REQUIREMENTS ENGINEERING PRACTICES MODEL FOR SOFTWARE DEVELOPMENT OUTSOURCING ISSUES

JAVED IQBAL

THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

FACULTY OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY
UNIVERSITY OF MALAYA
KUALA LUMPUR

2016

UNIVERSITI MALAYA

ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: Javed Iqbal

Registration/Matric No: WHA110021

Name of Degree: Doctor of Philosophy

Title of Project Paper/Research Report/Dissertation/Thesis ("this Work"): Thesis

Field of Study: Software Process Improvement

I do solemnly and sincerely declare that:

(1) I am the sole author/writer of this Work;
(2) This Work is original;
(3) Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;
(4) I do not have any actual knowledge nor ought I reasonably to know that the making of this work constitutes an infringement of any copyright work;
(5) I hereby assign all and every rights in the copyright to this Work to the University of Malaya ("UM"), who henceforth shall be owner of the copyright in this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;
(6) I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate's Signature Date:

Subscribed and solemnly declared before,

Witness's Signature Date:

Name: Rodina Binti Ahmad

Designation: Associate Professor

ABRTRACT

Software Development Outsourcing (SDO) has become a common practice due to its reported benefits like cost reduction, process improvement, and dealing with a lack of required skills. The trend for outsourcing the software development projects is growing day by day. However, a considerable proportion of such outsourcing projects fails to materialize the anticipated benefits. The reasons for the failure are often traced back to the Requirements Engineering (RE) process. This establishes the importance of the RE for SDO. The geographical dispersion of the stakeholders is the basic source of issues during the RE process for SDO. The delayed responses, unawareness from the effects of new system implementation, poorly defined requirements, and incomplete requirements are some of such important issues.

The primary focus of this research work is to develop and evaluate the sets of the best RE practices to address the frequently or commonly occurring issues of the SDO RE process. Therefore, issues of the RE process for SDO and relevant RE practices to address those issues have been identified from the literature. To incorporate the industrial perspective, SDO practitioners have been solicited for reporting the additional issues and relevant RE practices to address the issues. Then, frequently occurring issues have been extracted, ranked, the root causes for those issues have been identified, sets of the best RE practices have been recommended to address the corresponding issues and have been evaluated. The sets of the best RE practices are referred to as Requirements Engineering Practices (REP) Model.

To accomplish the research objectives, an extensive Systematic Literature Review has been performed and questionnaire-based surveys have been conducted with the SDO practitioners. The Delphi method has been employed to develop a consensus among the practitioners. By applying the Delphi method and the Cut-off value method, frequently

occurring issues have been filtered out and ranked. The Root Cause Analysis has been performed to discover the root causes for frequently occurring issues and for recommending the relevant RE practices to address those issues.

The REP Model is evaluated from: i) The academic point of view through the expert panel of 3 researchers and academicians, ii) The industrial perspective through 11 experienced SDO practitioners. Three criteria for evaluation from the academic point of view are: i) Completeness, ii) Practicality, and iii) Usefulness. The criterion for the industrial evaluation is 'usefulness of the recommended RE practice(s) to address the corresponding issue of the RE process for SDO in the case of the respective root cause'. The REP Model presents frequently occurring issues of the SDO RE process, provides the Category-wise and the Overall ranking of those issues, ranks the categories of the issues, specifies the root causes for those issues and hence maps the issues to the root causes and the relevant best RE practices to address the respective issues. Thus, the REP Model supports the RE process for SDO, and helps to avoid the adoption of random and ad-hoc RE practices for dealing with the common issues of this process.

ABSTRAK

Penyumber luaran pembangunan perirsian (SDO) telah menjadi amalan biasa disebabkan oleh faedahnya dari segi pengurangan kos, penambahbaikan proses, dan dapat menangani kekurangan kemahiran yang diperlukan. Kecenderungan untuk menyumber luarkan projek pembangunan perisian meningkat setiap hari. Walau bagaimanapun, sebahagian daripada projek penyumber luaran tersebut gagal untuk mencapai faedah yang diharapkan. Antara sebab kegagalan yang dikenalpasti adalah berpunca daripada proses keperluan kejuruteraan perisian (RE). Ini menunjukkan kepentingan RE untuk SDO. Penyebaran geografi pihak berkepentingan adalah sumber asas isu-isu semasa proses RE untuk SDO. Antara isu-isu penting ini termasuklah maklum balas yang lambat, ketidaksedaran daripada kesan pelaksanaan baru sistem, penafsiran keperluan yang lemah, dan keperluan yang tidak lengkap.

Fokus utama penyelidikan ini adalah untuk membangunkan dan menilai set amalan terbaik RE untuk menangani isu-isu yang kerap atau biasa berlaku dalam proses SDO RE. Oleh itu , isu-isu proses RE untuk SDO dan amalan RE yang berkaitan untuk menangani isu-isu tersebut telah diperolehi daripada kesusasteraan. Bagi memasukkan perspektif industri, pengamal SDO telah diminta untuk melaporkan isu-isu tambahan dan amalan RE yang relevan untuk menangani isu-isu. Kemudian, isu-isu yang sering berlaku telah diekstrak, dikelaskan, punca bagi isu-isu tersebut telah dikenalpasti, set amalan terbaik RE telah disyorkan untuk menangani isu-isu berkaitan dan telah dinilai. Set amalan terbaik RE dirujuk sebagai Model Keperluan Amalan Kejuruteraan (REP).

Untuk mencapai objektif kajian, kajian sastera sistematik mendalam telah dijalankan dan tinjauan berdasarkan soal selidik - telah dijalankan dengan pengamal SDO. Kaedah Delphi telah digunakan untuk membina kesepakatan di kalangan pengamal.

Dengan menggunakan kaedah Delphi dan kaedah nilai potong, isu-isu yang sering berlaku telah ditapis dan dikelaskan. Analisis penyebab punca telah dijalankan untuk mencari punca utama bagi isu-isu yang kerap berlaku dan untuk mengesyorkan amalan RE relevan untuk menangani isu-isu tersebut.

Model REP dinilai daripada: i) Sudut pandang ilmiah melalui panel pakar yang terdiri daripada 3 orang penyelidik dan ahli akademik, ii) Perspektif industri melalui 11 orang pengamal SDO yang berpengalaman. Tiga kriteria untuk penilaian dari sudