generic role names rather than organisation-specific role names.

H.3. What information on the participants will be obtained from third parties?

This includes use of third parties, such as employers or professional organisations, in recruitment.

Initial contact information will be sought from employers or managers.

H.4. How will potential participants' contact details be obtained for the purposes of recruitment?

As noted above, organisations that agree to take part in the research will be asked to provide the researchers with the contact details of the candidate participants for the purpose of recruitment. The candidate participants will then be contacted through email, phone call or face to face meetings to finalise the recruitment process.

H.5. What identifiable information on the participants will be given to third parties? None

H.6. Who will have access to the data during the data collection and analysis stages? Primary Researcher and the Applicant

H.7. Who will have access to the data after the findings have been produced?

Primary Researcher and the Applicant

H.8. What plans are there for the future use of the data beyond those already described?

The applicant's attention is drawn to the requirements of the Privacy Act 1993 (see Appendix I of AUTEC's applying for Ethics Approval: Guidelines and Procedures). If there are future plans for the use of the data, then this needs to be explained in the Information Sheets for participants.

H.8.1.1 If data will be stored in a database, who will have access to that data and how will it be used and for what?

The primary researcher will have on-going access to the data. The data may be used for conducting subsequent research into software measurement process implementation by the researcher and applicant.

H.8.1.2 Will any contact details be stored for future use and if so, who will have access to that data and how will it be used and for what?

The primary researcher and applicant will have on-going access to contact details. This information may be used to recruit participants for future research. If this is done a separate application for ethical approval will be submitted.

H.9. Where will the data be stored once the analysis is complete?

Please provide the exact storage location. AUTEC normally requires that the data be stored securely on AUT premises in a location separate from the consent forms. Electronic data should be downloaded to an external storage device (e.g. an external

hard drive, a memory stick etc.) and securely stored. If you are proposing an alternative arrangement, please explain why.

The final storage of data and consent forms will be on AUT servers and in the WY Building Level 2 at SERL in the specified storage facilities provided and maintained by the School of Computing and Mathematical Sciences. Paper documents will be stored at the same location in a locked cupboard along with digital material stored on CD/DVD. A copy of data will be kept separately in an archive CD/DVD in a secure location in the WY building level 2 at SERL.

H.10. For how long will the data be stored after completion of analysis?

AUTEC normally requires that the data be stored securely for six years, or ten years for health related research. If you are proposing an alternative arrangement, please explain why.

For six years.

H.11. How will the data be destroyed?

Documents will be shredded and computer files will be deleted from storage to protect the confidentiality of participants. Electronic devices (hard disks, memory sticks etc.) will be re-formatted in a manner that means the data is beyond recovery.

H.12. Who will have access to the Consent Forms? The

primary researcher

H.13. Where will the completed Consent Forms be stored?

Please provide the exact storage location. AUTEC normally requires that the Consent Forms be stored securely on AUT premises in a location separate from the data. If you are proposing an alternative arrangement, please explain why.

The Consent Forms will be stored securely in WY Building Level 2 at SERL in a locked cupboard. The consent forms will be stored separately from the data.

H.13.1. For how long will the completed Consent Forms be stored?

AUTEC normally requires that the Consent Forms be stored securely for six years, or ten years in the case of health related research. If you are proposing an alternative arrangement, please explain why. For six years.

H.13.2. How will the Consent Forms be destroyed?

If the Consent Forms will not be destroyed, please explain why.

Hard copies would be shredded and electronic devices (hard disks, memory sticks etc.) will be re-formatted in a manner that means the data is beyond recovery.

H.14. Does your project involve the use of previously collected information or biological samples for which there was no explicit consent for this research? ☐ **Yes** ☒ **No** ***If the answer is 'Yes' please answer H.12.1 and the following sections, otherwise please answer H.13 and continue from there.***

H.14.1. What previously collected data will be involved?

N/A

H.14.2. Who collected the data originally?

N/A

H.14.2.1 Why the data was originally collected?

N/A

H.14.2.2 For what purposes was consent originally given when the data was collected?

N/A

H.14.3. How will the data be accessed?

N/A

H.15. Does your project involve any research about organisational practices where information of a personal or sensitive nature may be collected and / or where participants may be identified? ☒ **Yes No** ☐

If the answer is 'Yes' please answer G.13.1 and the following sections, otherwise please answer H.1 and continue from there.

H.15.1. How will organisational permission be obtained and recorded?

The organisations will be made fully aware of the nature of the research, its aims and objectives, and the type of information required both about the organisation itself as well as the participants. As stated above, a project Information Sheet containing project details will be provided when they are asked to consider participation in the research. Each participant will be asked to sign a Consent Form if they agree to take part.

H.15.2. Will the organisation know who the participants are?

The organisation will provide a list of candidate participants but will not be told who is involved. Having said that, in small organisations it may not be possible to keep participants' involvement private.

H.15.3. How will the identity of the participants be kept confidential?

All information (including the identity of participants) will be kept confidential and secure from interception or appropriation by unauthorised persons, or for purposes other than the approved research. This will be done by coding of data and removal of identifying material from documentation. Furthermore the participants will be addressed by their generic roles rather than individual roles to maintain confidentiality.

I. Minimisation of risk

I.1. Risks to Participants

Please consider the possibility of moral, physical, psychological or emotional risks to participants, including issues of confidentiality and privacy, from the perspective of the participants, and not only from the perspective of someone familiar with the subject matter and research practices involved. Please clearly state what is likely to be an issue, how probable it is, and how this will be minimised or mitigated (e.g. participants do not need to answer a question that they find embarrassing or they may terminate an interview or there may be a qualified counsellor present in the interview or the findings will be reported in a way that ensures that participants cannot be individually identified, etc.) Possible risks and their mitigation should be fully described in the Information Sheets for participants.

I.1.1. How much time will participants be required to give to the project?

The participants will be asked to take part in a one-hour open-ended interview and a 30-minute follow-up discussion for transcript checking and confirmation. It is anticipated that some of the key participants may be interviewed more than once, for up to 5 hours in total. Some observation may also occur.

I.1.2. What level of discomfort or embarrassment may participants be likely to experience?

Low or none

I.1.3. In what ways might participants be at risk in this research?

The participants may feel an obligation to participate.

The participants may express views that do not meet with the approval of the organisation.

The participating organisation may be worried about commercial sensitivity.

The participants may be concerned that their processes, practices and methods will be criticised.

These risks will be mitigated by reassuring participants regarding their voluntary participation and the provisions for confidentiality, and being clear that the information gathered from their views will not be discussed with others. They will be reassured that it is how things are done in practice that is of interest, and no judgement is made whether these practices are somehow ‘right’ or ‘wrong’. The participants will be provided with the opportunity to review the drafts of interview transcripts in order to make sure they do not contain any content which might reveal participants’ identities.

The participating organisations will also be assured that their commercial sensitivity will be guarded and their organisational identities will not be disclosed in the publication of results from this research.

I.1.4. In what ways are the participants likely to experience risk or discomfort as a result of cultural, employment, financial or similar pressures?

The participants may feel uncomfortable criticising or providing negative evaluation of their existing practices or processes.

The participants may fear that their opinions expressed in the interviews are not confidential.

The participants may feel that their personal performance is being monitored.

I.1.5. Will your project involve processes that are potentially disadvantageous to a person or group, such as the collection of information, images etc. which may expose that person/group to discrimination, criticism, or loss of privacy? ☐ Yes ☒ No

If your answer is 'Yes', please detail how these risks will be managed and how participants will be informed about them. N/A

I.1.6. Will your project involve collection of information of illegal behaviour(s) gained during the research which could place the participants at current or future risk of criminal or civil liability or be damaging to their financial standing, employability, professional or personal relationships? ☐ Yes ☒ No

If your answer is 'Yes', please detail how these risks will be managed and how participants will be informed about them. N/A

I.1.7. If the participants are likely to experience any significant discomfort, embarrassment, or incapacity, please state what provision for counselling has been made, either with AUT Counselling (who also provide an online service) or with other counselling professionals (this is to be at no charge to the participants)?

N/A

I.1.8. Will any use of human remains, tissue or body fluids which does not require submission to a Regional Ethics Committee occur in the research? ☐ Yes ☒ No

e.g. finger pricks, urine samples, etc. (please refer to section 13 of AUTEC's <u>Applying for Ethics Approval: Guidelines and Procedures</u>). If your answer is yes, please provide full details of all arrangements, including details of agreements for treatment, how participants will be able to request return of their samples in accordance with right 7 (9) of the Code of Health and Disability Services Consumers' Rights, etc. N/A

I.1.9. Will this research involve potentially hazardous substances? ☐ Yes ☒ No

e.g. radioactive material, biological substances (please refer to section 15 of AUTEC's <u>Applying for Ethics Approval: Guidelines and Procedures</u> and the Hazardous Substances and New Organisms Act 1996).

If the answer is 'Yes', please provide full details, including hazardous substance management plan. N/A

I.2. Risks to Researchers

If this project will involve interviewing participants in private homes, undertaking research overseas, or going into similarly vulnerable situations, then a Researcher Safety protocol should be designed and appended to this application. This should identify simple and effective processes for keeping someone informed of the researcher's whereabouts and provide for appropriate levels of assistance.

I.2.1. Are the researchers be likely to be at risk? ☐ **Yes** ☒ **No**

If the answer is 'Yes' please answer I.2.1.1 and then continue, otherwise please answer I.3 and continue from there.

I.2.1.1 In what ways might the researchers be at risk and how will this be managed? N/A

I.3. Risks to AUT

I.3.1. Is AUT or its reputation likely to be at risk because of this research? ☐ **Yes** ☒ **No**

If the answer is 'Yes' please answer I.3.1.1 and then continue, otherwise please answer I.3.2 and continue from there.

I.3.1.1 In what ways might AUT be at risk in this research?

Please identify how and detail the processes that will be put in place to minimise any harm. N/A

I.3.2. Are AUT staff and/or students likely to encounter physical hazards during this project? ☐ ☒

Yes No

If yes, please provide a hazard management protocol identifying how harm from these hazards will be eliminated or minimised. N/A

J. Truthfulness and limitation of deception

J.1. Does your research include any deception of the participants, such as nondisclosure of aims or use of control groups, concealment, or covert observations?

☐ **Yes** ☒ **No**

Deception of participants in research may involve deception, concealment or covert observation. Deception of participants conflicts with the principle of informed consent, but in some areas of research it may sometimes be justified to withhold information about the purposes and procedures of the research. Researchers must make clear the precise nature and extent of any deception and why it is thought necessary. Emphasis on the need for consent does not mean that covert research can never be approved. Any departure from the standard of properly informed consent must be acceptable when

measured against possible benefit to the participants and the importance of the knowledge to be gained as a result of the project or teaching session. This must be addressed in all applications. Please refer to Section 2.4 of AUTEC's Applying for Ethics Approval: Guidelines and Procedures when considering this question.

If the answer is 'Yes' please answer J.1.1 and the following sections, otherwise please answer J.2 and continue from there.

J.1.1. Is deception involved?

N/A

J.1.2. Why is this deception necessary?

N/A

J.1.3. How will disclosure and informed consent be managed?

N/A

J.2. How will feedback or a summary of the research findings be disseminated to participants (individuals or groups)?

Please ensure that this information is included in the Information Sheet.

Interview transcripts will be shared with the participants so that they may be checked for errors, inappropriate disclosures of identity or conflicts of interest. The results of the research will be offered to the participants as they are produced during the research in the form of scholarly articles (conference or journal papers) and the thesis itself.

J.3. Will this research involve use of a control group? **Yes**☐ **No** ☒

If the answer is 'Yes' please answer J.3.1 and the following sections, otherwise please answer K.1 and continue from there.

J.3.1. How will the Control Group be managed?

N/A

J.3.2. What percentage of participants will be involved in the control group?

N/A

J.3.3. What information about the use of a control group will be given to the participants and when? N/A

K. Avoidance of Conflict of Interest

Researchers have a responsibility to ensure that any conflict between their responsibilities as a researcher and other duties or responsibilities they have towards participants or others is adequately managed. For example, academic staff members who propose to involve their students as participants in research need to ensure that no conflict arises between their roles as teacher and researcher, particularly in view of the dependent relationship between student and teacher, and of the need to preserve integrity in assessment processes. Likewise researchers have a responsibility to ensure that any conflict of interest between participants is adequately managed for example, managers participating in the same research as their staff.

While none are anticipated, the researchers will seek to identify any potential conflicts of interest and specify measures proposed to deal with them. Any sponsorship, funding or commercial support of a research project will not compromise the adequacy or ethical integrity of the research.

K.1. What conflicts of interest are likely to arise as a consequence of the researcher's professional, social, financial, or cultural relationships?

There are no conflicts of interest that are deemed to arise as a consequence of this research engagement.

K.2. What possibly coercive influences or power imbalances in the professional, social, financial, or cultural relationships between the researcher and the participants or between participants (e.g. dependent relationships such as teacher/student; parent/child; employer/employee; pastor/congregation etc.) are there?

The only power imbalance that can be foreseen is the professional relationship between employee and employer. This is addressed in K3 below.

K.3. How will these conflicts of interest, coercive influences or power imbalances be managed through the research's design and practice to mitigate any adverse effects that may arise from them?

The interviews will be conducted in a private, soundproof area. The risks will be mitigated by maintaining confidentiality about any personal information that may reveal a participant's identity or their views on practices and processes.

Participants will be addressed by their generic roles rather than their individual titles or roles.

The interview data of individual participants will not be discussed with other participants.

Field notes will be taken off site at regular intervals and kept private.

The participants will be reassured that their performance is not being monitored. The research is about what kinds of information is important in the software measurement process.

The participants will be reassured that it is how things are done *in practice* that are of interest, and no judgement is being made whether they are somehow 'right' or 'wrong'.

Checking and confirmation of transcripts by participants is another measure to cover for any adverse effects that may arise.

K.4. Does your project involve payments or other financial inducements (including koha, reasonable reimbursement of travel expenses or time, or entry into a modest prize draw) to participants? **Yes**☐ **No** ☒

If the answer is 'Yes' please answer K.4.1 and the following sections, otherwise please answer K.5 and continue from there.

K.4.1. What form will the payment, inducement, or koha take?

N/A

K.4.2. Of what value will any payment, gift or koha be?

N/A

K.4.3. Will potential participants be informed about any payment, gift or koha as part of the recruitment process, and if so, why and how? N/A

K.5. Have any applications for financial support for this project been (or will be) made to a source external to AUT? ☐ **Yes** ☒ **No**

If the answer is 'Yes' please answer K.5.1 and the following sections, otherwise please answer K.6 and continue from there. N/A

K.5.1. What financial support for this project is being provided (or will be provided) by a source external to AUT? N/A

K.5.2. Who is the external funder?

N/A

K.5.3. What is the amount of financial support involved?

N/A

K.5.4. How is/are the funder/s involved in the design and management of the research?

K.6. Have any applications been (or will be) submitted to an AUT Faculty Research Grants Committee or other AUT funding entity? **Yes** ☐ **No** ☒

If the answer is 'Yes' please answer K.6.1 and the following sections, otherwise please answer K.7 and continue from there.

K.6.1. What financial support for this project is being provided (or will be provided) by an AUT Faculty Research Grants Committee or other AUT funding entity? N/A

K.6.2. What is the amount of financial support involved?

N/A

K.6.3. How is/are the funder/s involved in the design and management of the research?

K.7. Is funding already available, or is it awaiting decision? N/A

K.8. What is the financial interest in the outcome of the project of the researchers, investigators or research organisations mentioned in Part B of this application.

N/A

L. Respect for Property

Researchers must ensure that processes do not violate or infringe legal or culturally determined property rights. These may include factors such as land and goods, works of art and craft, spiritual treasures and information.

L.1. Will this research impact upon property owned by someone other than the researcher? ☐ **Yes** ☒ **No**

If the answer is 'Yes' please answer L.1.1 and the following sections, otherwise please answer L.2 and continue from there.

L.1.1. How will this be managed?

N/A

L.2. How do contexts to which copyright or Intellectual Property applies (e.g. virtual worlds etc.) affect this research and how will this be managed?

Particular attention should be paid to the legal and ethical dimensions of intellectual property. Care must be taken to acknowledge and reference the ideas of all contributors and others and to obtain any necessary permissions to use the intellectual property of others. Teachers and researchers are referred to AUT's Intellectual Property Policy for further guidance. N/A

M. References

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N. Checklist

Please ensure all applicable sections of this form have been completed and all appropriate documentation is attached as incomplete applications will not be considered by AUTEC.

Have you discussed this application with your AUTEC Faculty Representative, the Executive Secretary, or the Ethics Coordinator? ☐ ***Yes*** ☐ ***No***

Is this application related to an earlier ethics application? If yes, please provide the application number of the earlier application.	☐ *Yes* ☐ *No*
Are you seeking ethics approval from another ethics committee for this research? If yes, please identify the other committee.	☐ *Yes* ☐ *No*

Section A	*Project information provided*	*YES*
Section B	*Research Adequacy information provided*	*YES*
Section C	*Project details provided*	*YES*
Section D	*Three Principles information provided*	*YES*
Section E	*Social and Cultural Sensitivity information provided*	*YES*
Section F	*Consent information provided*	*YES*
Section G	*Privacy information provided*	*YES*
Section H	*Risk information provided*	*YES*
Section I	*Truthfulness information provided*	*YES*
Section J	*Conflict of Interest information provided*	*YES*
Section K	*Vulnerability information provided*	*YES*
Section L	*Respect for Property information provided*	*YES*
Section M	*References provided*	*YES*
Section N	*Checklist completed*	*YES*
Section O.1 and 2	*Applicant and student declarations signed and dated*	*YES*
Section O.3	*Authorising signature provided*	*YES*
Spelling and Grammar Check (please note that a high standard of spelling and grammar is required in documents that are issued with AUTEC approval)		
Attached Documents (where applicable)		
Participant Information Sheet(s)		*YES*
Consent Form(s)		*YES*
Questionnaire(s)		
Indicative Questions for Interviews or Focus Groups		*YES*
Observation Protocols		
Recording Protocols for Tests		
Advertisement(s)		
Researcher Safety Protocol		
Hazardous Substance Management Plan		
Any Confidentiality Agreement(s)		
Any translations that are needed		
Other Documentation		

O. Declarations

O.1. Declaration by Applicant

Please tick the boxes below.

☒ *The information in this application is complete and accurate to the best of my knowledge and belief. I take full responsibility for it.*

☒ *In conducting this study, I agree to abide by established ethical standards, contained in AUTEC's Applying for Ethics Approval: Guidelines and Procedures and internationally recognised codes of ethics.*

☒ ***I will continue to comply with AUTEC's Applying for Ethics Approval: Guidelines and Procedures, including its requirements for the submission of annual progress reports, amendments to the research protocols before they are used, and completion reports.***

☒ ***I understand that brief details of this application may be made publicly available and may also be provided to the University Postgraduate Centre, the University Research Office, or the University's insurers for purposes relating to AUT's interests.***

17 Sept 2013

Signature *Date*

O.2. Declaration by Student Researcher

Please tick the boxes below.

☒ ***The information in this application is complete and accurate to the best of my knowledge and belief.***

☒ ***In conducting this study, I agree to abide by established ethical standards, contained in AUTEC's Applying for Ethics Approval: Guidelines and Procedures and internationally recognised codes of ethics.***

☒ ***I will continue to comply with AUTEC's Applying for Ethics Approval: Guidelines and Procedures, including its requirements for the submission of annual progress reports, amendments to the research protocols before they are used, and completion reports.***

☒ ***I understand that brief details of this application may be made publicly available and may also be provided to the University Postgraduate Centre, the University Research Office, or the University's insurers for purposes relating to AUT's interests.***

17 Sept 2013

Signature *Date*

O.3. Authorisation by Head of Faculty/School/Programme/Centre

Please tick the boxes below.

☐ ***The information in this application is complete and accurate to the best of my knowledge and belief.***

☐ ***In authorising this study, I declare that the applicant is adequately qualified to undertake or supervise this research and that to the best of my knowledge and belief adequate resources are available for this research.***

☐ ***I understand that brief details of this application may be made publicly available and may also be provided to the University Postgraduate Centre, the University Research Office, or the University's insurers for purposes relating to AUT's interests.***

Signature *Date*

Notes for submitting the completed application for review by AUTEC

Please ensure that you are using the current version of this form before submitting your application.

Please ensure that all questions on the form have been answered and that none have been deleted.

Please provide ***one*** printed, single sided, A4, and signed copy of the application and all related documents.

Please deliver or post to the Ethics Coordinator, room WA 505D, WA Building, City Campus. The internal mail code is D-89. The courier address is 55 Wellesley Street East, Auckland 1010.

The application needs to have been received in the AUTEC Secretariat by 4 pm on the relevant agenda closing day [AUTEC's meeting dates are listed in the Ethics Knowledge Base (http://www.aut.ac.nz/research/research-ethics/ethics)]

If sending applications by internal mail, please post them at least two days earlier to allow for any delay that may occur.

Late applications will be placed on the agenda for the following meeting.

Appendix 5.9 Interview Invitation

Subject: Invitation to participate in research: Establishing Lean and Sustainable Software Measurement Programs

My name is Aftab Ahmad, and I am a Ph.D. student researcher in the School of Computing and Mathematical Sciences at AUT University in New Zealand. I am working on a project that aims to improve the utility of software measurement programs in small and medium sized enterprises (SMEs).

We met recently…/I or another explanation about how selected – will be individualised

I would like to invite you to participate in my research and take part in an in-depth interview addressing the design, implementation and use of software measurement programs. Your agreement to participate will be greatly appreciated, and should be beneficial for your organisation and the wider software industry. Your knowledge, experience and expertise will directly inform the framework I am building for SMPI-in-SMEs. Please note that your participation is entirely voluntary and you may withdraw at any time without any adverse consequence.

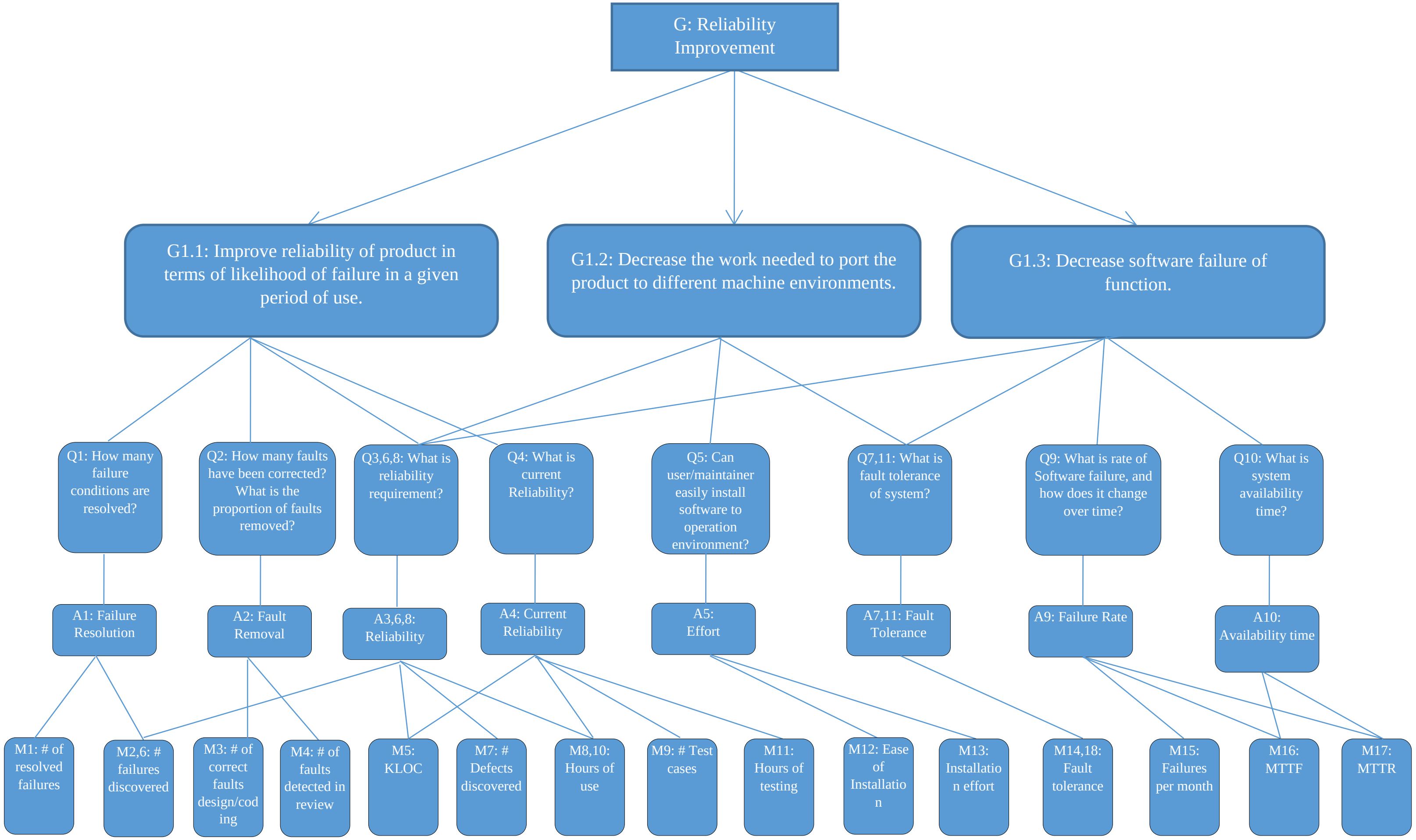
You can find more information about the project in the Information Sheet attached.

I hope that you will agree to take part in this research. To indicate your agreement please complete and return to me at amughal@aut.ac.nz or iffig2000@gmail.com the attached Consent Form, within a week of receiving this invitation. Please also let me know if you have any questions or if you need further information – I will be happy to provide clarification as needed.

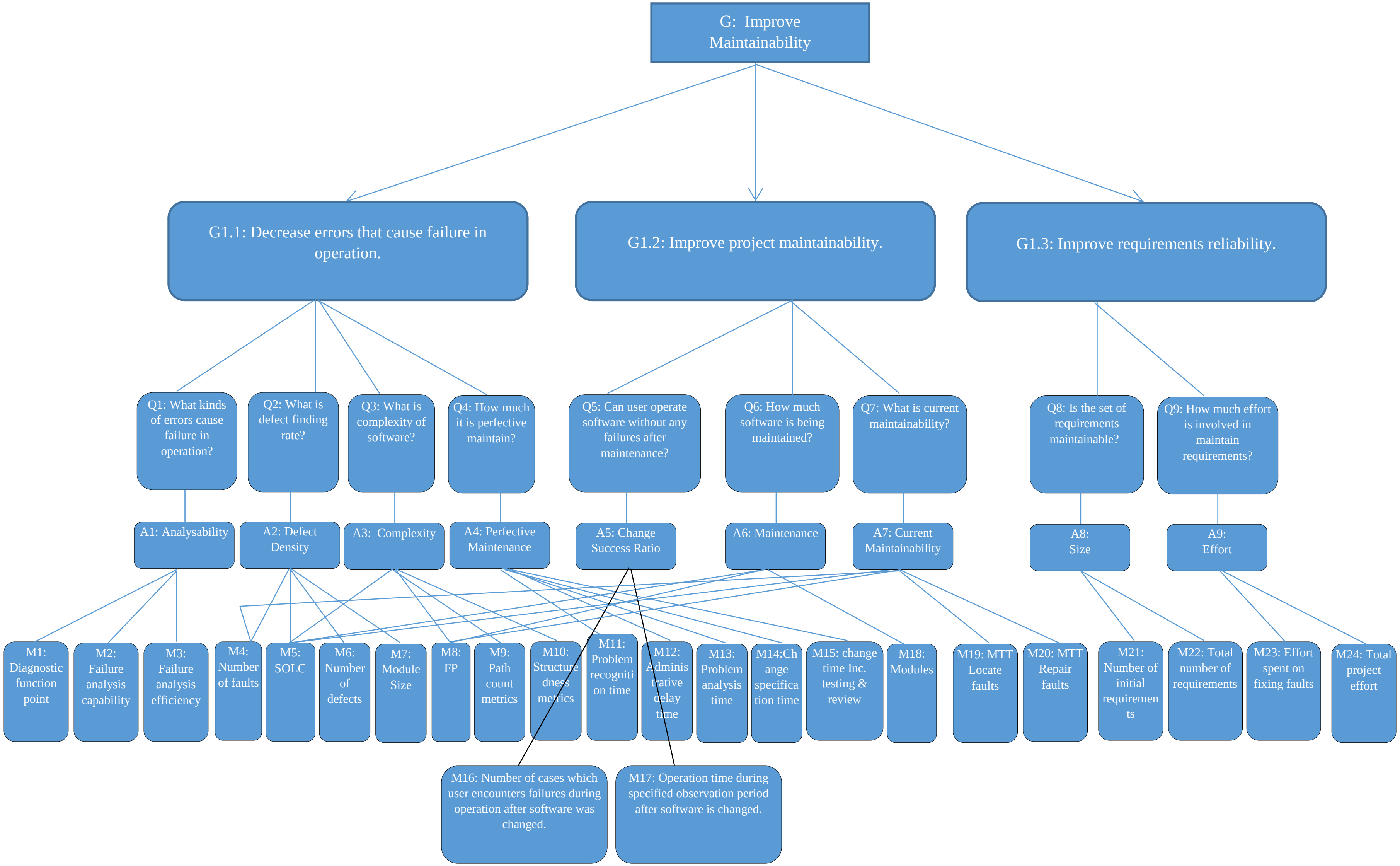
Sincerely yours,

Appendix 7.1 GQM Samples

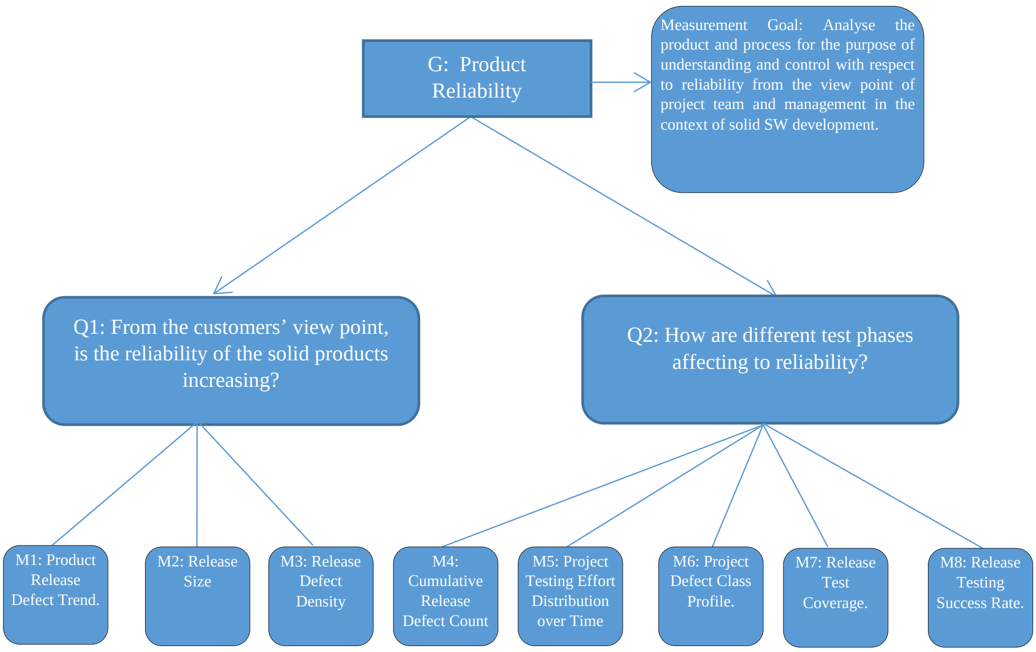
Sample 1: (Gencel et al., 2013)



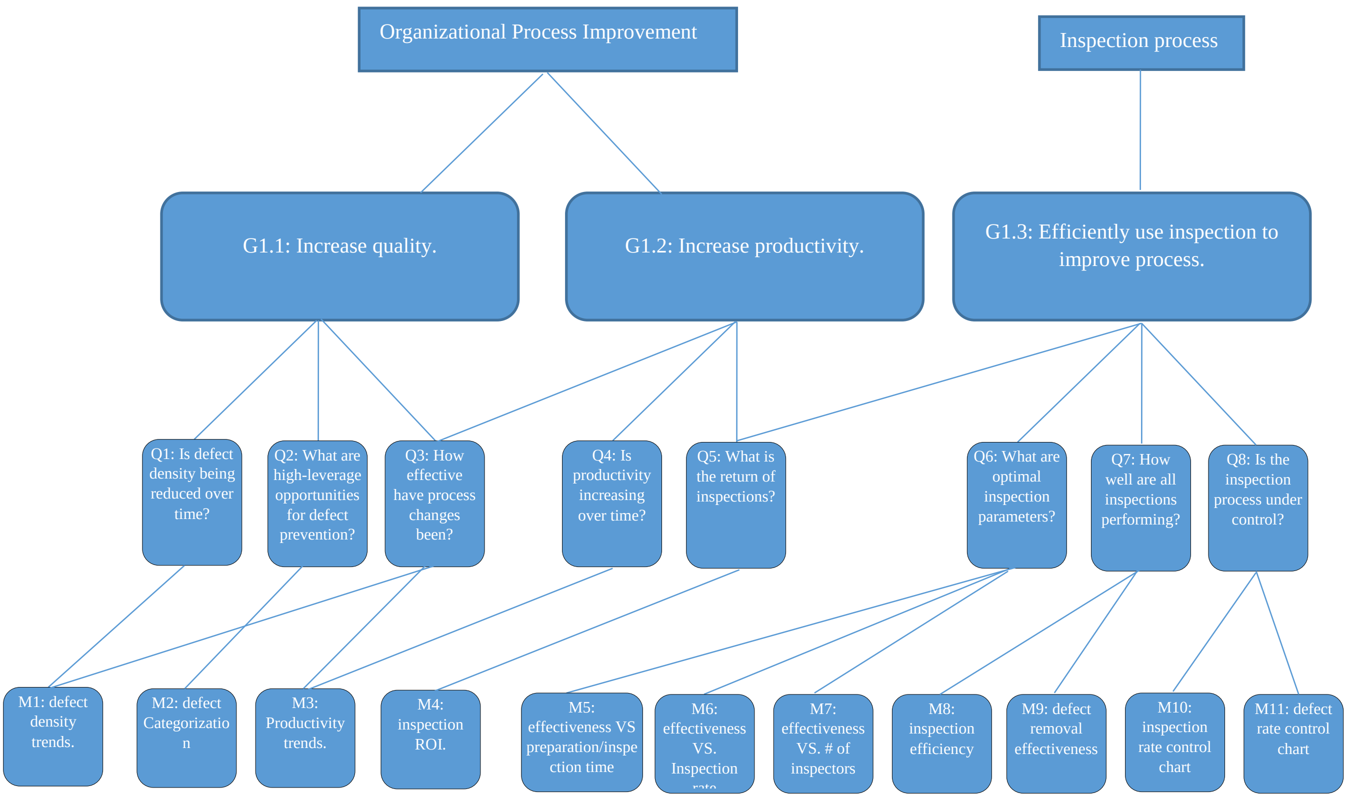
Sample 2: (Gencel et al., 2013)



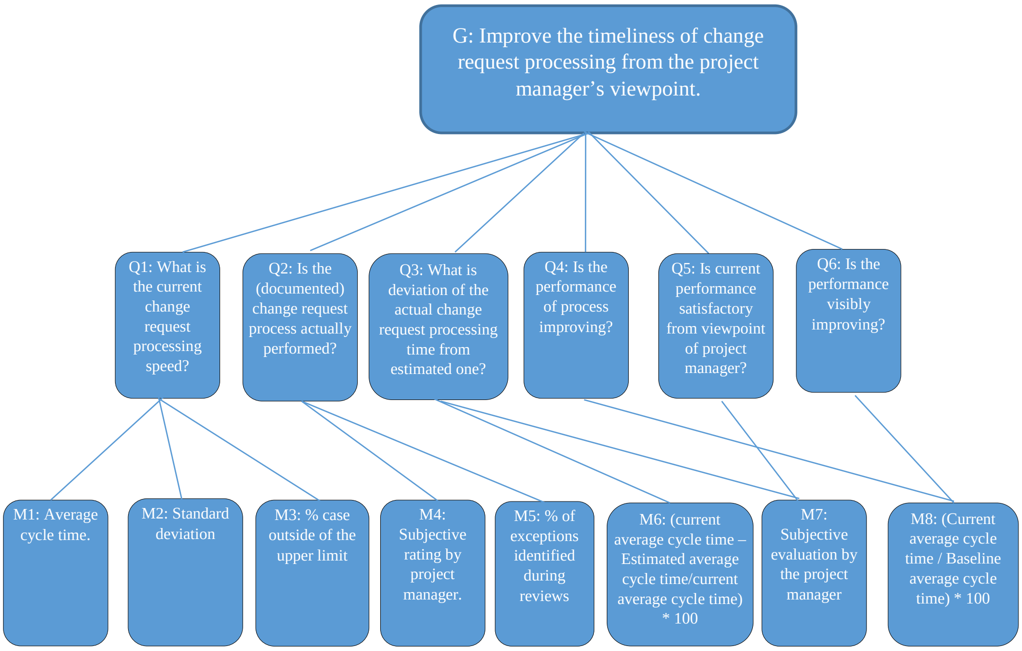
Sample 3: Tihinen and Järvinen (2006)



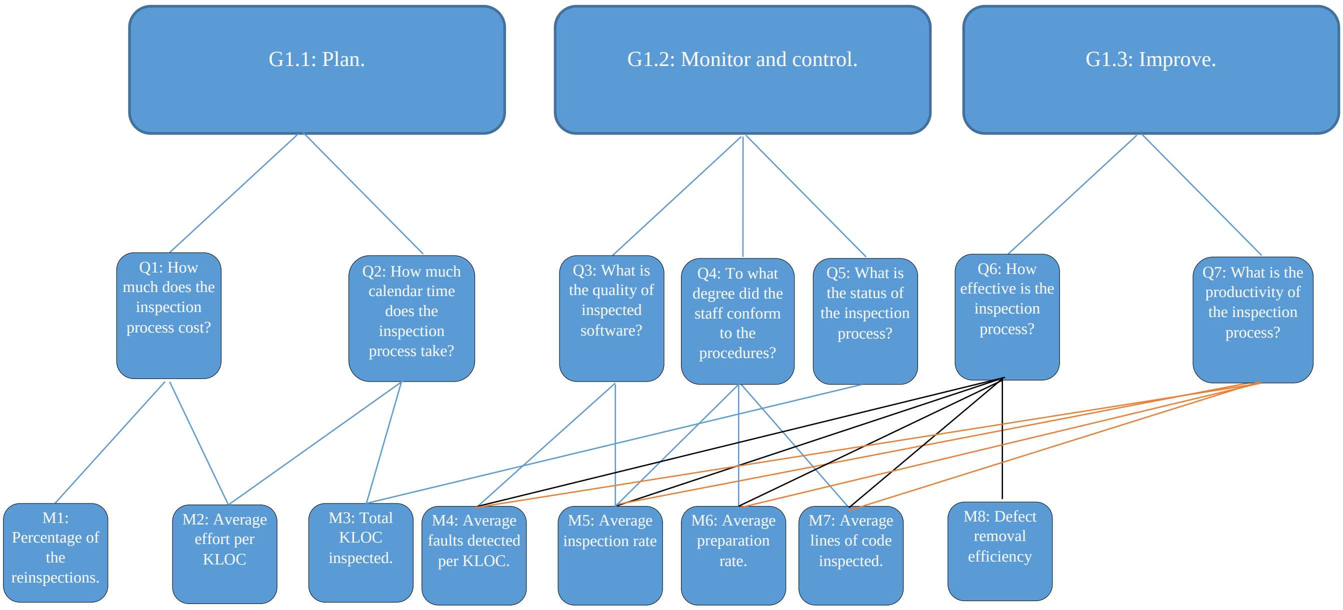
Sample 4: (Lingard, 2012)



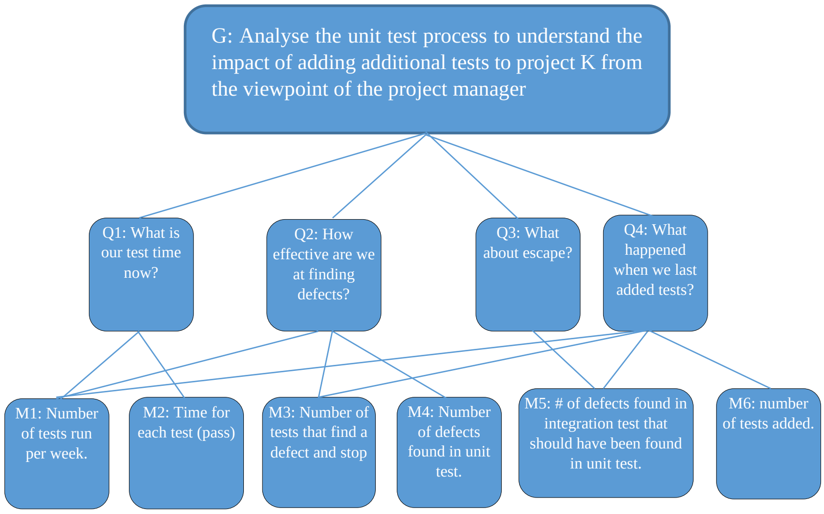
Sample 5: (Van Solingen, Basili, Caldiera, & Rombach, 2002)



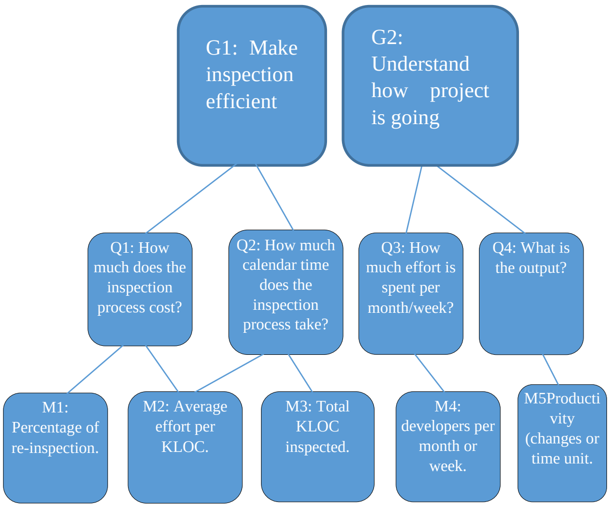
Sample 6: (Fenton & Pfleeger, 1998)



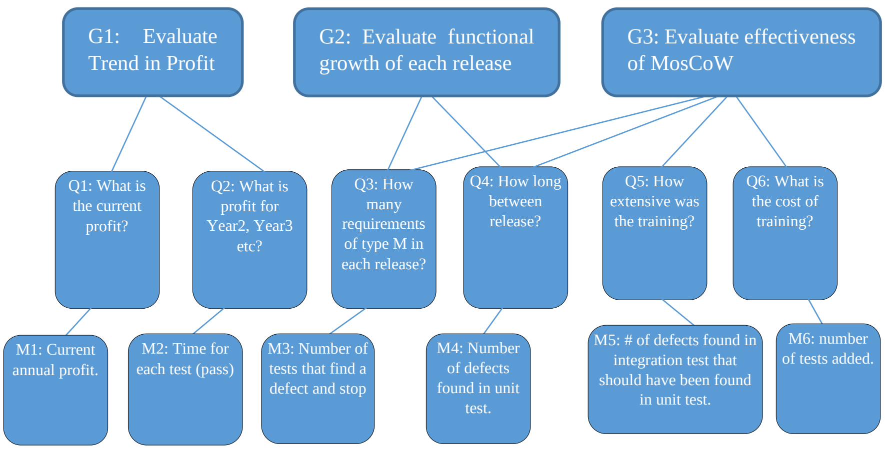
Sample 7: (Dow, 2007)



Sample 8: (Weiss, 2011)



Sample 9: (Basili et al., 2007)



Appendix 8.1 Survey Invitation

Survey Invitation: Software measurement customized for SMEs

To our colleagues in software development,

In spite of its widely acknowledged importance, planning, implementing and managing a suitable measurement program remains challenging for many software organizations. This is especially the case for small and medium-sized enterprises (SMEs), given their often highly constrained resources of time, budget, and personnel. According to the New Zealand Government, 97% of enterprises in this country have 19 or fewer employees, and SMEs dominate most industries. The overall goal of our work is to support better software SMEs in implementing lean and sustainable software measurement programs. Our research, conducted at the University of Otago and AUT, has led us to propose a novel Software Measurement Framework for SMEs (SMF4SMEs) which is intended to overcome (or, at least, reduce the severity of) measurement implementation challenges in SMEs.

We are now conducting a survey to evaluate the proposed SMF4SMEs through feedback from industry experts such as yourself. It is crucial that the perceptions of industry specialists are captured in order to validate independently our framework, as well as to inform potential improvements.

In particular, the objective of the survey is to evaluate the perceived usefulness of the proposed framework in the SME context. To achieve this objective, we are asking you to complete an online questionnaire (available here: https://aut.au1.qualtrics.com/SE/?SID=SV_cGUhnqhz2ZyTgGN). The questionnaire is designed to take around 20-30 minutes to answer, and all responses are handled anonymously and securely. At the end of the questionnaire, you may record your email address if you would like a summary of the aggregated results. (This information will be recorded separately from your responses.) More generally, however, we will make the results of the survey available in report form to the general community of New Zealand software practitioners.

Thank you for your participation and valuable input.

Aftab Ahmad Mughal (mugaf503@student.otago.ac.nz)

Ph.D. Researcher, University of Otago

Dr. Stephen MacDonell (stephen.macdonell@otago.ac.nz/stephen.macdonell@aut.ac.nz)

Professor, University of Otago/AUT

Jim Buchan (jim.buchan@aut.ac.nz)

Senior Lecturer in Software Engineering, AUT

Cigdem Gencel (cigdem.gencel@deiser.com)

Senior Researcher, DEISER (Madrid)

Department of Information Science

University of Otago, Business School

PO Box 56, Dunedin 9054

New Zealand

School of Engineering, Computer and Mathematical Sciences

Auckland University of Technology (AUT)

Private Bag 92006, Auckland 1142

New Zealand

DEISER Desarrollo e Integracion Desistemas SL

Calle Valentín Beato 22

Planta Baja Derecha 28037 Madrid

Spain

.

Appendix 8.2 Survey questionnaire

Software Measurement Programs Implementation in Small and Medium Enterprises (SMPI in SMEs)

Software Measurement Program Implementation (SMPI) in SMEs We have developed a new framework that we believe will support Small and Medium Enterprises (SMEs) in implementing a software measurement program for improved software development quality and productivity. We would like feedback from industry experts such as yourself to evaluate the usefulness of this framework through a short survey we are asking you to complete.

In this short survey, we present our new proposed Software Measurement Framework for SMEs (SMF4SMEs). To develop this framework we worked in software development companies – two field studies were carried out in a medium-sized organization and one in a small organization. The overall goal of our work is to better support Small and Medium Enterprises (SMEs) in implementing lean and sustainable software measurement programs. The objective of this survey is to evaluate the perceived usefulness of the proposed framework according to software practitioners working in SMEs. This survey is a collaboration of the Department of Information Science at the University of Otago, the School of Engineering, Computer and Mathematical Sciences at Auckland University of Technology (AUT), both located in New Zealand and DEISER Desarrollo e Integration Desistemas SL located in Madrid Spain.

All responses are recorded anonymously and secure confidentiality is assured. Published results will only include aggregated statistical observations so that it is impossible to identify individual answers. For any further questions and comments, please contact the signatories.

The questionnaire is designed to take around 20 - 30 minutes to answer. Please do NOT use the browser's back button to return to a previous page, instead use the "back" button at the bottom of each page.

Thank you for your valuable input.

Aftab Ahmad Mughal (mugaf503@student.otago.ac.nz)

Ph.D. Researcher, University of Otago

Prof Stephen MacDonell (Stephen.macdonell@otago.ac.nz / Stephen.macdonell@aut.ac.nz)

Professor, University of Otago/AUT

Jim Buchan (jim.buchan@aut.ac.nz)

Senior Lecturer in Software Engineering, AUT

Cigdem Gencel (cigdem.gencel@deiser.com)

Senior researcher, DEISER (Madrid)

Demographic Information:

Q 1: What is your current position? E.g. Project Manager, Team Lead, Software Engineer.

____

Q 2: How long (in years) have you been involved in this occupation?

1 - 3

4 - 7

> 7

Rather not say

Q 3: How many years of experience do you have in the software development industry?

1 - 5

6 - 10

11 - 15

> 15

General Information – Your Organization and Software Measurement

Q 4: Approximately how many people (full-time equivalent) does your organization employ?

< 10

10 - 50

51 - 100

101 - 250

> 250

Q 5: What proportion of the employees who are involved in some aspect of software development are likely to have some knowledge of software measurement, in your organization?

1 - 10 %

11 - 20 %

21 - 30 %

31 - 40 %

41 - 50 %

> 50 %

Rather not say

Don't know

Q 6: Have you ever been involved in the implementation of software measurement initiatives?

Yes

No

Q 7: In your opinion what effect can software measurement have on quality or productivity?

Strongly positive

Positive

No effect

Negative

Strongly negative

Rather not say

Software Measurement Program Implementation using SMF4SMEs

Structure of the Proposed SMF4SMEs

Before answering some questions specific to our proposed framework (SMF4SMEs), please read over the overview of the framework presented in this section and examine the framework diagram here: SMF4SMEs

Our proposed SMF4SMEs consists of nine main activities conducted in three different phases. Some activities should be carried out only one time (OT). These OT activities are undertaken if your company is implementing a software measurement program for the first time or if those involved in the initiative are new to the process. A red asterisk (*) indicates that an activity must be performed. The proposed framework also provides checklists (Chk.L) for some activities, to guide practitioners on what actions should be taken. All data generated during the process should be stored in a database (DB). We also provide recommendations as to who should or could be involved in each activity. The SMF4SMEs phases should be undertaken in sequence, and the meeting(s) in each phase could be synced with existing weekly or monthly meeting(s) in the organization.

Q8: With this overview in mind, please answer the questions in the table beside each phase of the SMF4SMEs.

The headings on each column relate to the questions being asked:

"**Current Practice?**" asks if you/your team are currently performing this activity in your organization.

"**Lean & Sustainable?**" asks if you believe the SMF4SMEs framework would be lean (simple and straightforward) and sustainable (fulfilling the current requirements without compromising future needs) in your place of work.

"**Cost and Time Efficient?**" asks if you believe the SMF4SMEs framework would cost and time efficient in your place of work.

Note: The role abbreviations noted against each activity are those that we recommend should be involved, based on our prior field study experience. (CEO: Chief Executive Officer; CTO: Chief Technology Officer; PM: Project Manager; SQM: Software Quality Manager; TL: Team Lead; SA: System Analyst; DBA: Data Base Administrator). You may customize them based on your organizational structure, or if certain aspects are not applicable. For instance, if global development is not relevant then there will be no onshore stakeholder; or if there is no SQM role this could be replaced with another role concerned with assuring quality outcomes. Click here to view SMF4SMEs implementation guidelines

Phase 1: **Planning (*How to Measure?*)**		Current Practice?		Lean & Sustainable?		Cost & Time Efficient?	
		YES	NO	YES	NO	YES	NO
A1(	A kick-off meeting in order to: (**Chk.L**) [*CEO/CTO, *PM, *SQM, *TL, SA, DBA, *Onshore stakeholders].	o	o	o	o	o	o
	e. *Discuss the purpose of SMPI. f. *select project(s) to be measured. g. *Discuss business and project objectives and desired outcomes, **DB.** h. *Determine potential challenges and obstacles to SMPI, (**Chk.L**), ***OT*, DB** [*PM, SQM, TL].	o	o	o	o	o	o
A11	*Brief introduction of SMPI and SMF4SMEs to the team(s) of selected project ***OT*** [PM, SQM, *TL].	o	o	o	o	o	o
A12	Daily meeting to evaluate data from A1 Such as 1: Confirming decisions. 2: Defining actions and responsibilities. 3: Address challenges and obstacles [*PM, *TL, SQM, Concerning roles] **DB.**	o	o	o	o	o	o
	Phase 2: Execution (What to Measure?)						
A13	Execution meeting in order to: [*PM, *SQM, *TL, *Key Developer, Team]. Feedback on phase 1 results. A short talk about activities performed up to now. Select a method for measurement goals and metrics determination (**Chk.L**). i. Determine required measurement goals and select corresponding metrics to satisfy goals, by using suggested method(s) (**Chk.L**). (b **OR** c) **AND** d Select measurement goals from library DB**.** Select metrics from the library to satisfy goals. Metrics should select at time of each goal definition **DB.** *Allocate selected metrics to concern team members for data collection. [PM, *TL, SQM].	o	o	o	o	o	o
A14	Daily meeting to evaluate data from A4, such as 1: Confirming goals and metrics. 2: Giving more understanding about goals and metrics to team members. 3: Guiding team members in data collection, if they stuck somewhere. [*PM, SQM, TL, Concerning roles].	o	o	o	o	o	o
A15	Team members report collected metrics data to the corresponding role. [PM/TL/SQM].	o	o	o	o	o	o
	Phase 3: **Analysis (*What's the Result?*)**						
A16	*Results analysis meeting(s). [*PM, *TL, SQM].	o	o	o	o	o	o
	c. Urgent, based on results criticality, or Daily meeting for results discussion and analysis conduct, or an important meeting, need-based. **DB.**	o	o	o	o	o	o

	d. Generate reports and graphs of measurement results in **DB.**						
A17	*Results Sharing Meeting [All stakeholders of SMPI].	o	o	o	o	o	o
	b. Reports, Graphs and results discussion.	o	o	o	o	o	o
A18	*Decision Making. [PM, TL, SQM].	o	o	o	o	o	o
	c. Make decisions and schedule actions based on SM results. d. Evaluate actions and Improvements.	o	o	o	o	o	o
Chief Executive Officer (CEO), Chief Technology Officer (CTO), Project Manager (PM), Software Quality Manager (SQM), Team Lead (TL), System Analyst (SA), Data Base Administrator (DBA)							

Your opinion – after reviewing the SMF4SMEs

Q 9: To what extent do you agree or disagree that the SMF4SMEs fulfils following characteristics:

Characteristics	Description	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Easy to use and manage	WBS, Implementation guidelines, Database.	o	o	o	o	o
Speedy	Results after each phase completion, Framework produce overall results quickly.	o	o	o	o	o
Visible	Daily stand-up meetings.	o	o	o	o	o
Portable	Independent of methodology/process, Could be integrated with any methodology/process.	o	o	o	o	o
Flexible	Determination of measurement goals with or without using any method. Synchronization of meetings schedules with routine meetings. Customization of roles and responsibilities. Optional checklists.	o	o	o	o	o
Informative	Descriptive, Check Lists, Roles and responsibilities, Precautions, Activities description.	o	o	o	o	o
Cost-effective	No need of experts hiring, Not too much time consuming for arranging extra meetings and GQMs determination	o	o	o	o	o
Supports sharing	Daily and Weekly Meetings, using backlogs of Agile, Meetings discussions and feedback.	o	o	o	o	o
Lean & sustainable	Framework following short time span, use economical, easy to use and manager, easy to learn and quality steps.	o	o	o	o	o
Imposes low overhead	Database, Check Lists, No specific knowledge required for implementation, predefined measurement goals and set of metric	o	o	o	o	o

Q 10: How well or poorly do you think the SMF4SMEs avoids the following challenges/obstacles often encountered in SMEs?

	Very well	Well	Adequately	Poorly	Very Poorly
Reluctance to use	o	o	o	o	o
Time Consuming	o	o	o	o	o
Resource Limitation	o	o	o	o	o
High Learning Curve	o	o	o	o	o
Experts Requirement	o	o	o	o	o
High Implementation cost	o	o	o	o	o
Lack of process/product knowledge	o	o	o	o	o
Measurements goals determination	o	o	o	o	o
Poorly defined escalation procedures	o	o	o	o	o
Lack of awareness about measurement process	o	o	o	o	o
Lack of communication between different levels of Organization	o	o	o	o	o

Q 11: What impact do you think SMF4SMEs would have on the following software development goals?*

	Significant Improvement in	Improvement in	No change in	Deterioration of	Significant deterioration of
Efficiency	o	o	o	o	o
Scheduling	o	o	o	o	o
Predictability	o	o	o	o	o
Sustainability	o	o	o	o	o
Process agility	o	o	o	o	o
Product quality	o	o	o	o	o
Results visibility	o	o	o	o	o
Process Transparency	o	o	o	o	o
Developer Productivity	o	o	o	o	o

Q 12: Overall, how well do you think SMF4SMEs would help SMEs to:

	Extremely well	Very well	Moderately well	Slightly well	Not well at all
Stay on schedule?	o	o	o	o	o
Increase productivity?	o	o	o	o	o
Make correct estimate?	o	o	o	o	o
Make good decisions?	o	o	o	o	o
Improve product quality?	o	o	o	o	o
Enhance process understanding?	o	o	o	o	o

Please go through the following: SMF4SMEs’ elements, to answer this question.

- o Risk Factors
- o Success Factors
- o Activities vs Check Lists
- o Activities vs Precautions
- o Activities vs Roles and Responsibilities

Q 13: Regarding software measurement programs implementation, how would you describe the following elements of SMF4SMEs?

	Extremely good	Somewhat good	Neither good nor bad	Somewhat bad	Extremely bad
Risk Factors	o	o	o	o	o
Success Factors	o	o	o	o	o
Activities vs Check Lists	o	o	o	o	o
Activities vs Precautions	o	o	o	o	o
Activities vs Roles and Responsibilities	o	o	o	o	o

Q 14: When thinking about the reasons why you might use SMF4SMEs please rate the following according to their relative importance 1 - 5 (lowest is 1 and highest is 5, reasons can have the same values).

	1	2	3	4	5	Rather not say	Don't know
Convenience to user	o	o	o	o	o	o	o
Easy to use and manage	o	o	o	o	o	o	o
Availability of Check Lists	o	o	o	o	o	o	o
Suitable in SME environment	o	o	o	o	o	o	o
Degree of customization possible	o	o	o	o	o	o	o
Roles and responsibilities definition	o	o	o	o	o	o	o
Flexibility to integrate with software development methodologies	o	o	o	o	o	o	o
Implementation guidance e.g. precautions, risk and success factors	o	o	o	o	o	o	o

<u>Q 15:</u> Overall how well do you think that using the SMF4SMEs would help you and your team to implement a software measurement program in practice?

- o Extremely well
- o Very well
- o Moderately well
- o Slightly well
- o Not well at all

<u>Q 16:</u> What would be the best course of action to improve the SMF4SMEs, so that it better suits your team/project?

- ❑ Enhancing the existing roles/responsibilities, precautions and Check Lists
- ❑ Integration with your development methodology
- ❑ Other____________________

<u>Q17:</u> What services or activities were you looking for in software measurement program implementation that are not found in SMF4SMEs?

Appendix 8.3 Comparative analysis

This table is showing the detailed comparative analysis of major survey questions based on SMK, experience and organizations sizes.

SMF4SMEs' Impact upon		SM Knowledge								
		Yes				No				
		Experience in Years								
		1-May		Senior (> 6)		1-May		Senior (> 6)		
		Organizations								
Characteristics	Scales	SMEs	Large	SMEs	Large	SMEs	Large	SMEs	Large	Total
Easy to use and manage	Strongly agree	11	1	19	3	1	0	8	2	45
		39.30%	100.00%	54.30%	50.00%	9.10%	0.00%	44.40%	22.20%	40.90%
	Agree	16	0	13	2	7	1	6	5	50
		57.10%	0.00%	37.10%	33.30%	63.60%	50.00%	33.30%	55.60%	45.50%
	Neither agree nor disagree	1	0	2	1	2	1	3	1	11
		3.60%	0.00%	5.70%	16.70%	18.20%	50.00%	16.70%	11.10%	10.00%
	Disagree	0	0	1	0	1	0	0	1	3
		0.00%	0.00%	2.90%	0.00%	9.10%	0.00%	0.00%	11.10%	2.70%
	Strongly disagree	0	0	0	0	0	0	1	0	1
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.60%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Speedy	Strongly agree	11	0	8	1	2	1	5	2	30
		39.30%	0.00%	22.90%	16.70%	18.20%	50.00%	27.80%	22.20%	27.30%
	Agree	15	1	22	3	3	1	7	6	58
		53.60%	100.00%	62.90%	50.00%	27.30%	50.00%	38.90%	66.70%	52.70%
	Neither agree nor disagree	2	0	5	1	6	0	4	1	19
		7.10%	0.00%	14.30%	16.70%	54.50%	0.00%	22.20%	11.10%	17.30%
	Disagree	0	0	0	1	0	0	2	0	3
		0.00%	0.00%	0.00%	16.70%	0.00%	0.00%	11.10%	0.00%	2.70%
	Strongly disagree	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Visible	Strongly agree	6	0	15	3	3	1	7	4	39
		21.40%	0.00%	42.90%	50.00%	27.30%	50.00%	38.90%	44.40%	35.50%
	Agree	14	0	18	3	6	1	5	3	50
		50.00%	0.00%	51.40%	50.00%	54.50%	50.00%	27.80%	33.30%	45.50%
	Neither agree nor disagree	6	1	1	0	0	0	6	1	15
		21.40%	100.00%	2.90%	0.00%	0.00%	0.00%	33.30%	11.10%	13.60%
	Disagree	2	0	1	0	2	0	0	1	6
		7.10%	0.00%	2.90%	0.00%	18.20%	0.00%	0.00%	11.10%	5.50%
	Strongly disagree	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Portable	Strongly agree	9	0	9	1	3	0	6	2	30
		32.10%	0.00%	25.70%	16.70%	27.30%	0.00%	33.30%	22.20%	27.30%
	Agree	14	0	19	4	6	2	6	4	55
		50.00%	0.00%	54.30%	66.70%	54.50%	100.00%	33.30%	44.40%	50.00%
	Neither agree nor disagree	4	0	3	1	1	0	6	1	16
		14.30%	0.00%	8.60%	16.70%	9.10%	0.00%	33.30%	11.10%	14.50%
	Disagree	1	1	4	0	0	0	0	2	8
		3.60%	100.00%	11.40%	0.00%	0.00%	0.00%	0.00%	22.20%	7.30%
	Strongly disagree	0	0	0	0	1	0	0	0	1
		0.00%	0.00%	0.00%	0.00%	9.10%	0.00%	0.00%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Flexible	Strongly agree	6	0	16	1	3	0	4	2	32
		21.40%	0.00%	45.70%	16.70%	27.30%	0.00%	22.20%	22.20%	29.10%
	Agree	14	0	16	3	6	1	10	6	56
		50.00%	0.00%	45.70%	50.00%	54.50%	50.00%	55.60%	66.70%	50.90%
	Neither agree nor disagree	6	0	2	2	2	1	4	1	18
		21.40%	0.00%	5.70%	33.30%	18.20%	50.00%	22.20%	11.10%	16.40%
	Disagree	2	0	1	0	0	0	0	0	3
		7.10%	0.00%	2.90%	0.00%	0.00%	0.00%	0.00%	0.00%	2.70%
	Strongly disagree	0	1	0	0	0	0	0	0	1
		0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Informative	Strongly agree	15	0	11	2	3	0	5	3	39
		53.60%	0.00%	31.40%	33.30%	27.30%	0.00%	27.80%	33.30%	35.50%
	Agree	11	0	22	3	7	1	10	5	59
		39.30%	0.00%	62.90%	50.00%	63.60%	50.00%	55.60%	55.60%	53.60%
	Neither agree nor disagree	1	0	2	0	1	1	2	1	8
		3.60%	0.00%	5.70%	0.00%	9.10%	50.00%	11.10%	11.10%	7.30%
	Disagree	1	1	0	1	0	0	1	0	4
		3.60%	100.00%	0.00%	16.70%	0.00%	0.00%	5.60%	0.00%	3.60%
	Strongly disagree	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Cost-effective	Strongly agree	7	0	7	0	1	0	4	1	20
		25.00%	0.00%	20.00%	0.00%	9.10%	0.00%	22.20%	11.10%	18.20%
	Agree	15	0	19	4	7	1	4	6	56
		53.60%	0.00%	54.30%	66.70%	63.60%	50.00%	22.20%	66.70%	50.90%
	Neither agree nor disagree	2	1	6	1	2	1	9	1	23
		7.10%	100.00%	17.10%	16.70%	18.20%	50.00%	50.00%	11.10%	20.90%
	Disagree	3	0	1	1	0	0	1	1	7
		10.70%	0.00%	2.90%	16.70%	0.00%	0.00%	5.60%	11.10%	6.40%

	Strongly disagree	1	0	2	0	1	0	0	0	4
		3.60%	0.00%	5.70%	0.00%	9.10%	0.00%	0.00%	0.00%	3.60%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Supports sharing	Strongly agree	8	0	13	2	4	1	7	2	37
		28.60%	0.00%	37.10%	33.30%	36.40%	50.00%	38.90%	22.20%	33.60%
	Agree	16	1	17	4	5	1	3	3	50
		57.10%	100.00%	48.60%	66.70%	45.50%	50.00%	16.70%	33.30%	45.50%
	Neither agree nor disagree	3	0	5	0	1	0	7	3	19
		10.70%	0.00%	14.30%	0.00%	9.10%	0.00%	38.90%	33.30%	17.30%
	Disagree	1	0	0	0	1	0	1	1	4
		3.60%	0.00%	0.00%	0.00%	9.10%	0.00%	5.60%	11.10%	3.60%
	Strongly disagree	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Lean and sustainable	Strongly agree	7	1	11	0	1	0	5	1	26
		25.00%	100.00%	31.40%	0.00%	9.10%	0.00%	27.80%	11.10%	23.60%
	Agree	17	0	17	5	5	2	6	6	58
		60.70%	0.00%	48.60%	83.30%	45.50%	100.00%	33.30%	66.70%	52.70%
	Neither agree nor disagree	2	0	6	1	4	0	6	2	21
		7.10%	0.00%	17.10%	16.70%	36.40%	0.00%	33.30%	22.20%	19.10%
	Disagree	2	0	1	0	1	0	0	0	4
		7.10%	0.00%	2.90%	0.00%	9.10%	0.00%	0.00%	0.00%	3.60%
	Strongly disagree	0	0	0	0	0	0	1	0	1
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.60%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Imposes low overhead	Strongly agree	5	0	16	1	2	0	5	1	30
		17.90%	0.00%	45.70%	16.70%	18.20%	0.00%	27.80%	11.10%	27.30%
	Agree	13	1	13	0	4	0	4	4	39
		46.40%	100.00%	37.10%	0.00%	36.40%	0.00%	22.20%	44.40%	35.50%
	Neither agree nor disagree	6	0	6	4	4	2	7	2	31
		21.40%	0.00%	17.10%	66.70%	36.40%	100.00%	38.90%	22.20%	28.20%
	Disagree	3	0	0	1	1	0	2	1	8
		10.70%	0.00%	0.00%	16.70%	9.10%	0.00%	11.10%	11.10%	7.30%
	Strongly disagree	1	0	0	0	0	0	0	1	2
		3.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	11.10%	1.80%
SMPI Challenges	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Reluctance to use	Very well	9	1	15	1	1	0	5	1	33
		32.10%	100.00%	42.90%	16.70%	9.10%	0.00%	27.80%	11.10%	30.00%
	Well	12	0	15	5	3	1	8	4	48
		42.90%	0.00%	42.90%	83.30%	27.30%	50.00%	44.40%	44.40%	43.60%
	Adequately	5	0	5	0	7	0	3	3	23

		17.90%	0.00%	14.30%	0.00%	63.60%	0.00%	16.70%	33.30%	20.90%
	Poorly	2	0	0	0	0	1	1	1	5
		7.10%	0.00%	0.00%	0.00%	0.00%	50.00%	5.60%	11.10%	4.50%
	Very Poorly	0	0	0	0	0	0	1	0	1
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.60%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Time Consuming	Very well	9	1	11	0	2	0	6	1	30
		32.10%	100.00%	31.40%	0.00%	18.20%	0.00%	33.30%	11.10%	27.30%
	Well	10	0	16	4	3	0	6	4	43
		35.70%	0.00%	45.70%	66.70%	27.30%	0.00%	33.30%	44.40%	39.10%
	Adequately	7	0	7	2	6	1	4	4	31
		25.00%	0.00%	20.00%	33.30%	54.50%	50.00%	22.20%	44.40%	28.20%
	Poorly	2	0	1	0	0	0	2	0	5
		7.10%	0.00%	2.90%	0.00%	0.00%	0.00%	11.10%	0.00%	4.50%
	Very Poorly	0	0	0	0	0	1	0	0	1
		0.00%	0.00%	0.00%	0.00%	0.00%	50.00%	0.00%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Resource Limitation	Very well	6	1	14	1	2	0	5	1	30
		21.40%	100.00%	40.00%	16.70%	18.20%	0.00%	27.80%	11.10%	27.30%
	Well	19	0	15	4	4	0	4	2	48
		67.90%	0.00%	42.90%	66.70%	36.40%	0.00%	22.20%	22.20%	43.60%
	Adequately	2	0	5	1	4	1	9	5	27
		7.10%	0.00%	14.30%	16.70%	36.40%	50.00%	50.00%	55.60%	24.50%
	Poorly	1	0	1	0	1	1	0	1	5
		3.60%	0.00%	2.90%	0.00%	9.10%	50.00%	0.00%	11.10%	4.50%
	Very Poorly	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
High Learning Curve	Very well	7	1	13	1	3	0	4	1	30
		25.00%	100.00%	37.10%	16.70%	27.30%	0.00%	22.20%	11.10%	27.30%
	Well	14	0	14	2	4	0	6	4	44
		50.00%	0.00%	40.00%	33.30%	36.40%	0.00%	33.30%	44.40%	40.00%
	Adequately	6	0	7	3	3	2	7	3	31
		21.40%	0.00%	20.00%	50.00%	27.30%	100.00%	38.90%	33.30%	28.20%
	Poorly	1	0	1	0	1	0	1	1	5
		3.60%	0.00%	2.90%	0.00%	9.10%	0.00%	5.60%	11.10%	4.50%
	Very Poorly	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Experts Requirement	Very well	7	0	6	0	4	0	6	1	24
		25.00%	0.00%	17.10%	0.00%	36.40%	0.00%	33.30%	11.10%	21.80%
	Well	14	1	22	5	3	0	7	5	57

		50.00%	100.00%	62.90%	83.30%	27.30%	0.00%	38.90%	55.60%	51.80%
	Adequately	4	0	4	1	4	0	4	2	19
		14.30%	0.00%	11.40%	16.70%	36.40%	0.00%	22.20%	22.20%	17.30%
	Poorly	3	0	3	0	0	2	1	1	10
		10.70%	0.00%	8.60%	0.00%	0.00%	100.00%	5.60%	11.10%	9.10%
	Very Poorly	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
High Implementation cost	Very well	8	0	8	1	1	0	6	1	25
		28.60%	0.00%	22.90%	16.70%	9.10%	0.00%	33.30%	11.10%	22.70%
	Well	9	1	19	3	4	0	4	5	45
		32.10%	100.00%	54.30%	50.00%	36.40%	0.00%	22.20%	55.60%	40.90%
	Adequately	6	0	6	0	6	0	6	3	27
		21.40%	0.00%	17.10%	0.00%	54.50%	0.00%	33.30%	33.30%	24.50%
	Poorly	5	0	2	2	0	1	2	0	12
		17.90%	0.00%	5.70%	33.30%	0.00%	50.00%	11.10%	0.00%	10.90%
	Very Poorly	0	0	0	0	0	1	0	0	1
		0.00%	0.00%	0.00%	0.00%	0.00%	50.00%	0.00%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Lack of process/product knowledge	Very well	13	0	14	0	1	0	2	1	31
		46.40%	0.00%	40.00%	0.00%	9.10%	0.00%	11.10%	11.10%	28.20%
	Well	8	1	17	5	5	0	9	4	49
		28.60%	100.00%	48.60%	83.30%	45.50%	0.00%	50.00%	44.40%	44.50%
	Adequately	5	0	4	1	3	1	7	3	24
		17.90%	0.00%	11.40%	16.70%	27.30%	50.00%	38.90%	33.30%	21.80%
	Poorly	2	0	0	0	1	1	0	1	5
		7.10%	0.00%	0.00%	0.00%	9.10%	50.00%	0.00%	11.10%	4.50%
	Very Poorly	0	0	0	0	1	0	0	0	1
		0.00%	0.00%	0.00%	0.00%	9.10%	0.00%	0.00%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Measurements goals determination	Very well	5	0	13	0	2	0	3	3	26
		17.90%	0.00%	37.10%	0.00%	18.20%	0.00%	16.70%	33.30%	23.60%
	Well	18	0	18	4	4	1	10	3	58
		64.30%	0.00%	51.40%	66.70%	36.40%	50.00%	55.60%	33.30%	52.70%
	Adequately	3	1	3	2	5	1	4	2	21
		10.70%	100.00%	8.60%	33.30%	45.50%	50.00%	22.20%	22.20%	19.10%
	Poorly	2	0	1	0	0	0	1	1	5
		7.10%	0.00%	2.90%	0.00%	0.00%	0.00%	5.60%	11.10%	4.50%
	Very Poorly	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	Very well	5	0	6	0	1	0	4	3	19

Poorly defined escalation procedures		17.90%	0.00%	17.10%	0.00%	9.10%	0.00%	22.20%	33.30%	17.30%
	Well	15	0	20	3	6	0	7	3	54
		53.60%	0.00%	57.10%	50.00%	54.50%	0.00%	38.90%	33.30%	49.10%
	Adequately	4	1	7	2	4	1	6	2	27
		14.30%	100.00%	20.00%	33.30%	36.40%	50.00%	33.30%	22.20%	24.50%
	Poorly	3	0	2	0	0	1	1	1	8
		10.70%	0.00%	5.70%	0.00%	0.00%	50.00%	5.60%	11.10%	7.30%
	Very Poorly	1	0	0	1	0	0	0	0	2
		3.60%	0.00%	0.00%	16.70%	0.00%	0.00%	0.00%	0.00%	1.80%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Lack of awareness about measurement process	Very well	10	0	16	1	1	0	6	2	36
		35.70%	0.00%	45.70%	16.70%	9.10%	0.00%	33.30%	22.20%	32.70%
	Well	9	0	14	5	7	1	7	4	47
		32.10%	0.00%	40.00%	83.30%	63.60%	50.00%	38.90%	44.40%	42.70%
	Adequately	7	1	3	0	3	1	4	2	21
		25.00%	100.00%	8.60%	0.00%	27.30%	50.00%	22.20%	22.20%	19.10%
	Poorly	1	0	1	0	0	0	1	1	4
		3.60%	0.00%	2.90%	0.00%	0.00%	0.00%	5.60%	11.10%	3.60%
	Very Poorly	1	0	1	0	0	0	0	0	2
		3.60%	0.00%	2.90%	0.00%	0.00%	0.00%	0.00%	0.00%	1.80%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Lack of communication between different levels of Organization	Very well	7	0	16	1	1	0	5	1	31
		25.00%	0.00%	45.70%	16.70%	9.10%	0.00%	27.80%	11.10%	28.20%
	Well	15	0	15	3	7	2	7	4	53
		53.60%	0.00%	42.90%	50.00%	63.60%	100.00%	38.90%	44.40%	48.20%
	Adequately	3	1	3	2	2	0	5	3	19
		10.70%	100.00%	8.60%	33.30%	18.20%	0.00%	27.80%	33.30%	17.30%
	Poorly	3	0	1	0	1	0	1	1	7
		10.70%	0.00%	2.90%	0.00%	9.10%	0.00%	5.60%	11.10%	6.40%
	Very Poorly	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SW Development Goals	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Efficiency	Significant Improvement in	19	0	19	1	3	1	10	2	55
		67.90%	0.00%	54.30%	16.70%	27.30%	50.00%	55.60%	22.20%	50.00%
	Improvement in	8	0	15	5	6	1	7	4	46
		28.60%	0.00%	42.90%	83.30%	54.50%	50.00%	38.90%	44.40%	41.80%
	No change in	1	1	1	0	2	0	1	3	9
		3.60%	100.00%	2.90%	0.00%	18.20%	0.00%	5.60%	33.30%	8.20%
	Deterioration of	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Significant deterioration of	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110

		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Scheduling	Significant Improvement in	12	0	14	0	3	0	7	2	38
		42.90%	0.00%	40.00%	0.00%	27.30%	0.00%	38.90%	22.20%	34.50%
	Improvement in	15	0	17	5	6	1	11	5	60
		53.60%	0.00%	48.60%	83.30%	54.50%	50.00%	61.10%	55.60%	54.50%
	No change in	1	1	4	1	2	1	0	2	12
		3.60%	100.00%	11.40%	16.70%	18.20%	50.00%	0.00%	22.20%	10.90%
	Deterioration of	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Significant deterioration of	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Predictability	Significant Improvement in	9	0	13	0	4	1	7	2	36
		32.10%	0.00%	37.10%	0.00%	36.40%	50.00%	38.90%	22.20%	32.70%
	Improvement in	14	0	19	4	3	0	7	5	52
		50.00%	0.00%	54.30%	66.70%	27.30%	0.00%	38.90%	55.60%	47.30%
	No change in	4	1	3	2	3	1	4	2	20
		14.30%	100.00%	8.60%	33.30%	27.30%	50.00%	22.20%	22.20%	18.20%
	Deterioration of	1	0	0	0	1	0	0	0	2
		3.60%	0.00%	0.00%	0.00%	9.10%	0.00%	0.00%	0.00%	1.80%
	Significant deterioration of	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Sustainability	Significant Improvement in	11	0	15	3	2	0	7	2	40
		39.30%	0.00%	42.90%	50.00%	18.20%	0.00%	38.90%	22.20%	36.40%
	Improvement in	13	0	15	2	8	2	7	5	52
		46.40%	0.00%	42.90%	33.30%	72.70%	100.00%	38.90%	55.60%	47.30%
	No change in	4	1	5	1	1	0	4	2	18
		14.30%	100.00%	14.30%	16.70%	9.10%	0.00%	22.20%	22.20%	16.40%
	Deterioration of	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Significant deterioration of	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Process Agility	Significant Improvement in	5	0	10	1	5	1	7	2	31
		17.90%	0.00%	28.60%	16.70%	45.50%	50.00%	38.90%	22.20%	28.20%
	Improvement in	17	1	20	3	4	1	7	4	57
		60.70%	100.00%	57.10%	50.00%	36.40%	50.00%	38.90%	44.40%	51.80%
	No change in	6	0	4	2	1	0	2	3	18
		21.40%	0.00%	11.40%	33.30%	9.10%	0.00%	11.10%	33.30%	16.40%
	Deterioration of	0	0	1	0	1	0	2	0	4
		0.00%	0.00%	2.90%	0.00%	9.10%	0.00%	11.10%	0.00%	3.60%
		0	0	0	0	0	0	0	0	0

	Significant deterioration of	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Product Quality	Significant Improvement in	10	0	15	0	4	2	8	4	43
		35.70%	0.00%	42.90%	0.00%	36.40%	100.00%	44.40%	44.40%	39.10%
	Improvement in	14	1	18	6	4	0	6	3	52
		50.00%	100.00%	51.40%	100.00%	36.40%	0.00%	33.30%	33.30%	47.30%
	No change in	2	0	2	0	1	0	3	2	10
		7.10%	0.00%	5.70%	0.00%	9.10%	0.00%	16.70%	22.20%	9.10%
	Deterioration of	1	0	0	0	2	0	1	0	4
		3.60%	0.00%	0.00%	0.00%	18.20%	0.00%	5.60%	0.00%	3.60%
	Significant deterioration of	1	0	0	0	0	0	0	0	1
		3.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Results Visibility	Significant Improvement in	14	0	18	2	3	1	8	2	48
		50.00%	0.00%	51.40%	33.30%	27.30%	50.00%	44.40%	22.20%	43.60%
	Improvement in	9	1	16	3	5	1	7	5	47
		32.10%	100.00%	45.70%	50.00%	45.50%	50.00%	38.90%	55.60%	42.70%
	No change in	4	0	1	1	2	0	2	2	12
		14.30%	0.00%	2.90%	16.70%	18.20%	0.00%	11.10%	22.20%	10.90%
	Deterioration of	1	0	0	0	1	0	0	0	2
		3.60%	0.00%	0.00%	0.00%	9.10%	0.00%	0.00%	0.00%	1.80%
	Significant deterioration of	0	0	0	0	0	0	1	0	1
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.60%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Process Transparency	Significant Improvement in	14	0	19	2	3	0	9	4	51
		50.00%	0.00%	54.30%	33.30%	27.30%	0.00%	50.00%	44.40%	46.40%
	Improvement in	12	0	14	3	6	1	7	3	46
		42.90%	0.00%	40.00%	50.00%	54.50%	50.00%	38.90%	33.30%	41.80%
	No change in	2	1	2	1	1	1	1	2	11
		7.10%	100.00%	5.70%	16.70%	9.10%	50.00%	5.60%	22.20%	10.00%
	Deterioration of	0	0	0	0	1	0	0	0	1
		0.00%	0.00%	0.00%	0.00%	9.10%	0.00%	0.00%	0.00%	0.90%
	Significant deterioration of	0	0	0	0	0	0	1	0	1
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.60%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Developer Productivity	Significant Improvement in	8	0	24	0	1	2	7	3	45
		28.60%	0.00%	68.60%	0.00%	9.10%	100.00%	38.90%	33.30%	40.90%
	Improvement in	16	0	10	5	9	0	6	2	48
		57.10%	0.00%	28.60%	83.30%	81.80%	0.00%	33.30%	22.20%	43.60%
	No change in	2	1	1	1	1	0	3	3	12

		7.10%	100.00%	2.90%	16.70%	9.10%	0.00%	16.70%	33.30%	10.90%
	Deterioration of	1	0	0	0	0	0	2	1	4
		3.60%	0.00%	0.00%	0.00%	0.00%	0.00%	11.10%	11.10%	3.60%
	Significant deterioration of	1	0	0	0	0	0	0	0	1
		3.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%
SMF4SMEs helps in	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Stay on Schedule?	Extremely well	14	0	17	0	2	1	9	1	44
		50.00%	0.00%	48.60%	0.00%	18.20%	50.00%	50.00%	11.10%	40.00%
	Very well	11	1	15	4	4	1	8	6	50
		39.30%	100.00%	42.90%	66.70%	36.40%	50.00%	44.40%	66.70%	45.50%
	Moderately well	1	0	2	2	4	0	0	2	11
		3.60%	0.00%	5.70%	33.30%	36.40%	0.00%	0.00%	22.20%	10.00%
	Slightly well	2	0	1	0	1	0	1	0	5
		7.10%	0.00%	2.90%	0.00%	9.10%	0.00%	5.60%	0.00%	4.50%
	Not well at all	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Increase Productivity?	Extremely well	11	0	19	1	1	0	6	1	39
		39.30%	0.00%	54.30%	16.70%	9.10%	0.00%	33.30%	11.10%	35.50%
	Very well	15	0	11	3	4	2	10	5	50
		53.60%	0.00%	31.40%	50.00%	36.40%	100.00%	55.60%	55.60%	45.50%
	Moderately well	1	1	4	2	4	0	2	2	16
		3.60%	100.00%	11.40%	33.30%	36.40%	0.00%	11.10%	22.20%	14.50%
	Slightly well	1	0	1	0	2	0	0	1	5
		3.60%	0.00%	2.90%	0.00%	18.20%	0.00%	0.00%	11.10%	4.50%
	Not well at all	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Make Correct Estimate?	Extremely well	8	0	13	0	1	0	5	2	29
		28.60%	0.00%	37.10%	0.00%	9.10%	0.00%	27.80%	22.20%	26.40%
	Very well	13	0	17	1	2	1	8	6	48
		46.40%	0.00%	48.60%	16.70%	18.20%	50.00%	44.40%	66.70%	43.60%
	Moderately well	6	1	4	5	6	1	3	1	27
		21.40%	100.00%	11.40%	83.30%	54.50%	50.00%	16.70%	11.10%	24.50%
	Slightly well	1	0	1	0	1	0	1	0	4
		3.60%	0.00%	2.90%	0.00%	9.10%	0.00%	5.60%	0.00%	3.60%
	Not well at all	0	0	0	0	1	0	1	0	2
		0.00%	0.00%	0.00%	0.00%	9.10%	0.00%	5.60%	0.00%	1.80%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Make Good Decisions?	Extremely well	8	0	14	1	1	0	7	2	33
		28.60%	0.00%	40.00%	16.70%	9.10%	0.00%	38.90%	22.20%	30.00%
	Very well	12	0	18	2	5	1	6	4	48

		42.90%	0.00%	51.40%	33.30%	45.50%	50.00%	33.30%	44.40%	43.60%
	Moderately well	4	1	3	3	2	1	4	3	21
		14.30%	100.00%	8.60%	50.00%	18.20%	50.00%	22.20%	33.30%	19.10%
	Slightly well	4	0	0	0	3	0	0	0	7
		14.30%	0.00%	0.00%	0.00%	27.30%	0.00%	0.00%	0.00%	6.40%
	Not well at all	0	0	0	0	0	0	1	0	1
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.60%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Improve Product Quality?	Extremely well	9	0	13	0	2	1	4	2	31
		32.10%	0.00%	37.10%	0.00%	18.20%	50.00%	22.20%	22.20%	28.20%
	Very well	12	0	20	2	3	1	9	5	52
		42.90%	0.00%	57.10%	33.30%	27.30%	50.00%	50.00%	55.60%	47.30%
	Moderately well	4	0	1	4	4	0	3	1	17
		14.30%	0.00%	2.90%	66.70%	36.40%	0.00%	16.70%	11.10%	15.50%
	Slightly well	1	1	1	0	2	0	2	1	8
		3.60%	100.00%	2.90%	0.00%	18.20%	0.00%	11.10%	11.10%	7.30%
	Not well at all	2	0	0	0	0	0	0	0	2
		7.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.80%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Enhance Process Understanding?	Extremely well	8	0	12	1	2	1	4	1	29
		28.60%	0.00%	34.30%	16.70%	18.20%	50.00%	22.20%	11.10%	26.40%
	Very well	13	0	19	2	5	0	8	6	53
		46.40%	0.00%	54.30%	33.30%	45.50%	0.00%	44.40%	66.70%	48.20%
	Moderately well	5	0	4	3	4	1	4	1	22
		17.90%	0.00%	11.40%	50.00%	36.40%	50.00%	22.20%	11.10%	20.00%
	Slightly well	1	1	0	0	0	0	2	1	5
		3.60%	100.00%	0.00%	0.00%	0.00%	0.00%	11.10%	11.10%	4.50%
	Not well at all	1	0	0	0	0	0	0	0	1
		3.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%
Elements	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Risk Factors	Extremely good	9	1	12	2	1	0	4	4	33
		32.10%	100.00%	34.30%	33.30%	9.10%	0.00%	22.20%	44.40%	30.00%
	Somewhat good	14	0	19	3	9	2	12	4	63
		50.00%	0.00%	54.30%	50.00%	81.80%	100.00%	66.70%	44.40%	57.30%
	Neither good nor bad	4	0	4	1	1	0	2	1	13
		14.30%	0.00%	11.40%	16.70%	9.10%	0.00%	11.10%	11.10%	11.80%
	Somewhat bad	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Extremely bad	1	0	0	0	0	0	0	0	1
		3.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	Extremely good	11	0	12	2	1	2	2	4	34

		39.30%	0.00%	34.30%	33.30%	9.10%	100.00%	11.10%	44.40%	30.90%
Success Factors	Somewhat good	15	1	21	4	7	0	13	5	66
		53.60%	100.00%	60.00%	66.70%	63.60%	0.00%	72.20%	55.60%	60.00%
	Neither good nor bad	1	0	2	0	3	0	3	0	9
		3.60%	0.00%	5.70%	0.00%	27.30%	0.00%	16.70%	0.00%	8.20%
	Somewhat bad	1	0	0	0	0	0	0	0	1
		3.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%
	Extremely bad	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Activities vs Check Lists	Extremely good	14	0	16	2	3	1	7	3	46
		50.00%	0.00%	45.70%	33.30%	27.30%	50.00%	38.90%	33.30%	41.80%
	Somewhat good	7	0	16	4	5	0	8	6	46
		25.00%	0.00%	45.70%	66.70%	45.50%	0.00%	44.40%	66.70%	41.80%
	Neither good nor bad	6	0	3	0	2	1	3	0	15
		21.40%	0.00%	8.60%	0.00%	18.20%	50.00%	16.70%	0.00%	13.60%
	Somewhat bad	1	1	0	0	1	0	0	0	3
		3.60%	100.00%	0.00%	0.00%	9.10%	0.00%	0.00%	0.00%	2.70%
	Extremely bad	0	0	0	0	0	0	0	0	0
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Activities vs Precautions	Extremely good	8	0	14	3	3	0	8	2	38
		28.60%	0.00%	40.00%	50.00%	27.30%	0.00%	44.40%	22.20%	34.50%
	Somewhat good	17	0	16	2	6	2	8	6	57
		60.70%	0.00%	45.70%	33.30%	54.50%	100.00%	44.40%	66.70%	51.80%
	Neither good nor bad	2	0	5	1	2	0	1	1	12
		7.10%	0.00%	14.30%	16.70%	18.20%	0.00%	5.60%	11.10%	10.90%
	Somewhat bad	1	0	0	0	0	0	1	0	2
		3.60%	0.00%	0.00%	0.00%	0.00%	0.00%	5.60%	0.00%	1.80%
	Extremely bad	0	1	0	0	0	0	0	0	1
		0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Activities vs Roles and Responsibilities	Extremely good	9	0	16	5	3	0	6	2	41
		32.10%	0.00%	45.70%	83.30%	27.30%	0.00%	33.30%	22.20%	37.30%
	Somewhat good	14	1	16	1	7	2	10	6	57
		50.00%	100.00%	45.70%	16.70%	63.60%	100.00%	55.60%	66.70%	51.80%
	Neither good nor bad	4	0	2	0	0	0	2	1	9
		14.30%	0.00%	5.70%	0.00%	0.00%	0.00%	11.10%	11.10%	8.20%
	Somewhat bad	0	0	1	0	1	0	0	0	2
		0.00%	0.00%	2.90%	0.00%	9.10%	0.00%	0.00%	0.00%	1.80%
	Extremely bad	1	0	0	0	0	0	0	0	1
		3.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%

Why use SMF4SMEs	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Convenience to user	1	2	0	2	1	0	0	0	1	6
		7.10%	0.00%	5.70%	16.70%	0.00%	0.00%	0.00%	11.10%	5.50%
	2	3	0	2	0	0	0	2	0	7
		10.70%	0.00%	5.70%	0.00%	0.00%	0.00%	11.10%	0.00%	6.40%
	3	8	1	13	2	4	1	5	3	37
		28.60%	100.00%	37.10%	33.30%	36.40%	50.00%	27.80%	33.30%	33.60%
	4	6	0	12	2	5	1	4	3	33
		21.40%	0.00%	34.30%	33.30%	45.50%	50.00%	22.20%	33.30%	30.00%
	5	9	0	4	1	0	0	6	1	21
		32.10%	0.00%	11.40%	16.70%	0.00%	0.00%	33.30%	11.10%	19.10%
	Rather not say	0	0	1	0	1	0	1	0	3
		0.00%	0.00%	2.90%	0.00%	9.10%	0.00%	5.60%	0.00%	2.70%
	Don't know	0	0	1	0	1	0	0	1	3
		0.00%	0.00%	2.90%	0.00%	9.10%	0.00%	0.00%	11.10%	2.70%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Easy to use and manage	1	0	0	1	0	0	0	2	1	4
		0.00%	0.00%	2.90%	0.00%	0.00%	0.00%	11.10%	11.10%	3.60%
	2	3	1	2	1	1	1	1	1	11
		10.70%	100.00%	5.70%	16.70%	9.10%	50.00%	5.60%	11.10%	10.00%
	3	7	0	6	0	4	0	4	3	24
		25.00%	0.00%	17.10%	0.00%	36.40%	0.00%	22.20%	33.30%	21.80%
	4	11	0	18	4	2	1	7	3	46
		39.30%	0.00%	51.40%	66.70%	18.20%	50.00%	38.90%	33.30%	41.80%
	5	6	0	8	1	3	0	2	1	21
		21.40%	0.00%	22.90%	16.70%	27.30%	0.00%	11.10%	11.10%	19.10%
	Rather not say	1	0	0	0	1	0	1	0	3
		3.60%	0.00%	0.00%	0.00%	9.10%	0.00%	5.60%	0.00%	2.70%
	Don't know	0	0	0	0	0	0	1	0	1
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.60%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Availability of Check Lists	1	2	0	0	1	0	0	1	1	5
		7.10%	0.00%	0.00%	16.70%	0.00%	0.00%	5.60%	11.10%	4.50%
	2	2	1	1	0	1	0	2	0	7
		7.10%	100.00%	2.90%	0.00%	9.10%	0.00%	11.10%	0.00%	6.40%
	3	5	0	8	2	5	1	5	2	28
		17.90%	0.00%	22.90%	33.30%	45.50%	50.00%	27.80%	22.20%	25.50%
	4	12	0	9	0	1	1	4	3	30
		42.90%	0.00%	25.70%	0.00%	9.10%	50.00%	22.20%	33.30%	27.30%
	5	6	0	16	3	3	0	6	3	37
		21.40%	0.00%	45.70%	50.00%	27.30%	0.00%	33.30%	33.30%	33.60%
	Rather not say	0	0	1	0	1	0	0	0	2
		0.00%	0.00%	2.90%	0.00%	9.10%	0.00%	0.00%	0.00%	1.80%
	Don't know	1	0	0	0	0	0	0	0	1
		3.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%
	Total	28	1	35	6	11	2	18	9	110

		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Suitable in SME Environment	1	2	0	1	0	0	0	3	1	7
		7.10%	0.00%	2.90%	0.00%	0.00%	0.00%	16.70%	11.10%	6.40%
	2	2	0	4	1	1	0	3	0	11
		7.10%	0.00%	11.40%	16.70%	9.10%	0.00%	16.70%	0.00%	10.00%
	3	4	0	6	3	4	1	4	3	25
		14.30%	0.00%	17.10%	50.00%	36.40%	50.00%	22.20%	33.30%	22.70%
	4	14	1	13	1	4	1	5	3	42
		50.00%	100.00%	37.10%	16.70%	36.40%	50.00%	27.80%	33.30%	38.20%
	5	4	0	10	1	1	0	3	2	21
		14.30%	0.00%	28.60%	16.70%	9.10%	0.00%	16.70%	22.20%	19.10%
	Rather not say	1	0	0	0	0	0	0	0	1
		3.60%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%
	Don't know	1	0	1	0	1	0	0	0	3
		3.60%	0.00%	2.90%	0.00%	9.10%	0.00%	0.00%	0.00%	2.70%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Degree of customisation possible	1	4	0	1	0	0	0	0	1	6
		14.30%	0.00%	2.90%	0.00%	0.00%	0.00%	0.00%	11.10%	5.50%
	2	2	0	2	1	0	1	2	0	8
		7.10%	0.00%	5.70%	16.70%	0.00%	50.00%	11.10%	0.00%	7.30%
	3	8	0	9	0	6	0	5	2	30
		28.60%	0.00%	25.70%	0.00%	54.50%	0.00%	27.80%	22.20%	27.30%
	4	9	1	18	4	1	1	7	4	45
		32.10%	100.00%	51.40%	66.70%	9.10%	50.00%	38.90%	44.40%	40.90%
	5	4	0	4	1	1	0	3	0	13
		14.30%	0.00%	11.40%	16.70%	9.10%	0.00%	16.70%	0.00%	11.80%
	Rather not say	0	0	0	0	2	0	0	0	2
		0.00%	0.00%	0.00%	0.00%	18.20%	0.00%	0.00%	0.00%	1.80%
	Don't know	1	0	1	0	1	0	1	2	6
		3.60%	0.00%	2.90%	0.00%	9.10%	0.00%	5.60%	22.20%	5.50%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Roles and Responsibilities Definition	1	2	0	0	0	0	0	1	1	4
		7.10%	0.00%	0.00%	0.00%	0.00%	0.00%	5.60%	11.10%	3.60%
	2	2	0	3	1	1	0	4	0	11
		7.10%	0.00%	8.60%	16.70%	9.10%	0.00%	22.20%	0.00%	10.00%
	3	4	1	9	1	3	0	6	5	29
		14.30%	100.00%	25.70%	16.70%	27.30%	0.00%	33.30%	55.60%	26.40%
	4	14	0	11	2	4	2	1	2	36
		50.00%	0.00%	31.40%	33.30%	36.40%	100.00%	5.60%	22.20%	32.70%
	5	4	0	10	2	1	0	5	1	23
		14.30%	0.00%	28.60%	33.30%	9.10%	0.00%	27.80%	11.10%	20.90%
	Rather not say	0	0	1	0	1	0	0	0	2
		0.00%	0.00%	2.90%	0.00%	9.10%	0.00%	0.00%	0.00%	1.80%
	Don't know	2	0	1	0	1	0	1	0	5
		7.10%	0.00%	2.90%	0.00%	9.10%	0.00%	5.60%	0.00%	4.50%
	Total	28	1	35	6	11	2	18	9	110

		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Flexibility to integrate with software development methodologies	1	2	0	0	0	1	0	2	1	6
		7.10%	0.00%	0.00%	0.00%	9.10%	0.00%	11.10%	11.10%	5.50%
	2	1	0	1	1	0	0	2	1	6
		3.60%	0.00%	2.90%	16.70%	0.00%	0.00%	11.10%	11.10%	5.50%
	3	7	0	6	2	2	1	2	4	24
		25.00%	0.00%	17.10%	33.30%	18.20%	50.00%	11.10%	44.40%	21.80%
	4	12	1	15	1	2	0	7	2	40
		42.90%	100.00%	42.90%	16.70%	18.20%	0.00%	38.90%	22.20%	36.40%
	5	2	0	12	2	3	1	3	0	23
		7.10%	0.00%	34.30%	33.30%	27.30%	50.00%	16.70%	0.00%	20.90%
	Rather not say	3	0	0	0	1	0	0	1	5
		10.70%	0.00%	0.00%	0.00%	9.10%	0.00%	0.00%	11.10%	4.50%
	Don't know	1	0	1	0	2	0	2	0	6
		3.60%	0.00%	2.90%	0.00%	18.20%	0.00%	11.10%	0.00%	5.50%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Implementation guidance e.g. precautions, risk and success factors	1	1	0	1	0	0	0	1	1	4
		3.60%	0.00%	2.90%	0.00%	0.00%	0.00%	5.60%	11.10%	3.60%
	2	1	1	4	1	0	0	2	0	9
		3.60%	100.00%	11.40%	16.70%	0.00%	0.00%	11.10%	0.00%	8.20%
	3	8	0	5	1	3	0	2	4	23
		28.60%	0.00%	14.30%	16.70%	27.30%	0.00%	11.10%	44.40%	20.90%
	4	8	0	12	3	4	1	4	4	36
		28.60%	0.00%	34.30%	50.00%	36.40%	50.00%	22.20%	44.40%	32.70%
	5	6	0	13	1	2	1	7	0	30
		21.40%	0.00%	37.10%	16.70%	18.20%	50.00%	38.90%	0.00%	27.30%
	Rather not say	2	0	0	0	0	0	0	0	2
		7.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.80%
	Don't know	2	0	0	0	2	0	2	0	6
		7.10%	0.00%	0.00%	0.00%	18.20%	0.00%	11.10%	0.00%	5.50%
SMF4SMEs help in	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
SMPI	Extremely well	6	0	8	0	1	0	2	1	18
		21.40%	0.00%	22.90%	0.00%	9.10%	0.00%	11.10%	11.10%	16.40%
	Very well	20	0	24	3	2	2	10	6	67
		71.40%	0.00%	68.60%	50.00%	18.20%	100.00%	55.60%	66.70%	60.90%
	Moderately well	2	1	3	3	7	0	4	1	21
		7.10%	100.00%	8.60%	50.00%	63.60%	0.00%	22.20%	11.10%	19.10%
	Slightly well	0	0	0	0	1	0	0	1	2
		0.00%	0.00%	0.00%	0.00%	9.10%	0.00%	0.00%	11.10%	1.80%
	Not well at all	0	0	0	0	0	0	2	0	2
		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	11.10%	0.00%	1.80%
Improvements in	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Factors		14	1	29	4	8	1	11	6	74

	Enhancing the existing roles/responsibilities, precautions and Check Lists	50.00%	100.00%	82.90%	66.70%	72.70%	50.00%	61.10%	66.70%	67.30%
	Integration with your development methodology	24	0	33	5	8	2	11	6	89
		85.70%	0.00%	94.30%	83.30%	72.70%	100.00%	61.10%	66.70%	80.90%
	Other	1	0	3	0	1	0	6	0	11
		3.60%	0.00%	8.60%	0.00%	9.10%	0.00%	33.30%	0.00%	10.00%
	Total	28	1	35	6	11	2	18	9	110
		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Appendix 8.4 Participants Opinion on SMF4SMEs

This tables is showing the excerpts from participants' opinion upon SMF4SMEs with respect to their role, SMK, experience and current designation. The Turquoise color highlighted "SMF4SMEs" is the replaced word of "it", "solution", "framework" and other related words. This replacement was made to generate some results through Nvivo.

ABC Feedback						
Title	Exp.	SMK	Role	Good	Bad	Improvements
Technical Director	11- 5	No	Top Mgmt	SMF4SME appears to be an effective tool as SMF4SMEs got clear answers of questions like what would be the role of a person and how we implement the SM strategy. SMF4SMEs checklist are easy to follow and fast to handle so they are most suited for an SME like us.		
TL	6 – 10	Yes	Other	ABC has been trying to use our SM policies but had few challenges in understanding the whole process and who would do what and when. SMF4SMEs a great way of achieving our SM goals using its recommendations in roles and checklists.		
SE	1 – 5	No	Other	SMF4SMEs is highly appreciated because of its clarity in roles and user-friendly checklists. SMF4SMEs is simple and less time consuming that's why it is suitable for an SME.		
Backend Dev	6 – 10	Yes	Other	ABC best fits into the scope of this tool SMF4SMEs because of our struggle with our measurement process. SMF4SMEs is a good solution. SMF4SMEs suitable for SME as it has defined the responsibilities and easy to use. SMF4SMEs Check Lists and other guidelines are great ways to do the measurement in a timely manner.		SMF4SMEs Reducing daily meeting would be highly appreciated.
Dev	1 – 5	Yes	Other	We found SMF4SMEs a great tool SM process Which is suitable for Small companies. SMF4SMEs roles & responsibilities, and check Lists and other guidelines are well structured and easy to use. It is time efficient		SMF4SMEs Daily stand-up meetings are a bit excessive.

PM	1 – 5	Yes	Top Mgmt	SMF4SMEs one of the next step that could help SM. Well defined SMF4SMEs roles and responsibilities in the form of easy to use checklist are very helpful.		
SQM	6 – 10	Yes	Top Mgmt	The SMF4SME is a good framework for measurement. Provided information is enough for the implementation.	The SMF4SMEs guidelines are very lengthy.	Further automating SMF4SMEs can reduce quite a good workload from my team. That SMF4SMEs guidelines should be converted into user manual, and the addition of some more supportive information into checklists can provide us further standard goals and metrics for all projects.
Assistant PM	6 – 10	Yes	Top	The SMF4SMEs is a good addition to our company. I was not feeling much control on my project as much I have now after using this framework. The process through this framework SMF4SMEs could be more accurate about my predictions. The SMF4SMEs provided implementation guideline is really good		
CEO	>15	Yes	top	SMF4SMEs will give me more control and visibility of my business.		As much as the reporting system is good it will help me to know about my business.
PM	11–15	Yes	Top Mgmt	The SMF4SMEs checklists, and roles and responsibilities division, which is very helpful.	The SMF4SMEs implementation guidelines attached to this survey are quite lengthy.	SMF4SMEs Checklists needs more improvement to initiate the users. I still think that SMF4SMEs GQM need to be more standardized and would be great if we link them with our business goals. The involvement of all team players is fruitful, and we tried during this project, but sometimes it is not possible, so it's better to keep it flexible. better to keep SMF4SMEs implementation guidelines short and in bullets so one can follow easily
Sr, Architect	11 – 15	Yes	Other	SMF4SMEs is easy and manageable as it provides all the information which we need to implement.		It will be great if you could provide some basic material about software measurement. If training, presentations and some general information can be

						provided for SMF4SMEs and software measurement, then it will be a big plus.
Off-shore PM	11 – 15	Yes	Top Mgmt	SMF4SMEs is really a cool idea for software measurements. SMF4SMEs will give us really great opportunity to keep an eye on work quality and how it is progressing. SMF4SMEs will also help us achieving our business goals. SMF4SMEs will really make a difference in terms of our work visibility.		
Principle SW architect	> 15	Yes	other	SMF4SMEs works well for SM process and well suited for Small and Medium Enterprises. Overall, the guidelines are extremely helpful and good,		I would recommend adding more SMF4SMEs checklists for improving the process, such as a standard set of goals and metrics.
Solution Architect	6 – 10	Yes	Other	The availability of SMF4SMEs checklists, precautions and the list of roles and responsibilities make it easier for us to manage the whole process.		
Product Manager	11 – 15	Yes	Top Mgmt	SMF4SMEs is a good proposal for SM process, it is suitable for small and medium size organization. The SMF4SMEs roles & responsibilities, checklists, and other guidelines are extremely good		There is still a chance of improvement in SMF4SMEs checklist like the addition of a standard set of goals and metrics required could be a great addition.
Dev TL	6-10	Yes	Other	This SMF4SMEs is a good step towards keeping the processes and progress more visible and in control. I find the good help is provided for each phase.	A lot more information is provided for everything and sometimes unnecessary.	Improve the key areas as phase 2, I find trickier, and Phase 3 which handle the actual results. So make them more clear through your provided guidelines and add some examples for them.

XYZ Feedback						
Title	Exp.	SMK	Role	Good	Bad	Improvements
TL	6 – 10	Yes	other	SMF4SMEs is easy because SMF4SMEs is guiding to implement for each step in detail and providing the checklists to keep an eye on. Most interesting thing about this program is that SMF4SMEs provides rules and responsibilities and being a team lead it gets difficult sometimes to define something, but overall I find SMF4SMEs really easy to manage.		There is a need of some improvement in the SMF4SMEs analysis phase. It will be great if SMF4SMEs provide some template of reporting the different matrix. I recommend to enhance SMF4SMEs checklist and provide

						checklists for all nine activities of your framework SMF4SMEs.
PM	6 – 10	Yes	Top Mgmt.	**1**. SMF4SMEs is simple and straight forward, as I studied about other quality improvement processes they were mostly complicated. **2**. The introduction of the measurement process to the whole team is good at the start. **3**. SMF4SMEs is merged with our current methodology which mainly save the time of implementation. **4**. SMF4SMEs has really good features checklists, roles responsibilities, and above all the list of goals and metrics, though I can't find in this survey but were shared with us during the process implementation in our company. **5**. SMF4SMEs did not disturb our team work routine in the context of spending extra time or creating confusions which are key for us.		**1**. As SMF4SMEs providing the measurement Goals and metrics also add one more thing on the board, add business goals in that list and link with measurement goals. I know every business has different goals but if you can provide some basic/standard business goals and link those with corresponding measurement goals it will be very beneficial for the small companies like us. **2**. SMF4SMEs also providing the questions with goals and metrics which is good, but we don't have any interest in them. They are good for better understanding. **3**. SMF4SMEs Daily quick meetings are not good for our work structure but might be good for others. I think 2, or 3 quick meetings a week should be enough with the following sprint meeting at last day of the week. **4**. SMF4SMEs Metrics data collection and results analysis should be automated to save more time.
SE	6 – 10	Yes	Other	SMF4SMEs Roles and responsibilities and checklist provided are extremely helpful		
TL	6 – 10	Yes	Other	SMF4SMEs is a good proposal from SM process.		
SE	6 – 10	Yes	Other	SMF4SMEs is a perfect proposal for SM Activity. SMF4SMEs roles and responsibilities, and checklists and others provided guidelines are so much effective.		
SE	6 – 10	Yes	Other	SMF4SMEs is an effective proposal for SM processes. Roles and responsibilities and checklists are good.		
SE	1 – 5	Yes	Other			We required the measurement related activities at the time of requirement

						engineering. But I am not sure how to use SMF4SMEs specifically over there. I would suggest adding the guidance about your framework SMF4SMEs implementation during each development phase.
SE	1 – 5	Yes	other		SMF4SMEs the daily meetings is quite time-consuming,	I suggest to reduce these daily meetings to need-based or 2 or 3 meetings a week.
SE	1 – 5	Yes	Other	I think SMF4SMEs is providing enough information	But I find SMF4SMEs sometimes quite lengthy and sometimes missing.	I will be more interested in looking at the business and measurement goals link any example! I will also like to have goals and metrics and further some examples how to collect those metrics. Being a small company we need such examples and standard sets.
SE	6 – 10	Yes	Other	SMF4SMEs was quite easy and simple. The idea of SMF4SMEs providing a set of goals and metrics is really cool and will work definitely.		SMF4SMEs Give more understanding of measurement goals definition.
SE	1 - 5	Yes	Other			A small setup like us need some more enhanced SMF4SMEs checklists with more details. I would suggest adding more examples and details in you checklists.
SE	1- 5	Yes	Other	I have some exposure to the software process improvements using CMMI; I find comparatively this framework SMF4SMEs quite simple and easy to handle. I like especially the way of providing the support products.		Try to come up with some **standard** set of business goals and their **link** to measurement goals.
SE	1- 5	Yes	other	The framework SMF4SMEs a good initiative.		Be in contact with organizations where you are implementing your tool and keep on maturing it.

TL	6-10	Yes	other	I find the SMF4SMEs roles and responsibilities definition a really good addition to any solution like this. I also like other elements as you attached to the survey.	The SMF4SMEs implementation guideline is quite a lengthy	Try to concise and to the point for guidelines.

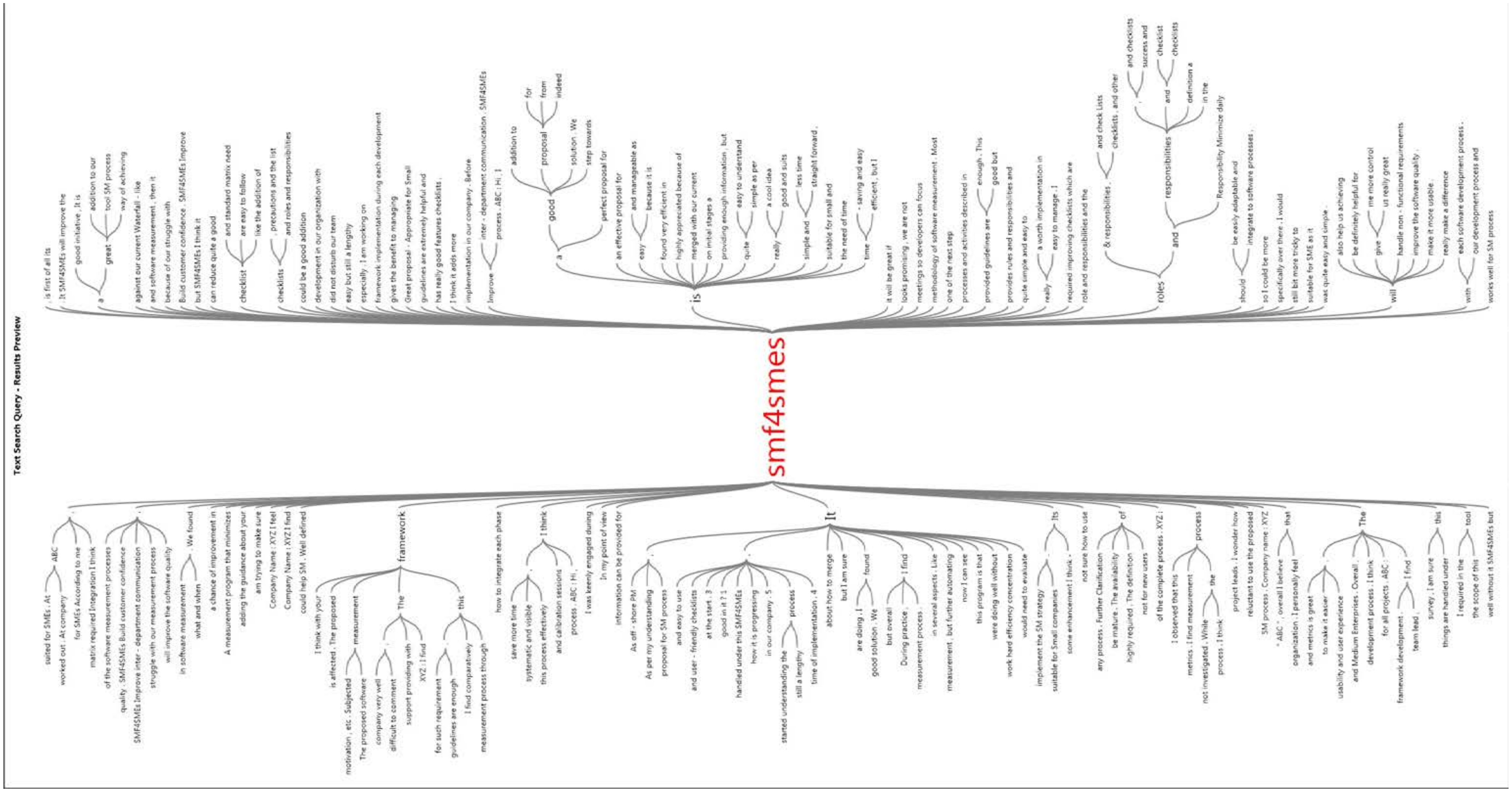
Rest-of-SMEs' Feedback							
Title	Exp	SMK	Role	Size	Good	Bad	Improvements
PM	>15	No	top	<10			Question would be easier to answer after we have trailed a measurement program within our organization.
TL	>15	No	Other	10 – 50	While the SMF4SMEs process looks promising,		We would need to evaluate SMF4SMEs against our current Waterfall-like processes which are currently being re-evaluated.
TL	6 – 10	No	Other	101 – 250			Client participation and interaction should be highlighted more.
SE	1 – 5	Yes	Other	101 – 250	The proposed software measurement framework SMF4SMEs is really good and suits our company very well. The framework SMF4SMEs gives the benefit to managing easily roles and responsibilities as per the organization requirements. SMF4SMEs Provided the good guideline and the checklist that team members can use to achieve organizational goals. I don`t think so any of our team members will be reluctant to use the proposed methodology of software measurement		
Principal SE	> 15	No	Other	10 – 50	SMF4SMEs will improve the software quality. SMF4SMEs Build customer confidence. Improve inter-department communication. Improve process.		
SE	6 – 10	No	Other	10 - 50			SMF4SMEs A measurement program that minimizes meetings so developers can focus on code time. That may mean utilizing smarter software to aggregate those metrics that PMs care about.

PM	6 – 10	Yes	Top Mgmt	<10			Walkthroughs and calibration sessions
SW architect	11 – 15	No	other	51 – 100	SMF4SMEs is a good proposal indeed. checklists which are a good addition and facilitating. I think providing a list of goals and metrics is great.		SMF4SMEs Still required more enhancement in several aspects. Like it required improving checklists
SE	1 – 5	Yes	Other	10 – 50	The processes and activities described in SMF4SMEs are delicately designed.		I am looking for the possibility of integrating SMF4SMEs with our existing individual performance assessment. I assume the activity of SMF4SMEs "Data Definition" may provide some insight for such requirement.
PM	6 – 10	No	Top Mgmt	101 – 250			The checklist and standard matrix need some enhancement
TL	11 – 15	Yes	Other	<10	SMF4SMEs Great proposal - Appropriate for Small business Enterprise		SMF4SMEs Checklists are good but need some addition - standard matrix required
TL	11 – 15	Yes	Other	<10			Integration
PM	6 -1 0	No	Top Mgmt	51 – 100	SMF4SMEs is the need of time when everyone is busy especially in SMEs. The definition of role and responsibilities and the checklists are the really good addition.		The SMF4SMEs checklists need more improvements
Assistant PM	1 -5	Yes	Top Mgmt	10 – 50			SMF4SMEs Need more work on user visibility, diagrammatic access to all users and motivation
SW dev	6 – 10	Yes	Other	10 – 50	Subjected measurement framework SMF4SMEs is found very efficient in terms of adoption for SMEs that are lacking behind in measurement within their processes due to extra resource allocation.	SMF4SMEs Strictly following daily meeting approach seems a countable con while accessing it critically.	
SE	6 – 10	Yes	Other	51 – 100	The proposed framework SMF4SMEs will be definitely helpful for the SMEs due to its flexibility, proposed roles and responsibilities and checklists.		

SE	1- 5	No	other	51 - 100			Use of function points and other complexity metrics.
SE	1 – 5	Yes	other	51 – 100			I say the more support providing with the framework SMF4SMEs will make it more usable. What more I required in the tool SMF4SMEs, is first of all SMF4SMEs automation and then more centralized control through project leads.
SE	6 – 10	Yes	Other	10 – 50			I wonder how SMF4SMEs will handle non-functional requirements such as usability and user experience.
QA Eng	6 – 10	No	other	10 – 50	The SMF4SMEs roles and responsibilities, success and risk factors are good		, I think the SMF4SMEs flow of information and communication should be stronger for the success of any process.
QA	1-5	Yes	Other	101 – 250			efficiency
SE	1 – 5	yes	other	51 – 100	SMF4SMEs is time-saving and easy to manage.		
TL	6 – 10	yes	other	10 – 50	I find the SMF4SMEs checklists and roles and responsibilities division is good to manage the measurement process.		I think the process SMF4SMEs should integrate to software processes, and there should be an explanation about how to merge SMF4SMEs with each software development process.
SE	1 – 5	Yes	other	51- 100	I think the SMF4SMEs provided guidelines are enough.		
SE Deployment eng	1 – 5	Yes	other	101 – 250	This framework SMF4SMEs is quite simple as per its activities	But the SMF4SMEs implementation guideline is quite a lengthy document.	I recommend shorting that to attract people to use your framework SMF4SMEs.

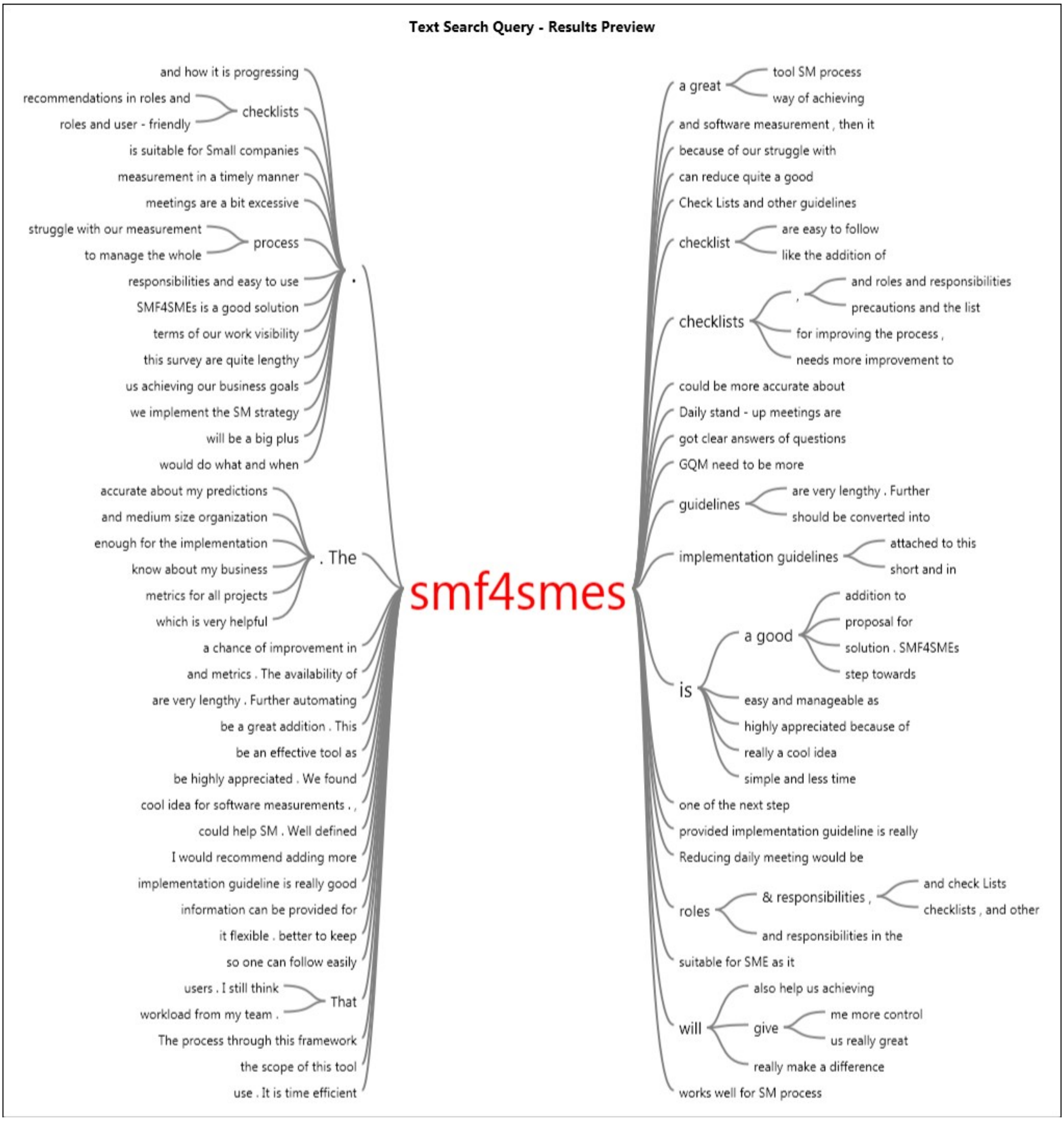
Large Organizations' Feedback						
Title	Exp.	SMK	Role	Good	Bad	Improvements
BA	>15	No	Top mgmt.	SMF4SMEs Provided guidelines are good.		Add some practical examples of the complete process.
Program Manager	>15	Yes	Top mgmt.		There is very limited detail available on the SMF4SME project, it is difficult to comment. Note: Might be this participants didn't explored the attached document.	The framework SMF4SMEs should be easily adaptable and manageable and professionally worked out.
PM	6 – 10	No	Top mgmt.	This framework SMF4SMEs is quite easy to understand	The provided SMF4SMEs guideline is too lengthy to follow.	Guidelines should be small and concise. I would like to have the list of goals and metrics for measurement to make it easier.
SE	6 – 10	No	Other			Can we introduce something which helps to communicate the measurement decisions to the developers at PBI(product backlog item) level
TL	11 – 15	Yes	Other			Further Clarification of SMF4SMEs Roles and Responsibility Minimize daily meetings, should be maximum twice in a week and should be more focused Follow-up of each activity Signed offs after implementation of each activity.

Appendix 8.5 Words Trees based on participants comments upon SMF4SMEs

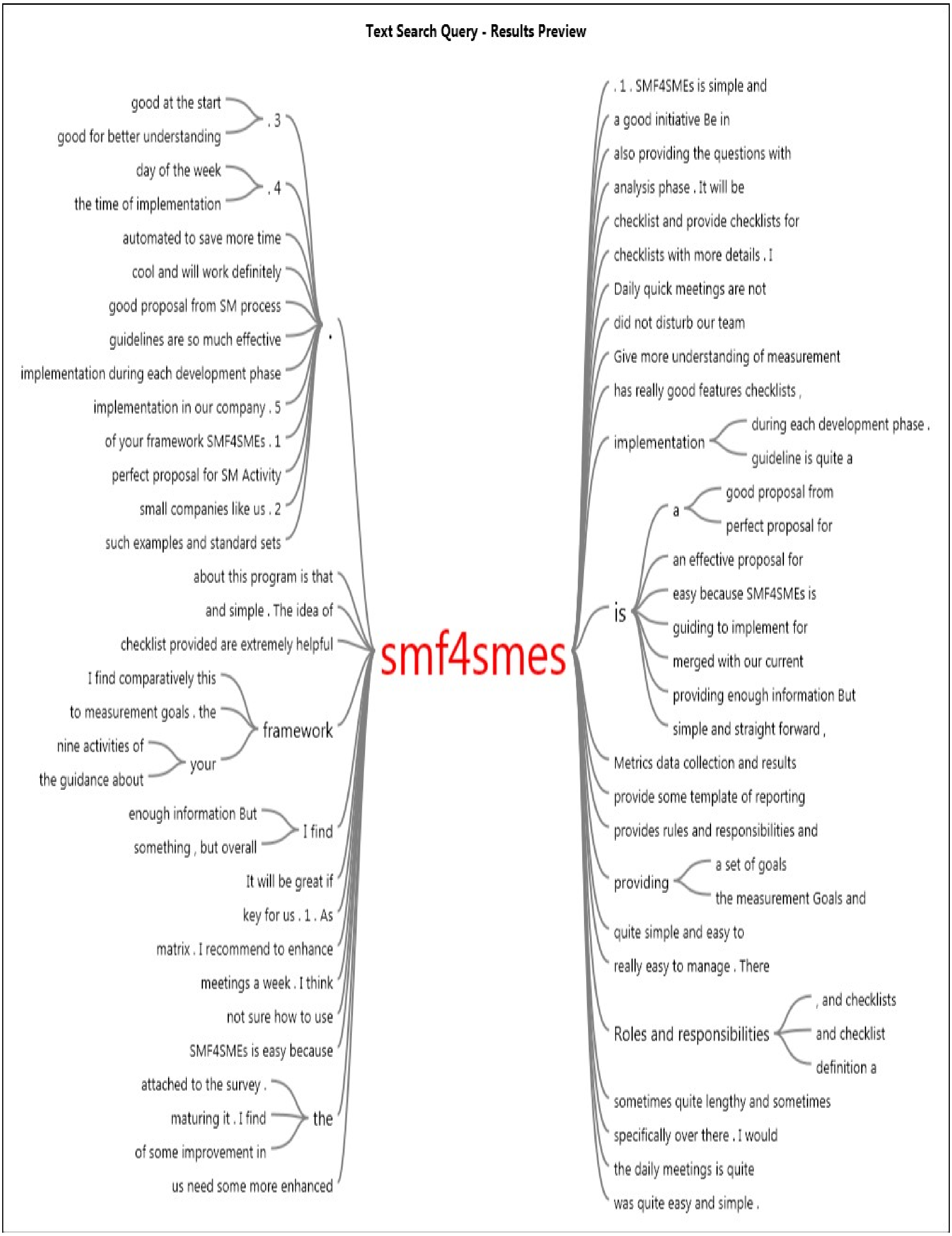


Appendix 8.6 Words Trees based participants comments

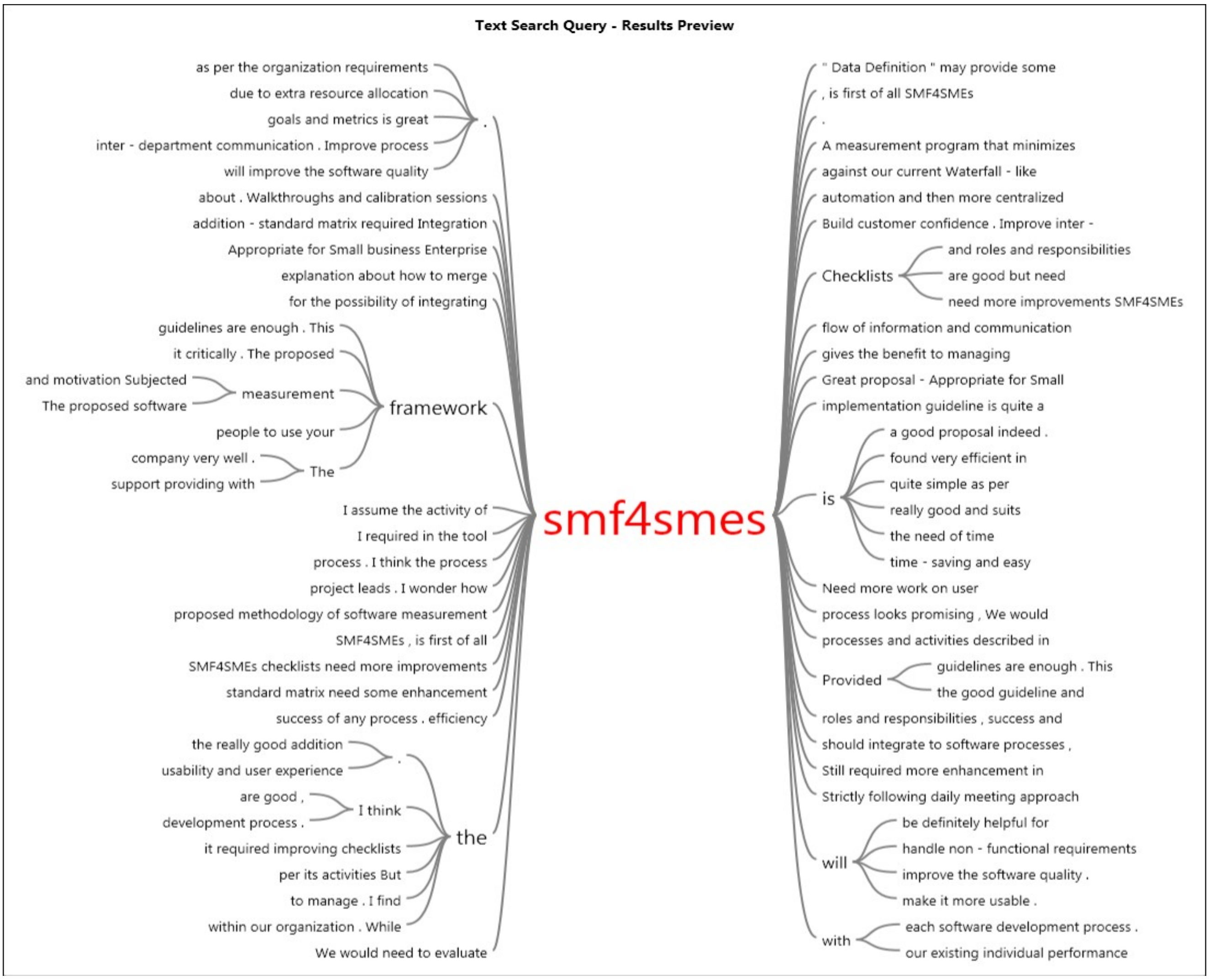
ABC Participants



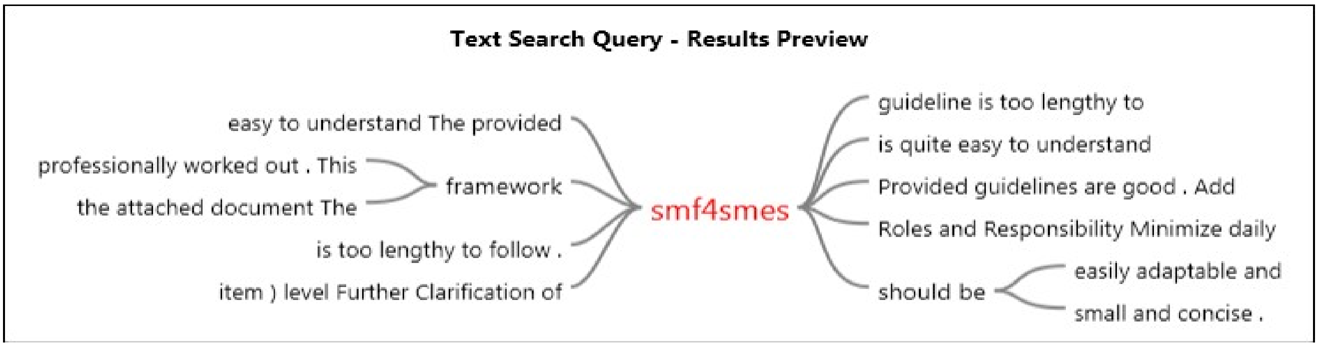
XYZ Participants



Rest-of-SMEs Comments



Large Organizations Comments



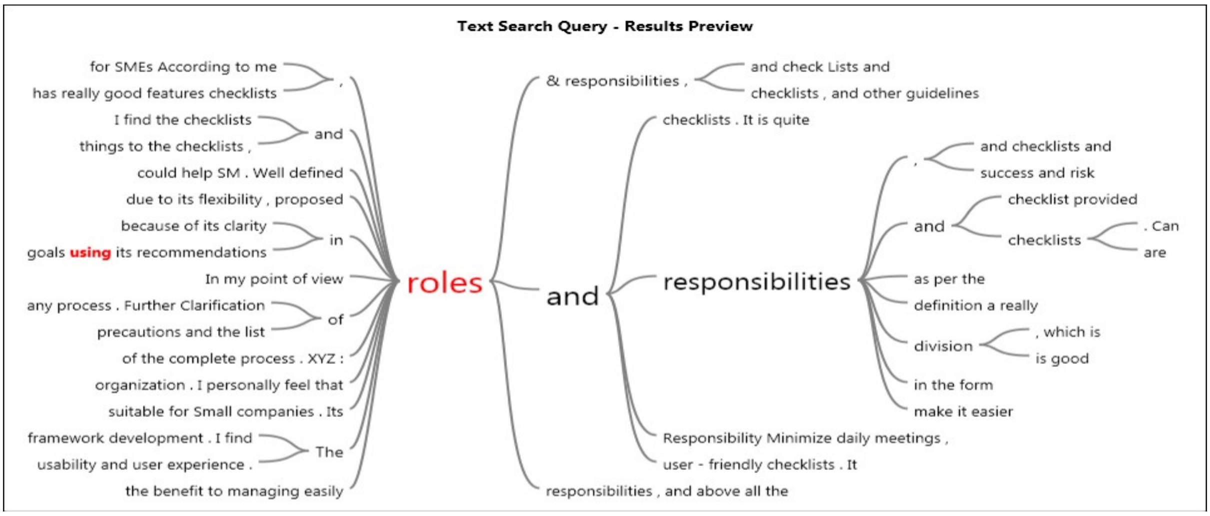
Appendix 8.7 SMF4SMEs' Impact on Software Development Goals

Question	Significant Improvement in		Improvement in		No change in		Deterioration of		Significant deterioration of		Total
Efficiency	50.0%	55	41.8%	46	8.2%	9	0.0%	0	0.0%	0	110
Scheduling	34.5%	38	54.5%	60	10.9%	12	0.0%	0	0.0%	0	110
Predictability	32.7%	36	47.3%	52	18.2%	20	1.8%	2	0.0%	0	110
Sustainability	36.4%	40	47.3%	52	16.4%	18	0.0%	0	0.0%	0	110
Process agility	28.2%	31	51.8%	57	16.4%	18	3.6%	4	0.0%	0	110
Product quality	39.1%	43	47.3%	52	9.1%	10	3.6%	4	0.9%	1	110
Results visibility	43.6%	48	42.7%	47	10.9%	12	1.8%	2	0.9%	1	110
Process Transparency	46.4%	51	41.8%	46	10.0%	11	0.9%	1	0.9%	1	110
Developer Productivity	40.9%	45	43.6%	48	10.9%	12	3.6%	4	0.9%	1	110

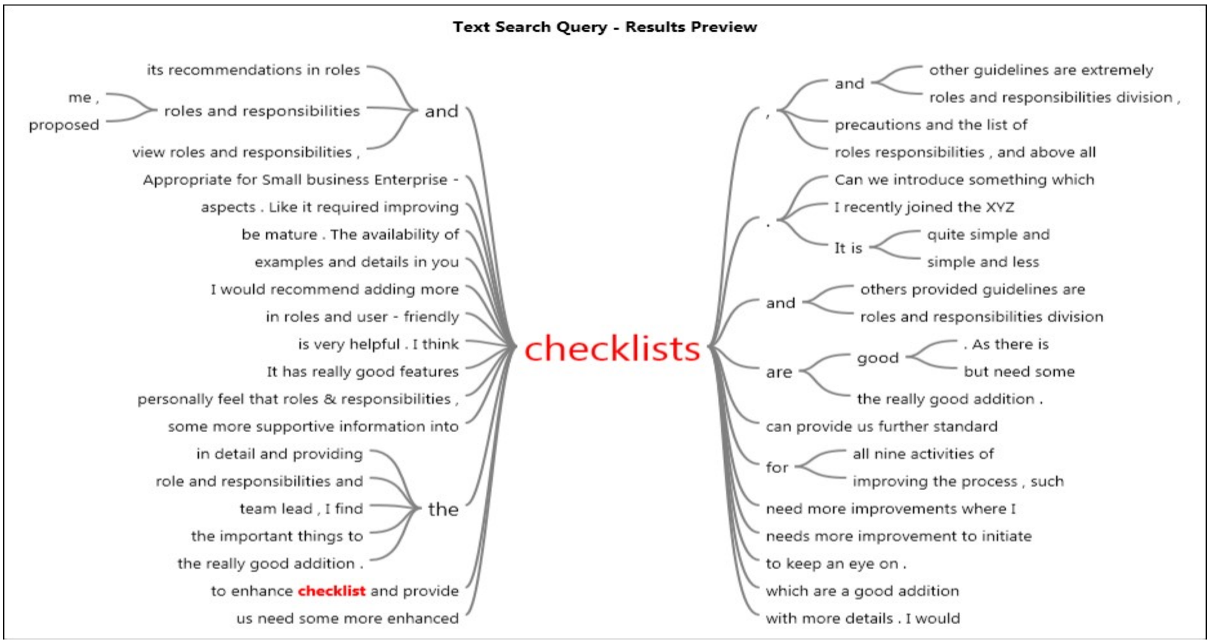
Appendix 8.8 SMF4SMEs help SMEs in

Question	Extremely well		Very well		Moderately well		Slightly well		Not well at all		Total
Stay on schedule?	40.0%	44	45.5%	50	10.0%	11	4.5%	5	0.0%	0	110
Increase productivity?	35.5%	39	45.5%	50	14.5%	16	4.5%	5	0.0%	0	110
Make correct estimate?	26.4%	29	43.6%	48	24.5%	27	3.6%	4	1.8%	2	110
Make good decisions?	30.0%	33	43.6%	48	19.1%	21	6.4%	7	0.9%	1	110
Improve product quality?	28.2%	31	47.3%	52	15.5%	17	7.3%	8	1.8%	2	110
Enhance process understanding?	26.4%	29	48.2%	53	20.0%	22	4.5%	5	0.9%	1	110

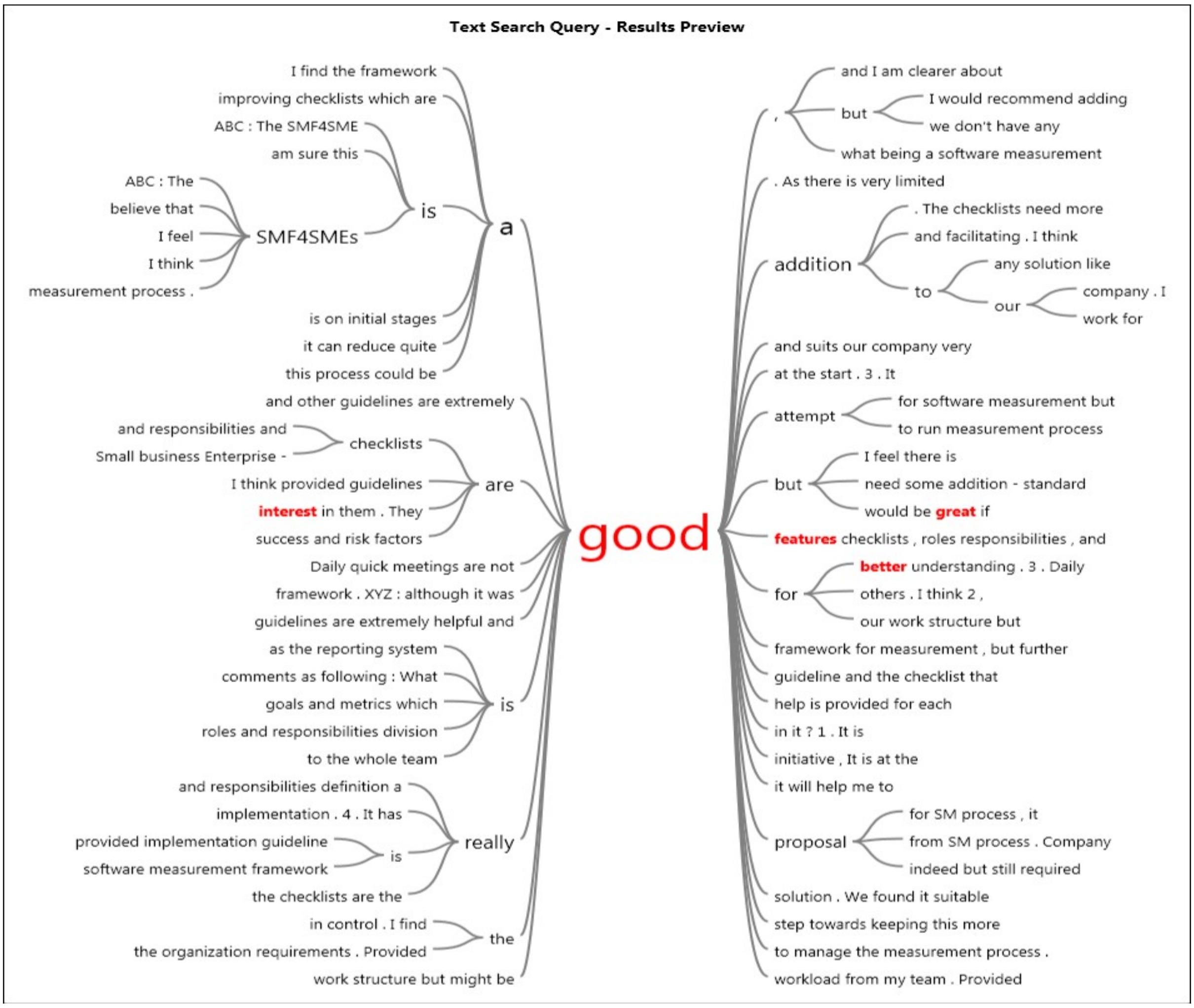
Appendix 8.9 Miscellaneous results (Word Trees, Graphs and Tables)



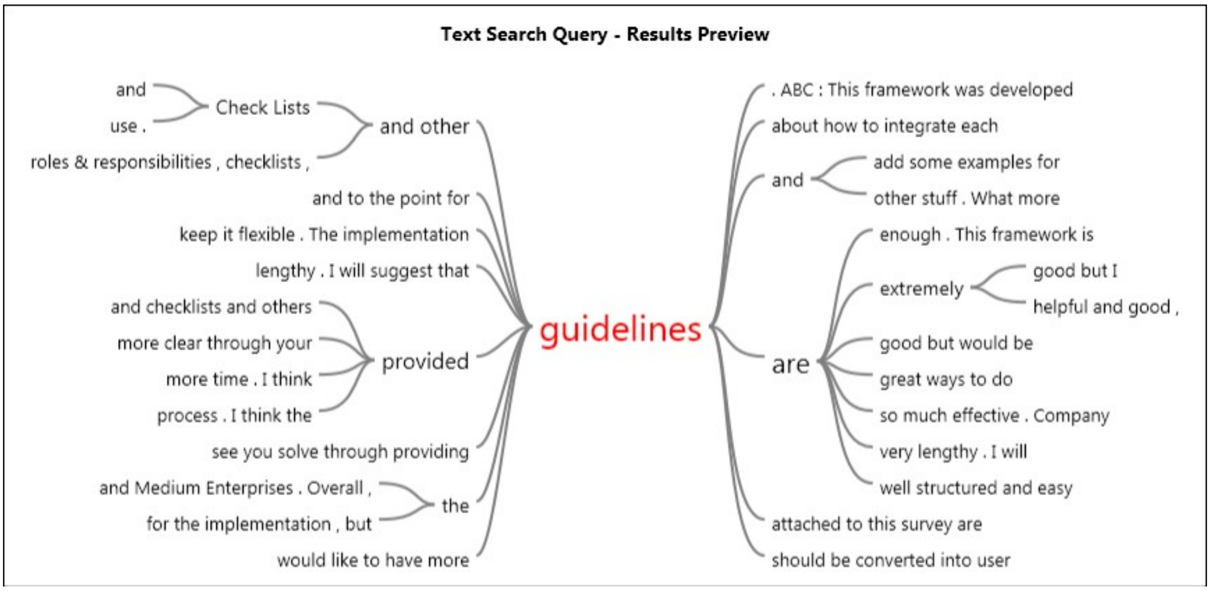
Excerpts for Roles and Responsibilities



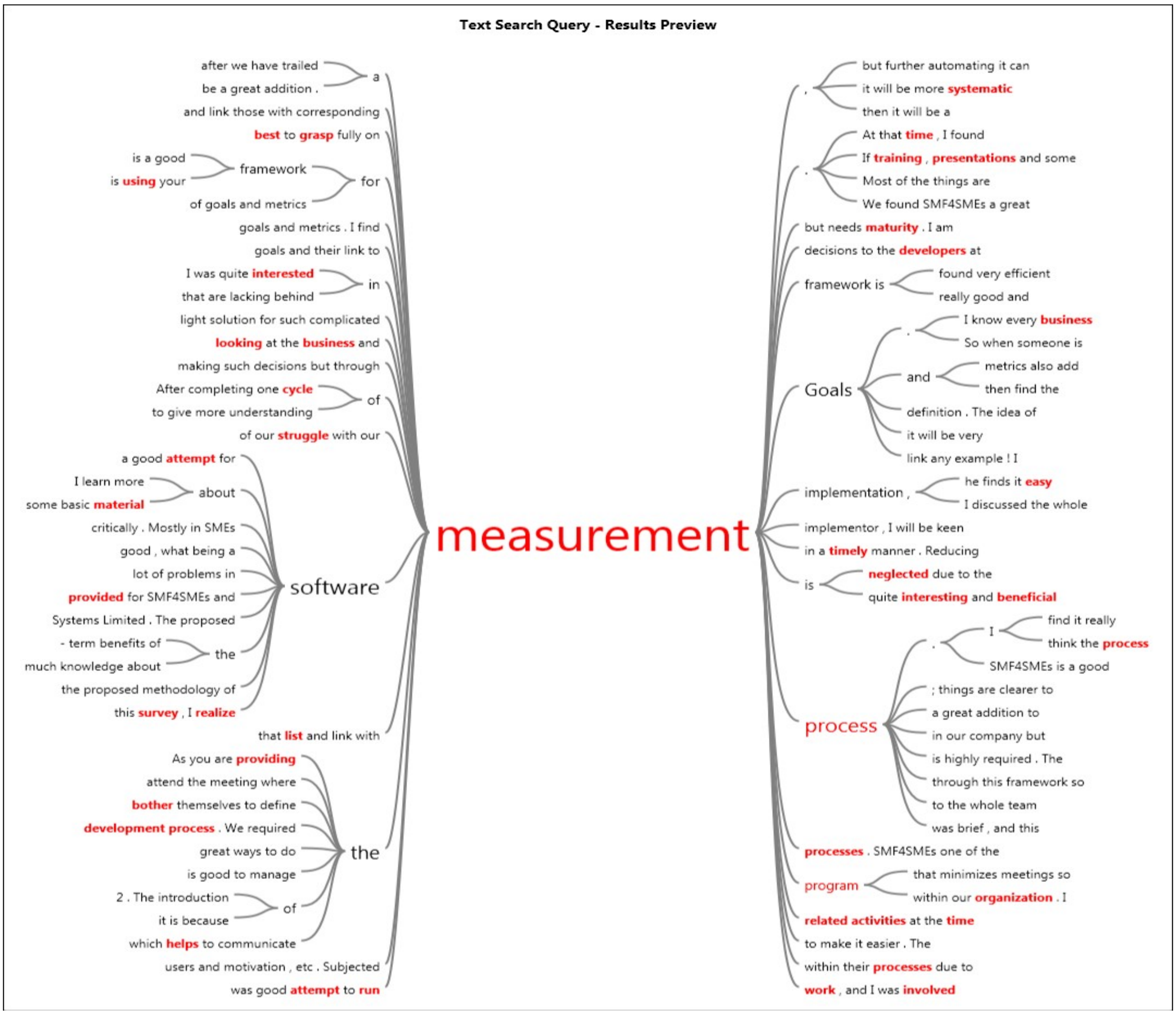
Excerpts for Checklists



Excerpts about effectiveness of SMF4SME

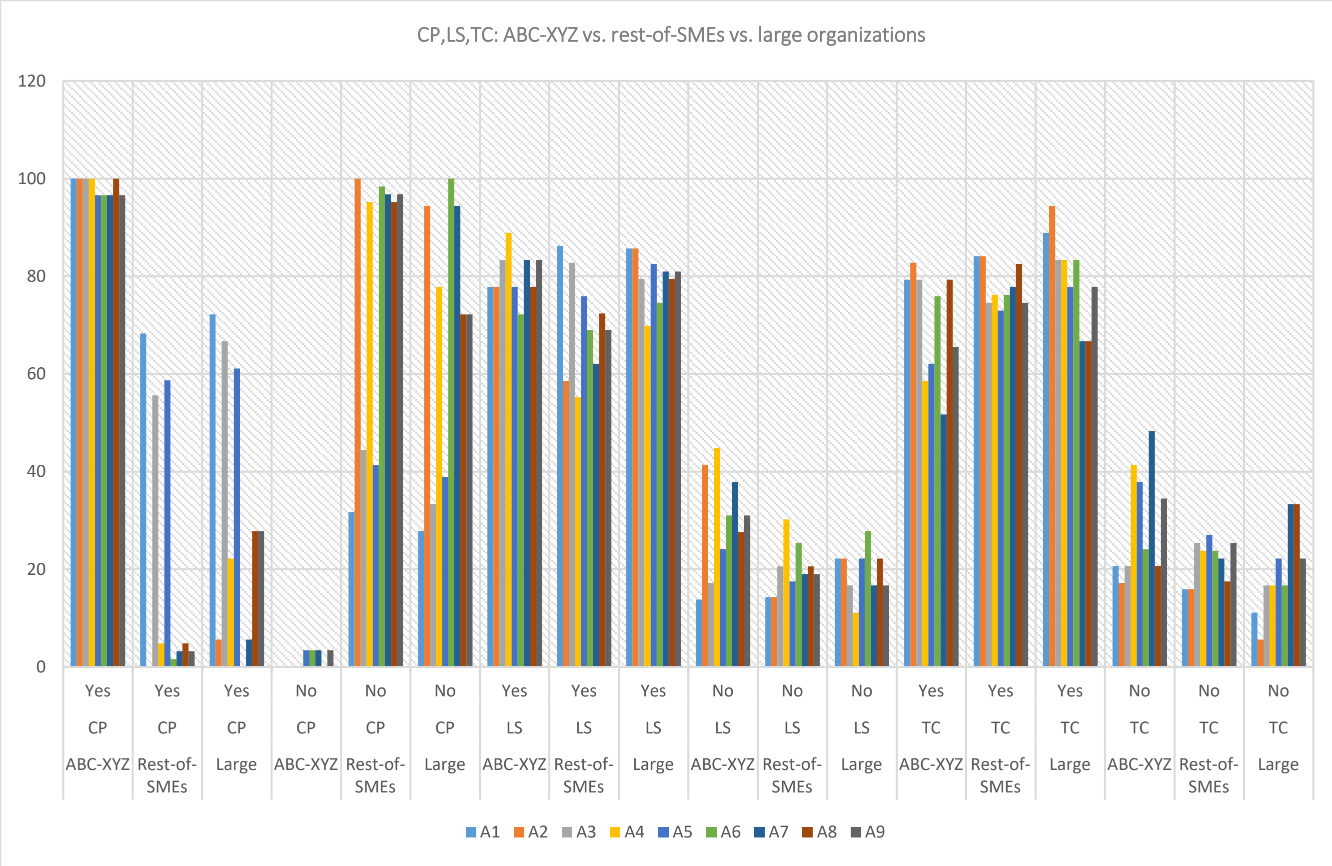


SMF4SME guidelines excerpts

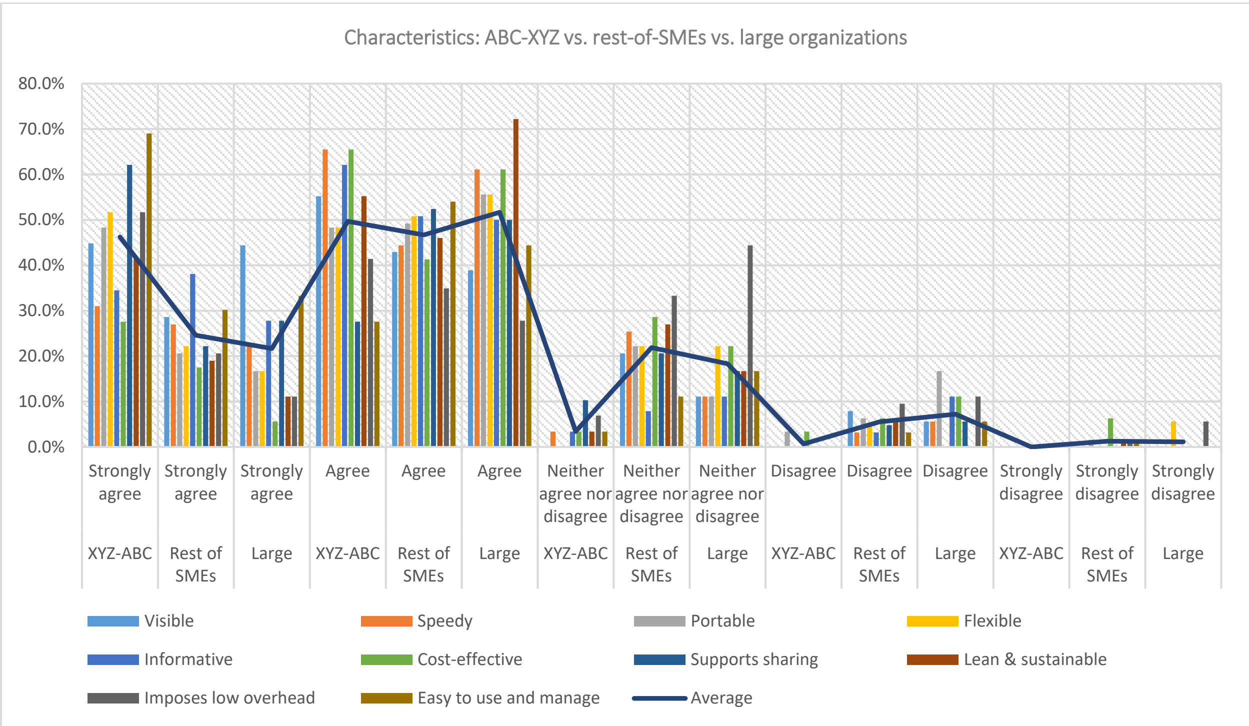


The excerpts about software measurement activities

Words cloud about most discussed topics



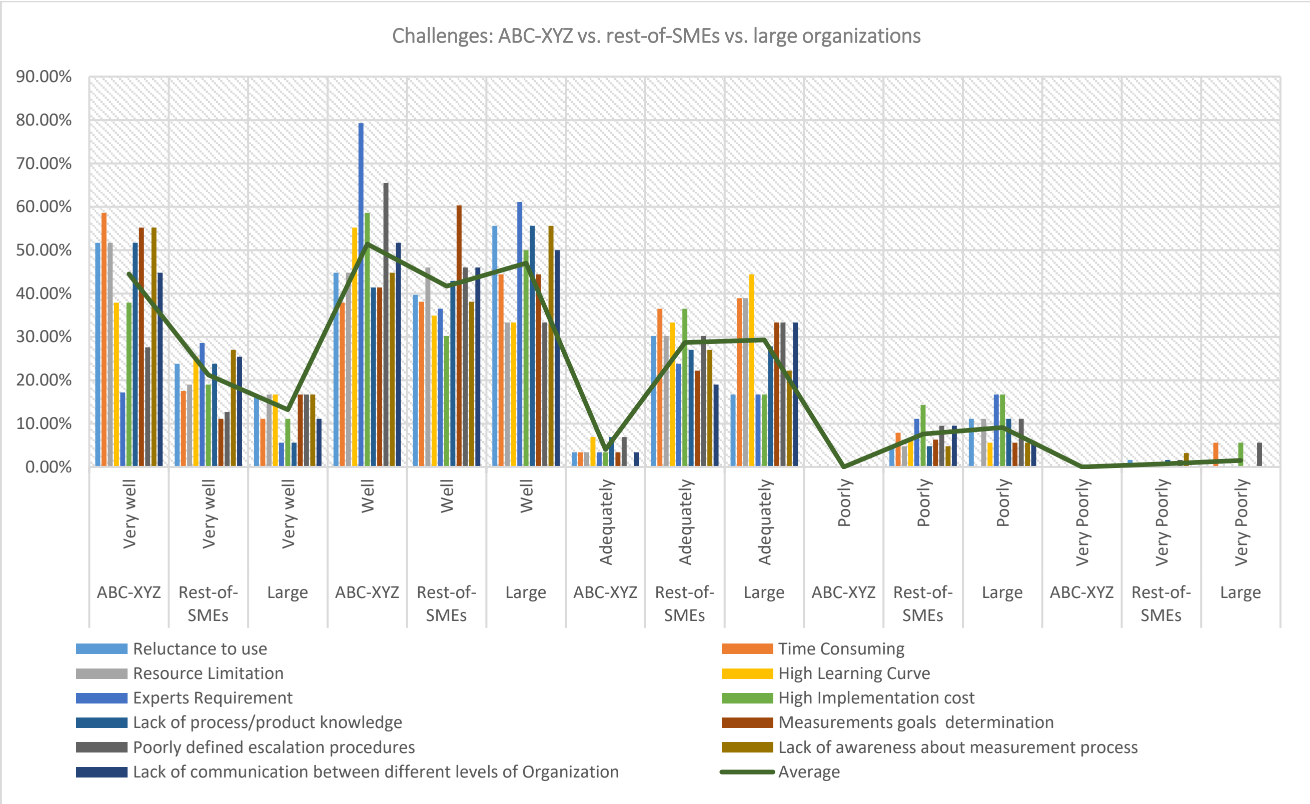
Responses upon ‘CP’, ‘LS’, and ‘TC’ by ABC-XYZ vs. rest-of-SMEs vs. large organizations’ participants



Responses to Characteristics by ABC-XYZ vs. rest-of-SMEs vs. large organizations’ participants

Average fulfilment of Challenges by SMF4SME w.r.t. to each type/size of organizations

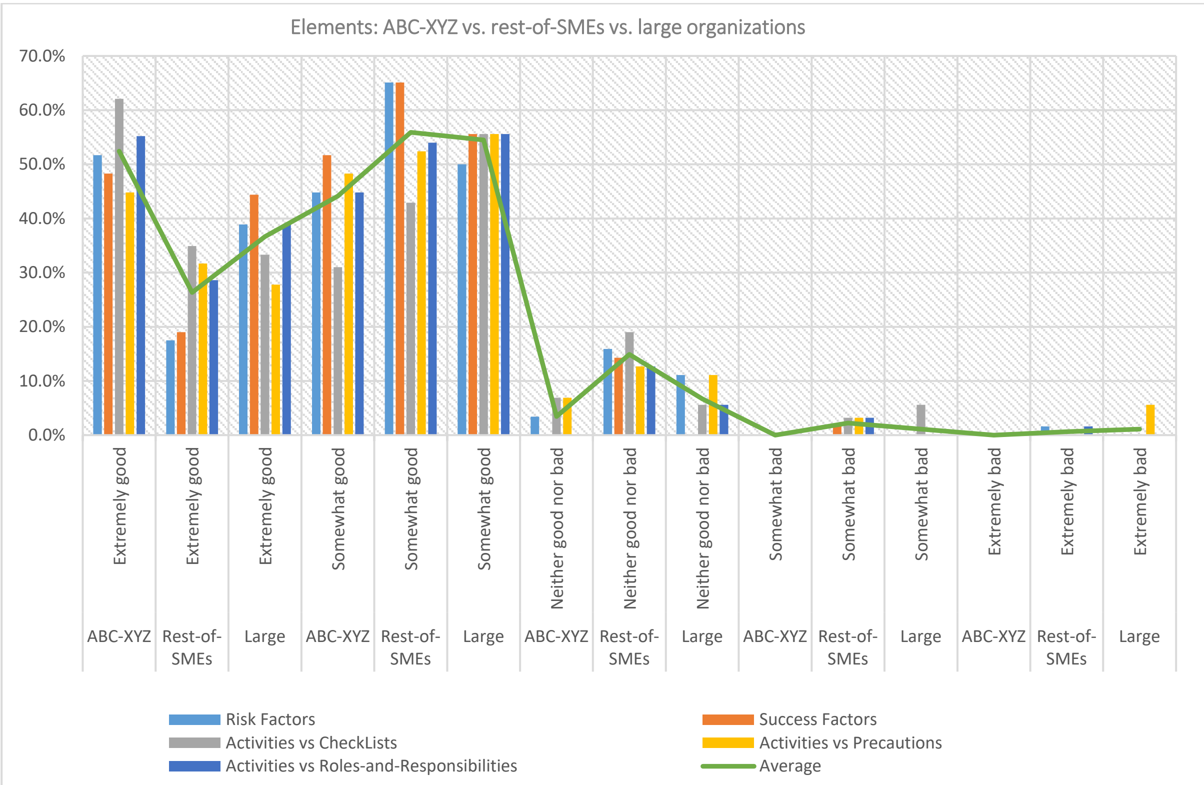
Organization Size	Scales	Average
XYZ-ABC	Strongly agree	46.20%
Rest of SMEs	Strongly agree	24.60%
Large	Strongly agree	21.70%
XYZ-ABC	Agree	49.70%
Rest of SMEs	Agree	46.70%
Large	Agree	51.70%
XYZ-ABC	Neither agree nor disagree	3.40%
Rest of SMEs	Neither agree nor disagree	21.90%
Large	Neither agree nor disagree	18.30%
XYZ-ABC	Disagree	0.70%
Rest of SMEs	Disagree	5.60%
Large	Disagree	7.20%
XYZ-ABC	Strongly disagree	0.00%
Rest of SMEs	Strongly disagree	1.30%
Large	Strongly disagree	1.10%



Responses to Challenges by ABC-XYZ vs. rest-of-SMEs vs. large organizations' participants

Average resolution of Challenges by SMF4SME w.r.t. to each type/size of organizations

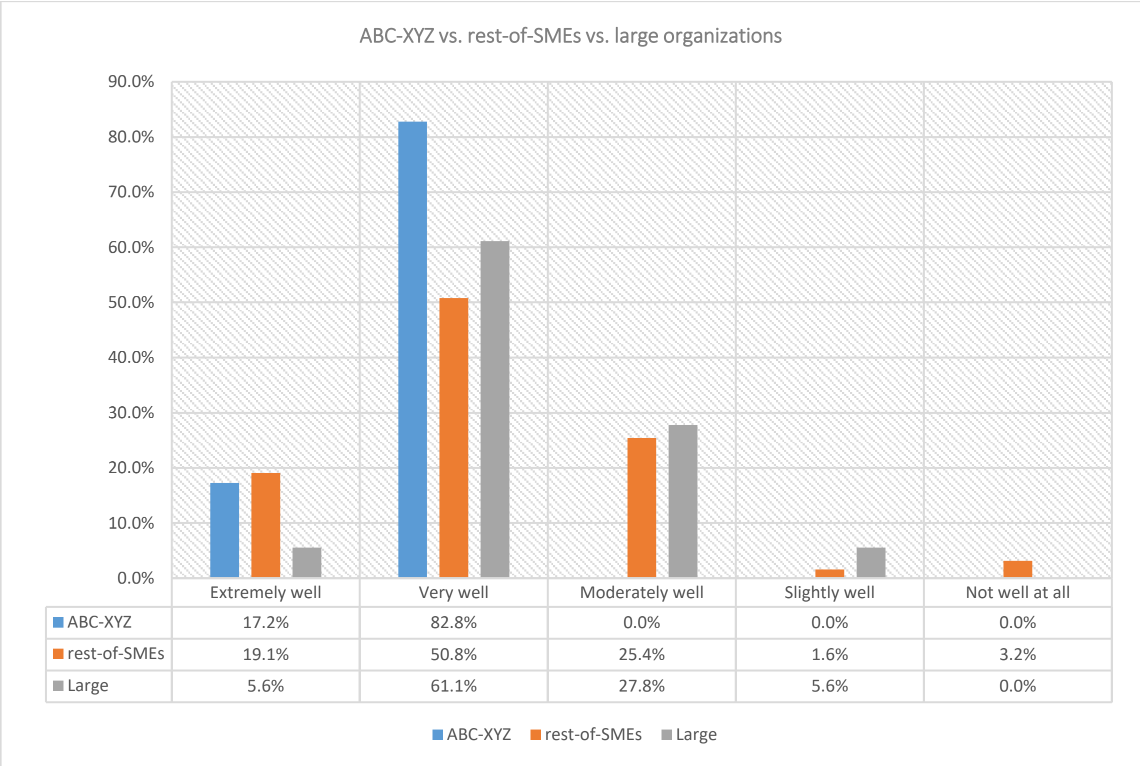
Organizations	Scales	Average
ABC-XYZ	Very well	44.50%
Rest of SMEs	Very well	21.20%
Large	Very well	13.20%
ABC-XYZ	Well	51.40%
Rest of SMEs	Well	41.70%
Large	Well	47.00%
ABC-XYZ	Adequately	4.00%
Rest of SMEs	Adequately	28.70%
Large	Adequately	29.30%
ABC-XYZ	Poorly	0.00%
Rest of SMEs	Poorly	7.60%
Large	Poorly	9.10%
ABC-XYZ	Very Poorly	0.00%
Rest of SMEs	Very Poorly	0.70%
Large	Very Poorly	1.50%



Responses to Elements by ABC-XYZ vs. rest-of-SMEs vs. large organizations' participants

Average acceptance of SMF4SME elements by to each type/size of organizations

Organizations	Scale	Average
ABC-XYZ	Extremely good	52.40%
Rest of SMEs	Extremely good	26.30%
Large	Extremely good	36.70%
ABC-XYZ	Somewhat good	44.10%
Rest of SMEs	Somewhat good	55.90%
Large	Somewhat good	54.50%
ABC-XYZ	Neither good nor bad	3.40%
Rest of SMEs	Neither good nor bad	14.90%
Large	Neither good nor bad	6.70%
ABC-XYZ	Somewhat bad	0.00%
Rest of SMEs	Somewhat bad	2.20%
Large	Somewhat bad	1.10%
ABC-XYZ	Extremely bad	0.00%
Rest of SMEs	Extremely bad	0.60%
Large	Extremely bad	1.10%



How well SMF4SME would be helpful for practitioners to SMPI

Top-management vs. Other-roles

SMF4SME Aspects	Top-management					Other-roles				
Characteristics	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Easy to use and manage	44.8%	41.4%	6.9%	3.4%	3.4%	39.5%	46.9%	11.1%	2.5%	0.0%
Speedy	27.6%	58.6%	10.3%	3.4%	0.0%	27.2%	50.6%	19.8%	2.5%	0.0%
Visible	37.9%	51.7%	10.3%	0.0%	0.0%	34.6%	43.2%	14.8%	7.4%	0.0%
Portable	20.7%	69.0%	3.4%	6.9%	0.0%	29.6%	43.2%	18.5%	7.4%	1.2%
Flexible	31.0%	51.7%	17.2%	0.0%	0.0%	28.4%	50.6%	16.0%	3.7%	1.2%
Informative	44.8%	51.7%	3.4%	0.0%	0.0%	32.1%	54.3%	8.6%	4.9%	0.0%
Cost-effective	24.1%	44.8%	20.7%	6.9%	3.4%	16.0%	53.1%	21.0%	6.2%	3.7%
Supports sharing	34.5%	48.3%	13.8%	3.4%	0.0%	33.3%	44.4%	18.5%	3.7%	0.0%
Lean & sustainable	34.5%	37.9%	17.2%	6.9%	3.4%	19.8%	58.0%	19.8%	2.5%	0.0%
Imposes low overhead	34.5%	20.7%	41.4%	3.4%	0.0%	24.7%	40.7%	23.5%	8.6%	2.5%
Average	33.4%	47.6%	14.5%	3.4%	1.0%	28.52%	48.50%	17.16%	4.94%	0.86%
Challenges	Very well	Well	Adequately	Poorly	Very Poorly	Very well	Well	Adequately	Poorly	Very Poorly
Reluctance to use	27.6%	44.8%	24.1%	3.4%	0.0%	30.9%	43.2%	19.8%	4.9%	1.2%
Time Consuming	13.8%	41.4%	34.5%	6.9%	3.4%	32.1%	38.3%	25.9%	3.7%	0.0%
Resource Limitation	31.0%	31.0%	27.6%	10.3%	0.0%	25.9%	48.1%	23.5%	2.5%	0.0%
High Learning Curve	20.7%	41.4%	31.0%	6.9%	0.0%	29.6%	39.5%	27.2%	3.7%	0.0%
Experts Requirement	20.7%	48.3%	13.8%	17.2%	0.0%	22.2%	53.1%	18.5%	6.2%	0.0%
High Implementation cost	24.1%	37.9%	20.7%	13.8%	3.4%	22.2%	42.0%	25.9%	9.9%	0.0%
Lack of process/product knowledge	6.9%	62.1%	24.1%	6.9%	0.0%	35.8%	38.3%	21.0%	3.7%	1.2%
Measurements goals determination	17.2%	62.1%	20.7%	0.0%	0.0%	25.9%	49.4%	18.5%	6.2%	0.0%
Poorly defined escalation procedures	13.8%	41.4%	34.5%	10.3%	0.0%	18.5%	51.9%	21.0%	6.2%	2.5%
Lack of awareness about measurement process	31.0%	44.8%	17.2%	6.9%	0.0%	33.3%	42.0%	19.8%	2.5%	2.5%
Lack of communication between different	20.7%	55.2%	20.7%	3.4%	0.0%	30.9%	45.7%	16.0%	7.4%	0.0%

levels of Organization										
Average	20.7%	46.4%	24.4%	7.8%	0.6%	27.9%	44.7%	21.6%	5.2%	0.7%
Elements	Extremely good	Somewhat good	Neither good nor bad	Somewhat bad	Extremely bad	Extremely good	Somewhat good	Neither good nor bad	Somewhat bad	Extremely bad
Risk Factors	31.0%	55.2%	13.8%	0.0%	0.0%	29.6%	58.0%	11.1%	0.0%	1.2%
Success Factors	41.4%	51.7%	6.9%	0.0%	0.0%	27.2%	63.0%	8.6%	1.2%	0.0%
Activities vs Check Lists	55.2%	31.0%	13.8%	0.0%	0.0%	37.0%	45.7%	13.6%	3.7%	0.0%
Activities vs Precautions	48.3%	44.8%	6.9%	0.0%	0.0%	29.6%	54.3%	12.3%	2.5%	1.2%
Activities vs Roles and Responsibilities	44.8%	48.3%	3.4%	3.4%	0.0%	34.6%	53.1%	9.9%	1.2%	1.2%
Average	44.1%	46.2%	9.0%	0.7%	0.0%	31.6%	54.8%	11.1%	1.7%	0.7%
How well SMF4SME would help	Percentage					Percentage				
Extremely well	17.2%					16.0%				
Very well	62.1%					60.5%				
Moderately well	17.2%					19.8%				
Slightly well	0.0%					2.5%				
Not well at all	3.4%					1.2%				

Response by participants having prior SMK

SMF4SME Aspect					
Characteristics	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Speedy	22.0%	61.0%	14.6%	2.4%	0.0%
Visible	43.9%	51.2%	2.4%	2.4%	0.0%
Portable	24.4%	56.1%	9.8%	9.8%	0.0%
Flexible	41.5%	46.3%	9.8%	2.4%	0.0%
Informative	31.7%	61.0%	4.9%	2.4%	0.0%
Cost-effective	17.1%	56.1%	17.1%	4.9%	4.9%
Supports sharing	36.6%	51.2%	12.2%	0.0%	0.0%
Lean & sustainable	26.8%	53.7%	17.1%	2.4%	0.0%
Imposes low overhead	41.5%	31.7%	24.4%	2.4%	0.0%
Easy to use and manage	53.7%	36.6%	7.3%	2.4%	0.0%
Average	33.92%	50.49%	11.96%	3.15%	0.49%
Challenges	Very well	Well	Adequately	Poorly	Very
Reluctance to use	39.0%	48.8%	12.2%	0.0%	0.0%
Time Consuming	26.8%	48.8%	22.0%	2.4%	0.0%
Resource Limitation	36.6%	46.3%	14.6%	2.5%	0.0%
High Learning Curve	34.1%	39.0%	24.4%	2.5%	0.0%
Experts Requirement	14.6%	65.9%	12.2%	7.3%	0.0%
High Implementation cost	22.0%	53.7%	14.6%	9.8%	0.0%
Lack of process/product	34.1%	53.7%	12.2%	0.0%	0.0%

Measurements goals	31.7%	53.7%	12.2%	2.4%	0.0%
Poorly defined escalation	14.6%	56.1%	22.0%	4.9%	2.4%
Lack of awareness about	41.5%	46.3%	7.3%	2.5%	2.4%
Lack of communication between different levels of	41.5%	43.9%	12.2%	2.4%	0.0%
Average	30.6%	50.6%	15.1%	3.3%	0.4%

Elements	Extremely good	Somewhat good	Neither good nor bad	Somewhat bad	Extremely bad
Risk Factors	34.1%	53.7%	12.2%	0.0%	0.0%
Success Factors	34.1%	61.0%	4.9%	0.0%	0.0%
Activities vs Check Lists	43.9%	48.8%	7.3%	0.0%	0.0%
Activities vs Precautions	41.5%	43.9%	14.6%	0.0%	0.0%
Activities vs Roles and	51.2%	41.5%	4.9%	2.4%	0.0%
Average	41.0%	49.8%	8.8%	0.5%	0.0%

How well SMF4SME help in	Percentage
Extremely well	19.5%
Very well	65.9%
Moderately well	14.6%
Slightly well	0.0%
Not well at all	0.0%

Response by participants having prior SMK with respect to their experience

				SMF4SME help in SMPI					
				Extremely well	Very well	Moderately well	Slightly well	Not well at all	Total
SMK	Yes	Experience	1-5 (Years)	6 20.70%	20 69.00%	3 10.30%	0 0.00%	0 0.00%	29 100.00%
			Senior (>6)	8 19.50%	27 65.90%	6 14.60%	0 0.00%	0 0.00%	41 100.00%
	No		1-5 (Years)	1 7.70%	4 30.80%	7 53.80%	1 7.70%	0 0.00%	13 100.00%
			Senior (>6)	3 11.10%	16 59.30%	5 18.50%	1 3.70%	2 7.40%	27 100.00%
			Total	18 16.40%	67 60.90%	21 19.10%	2 1.80%	2 1.80%	110 100.00%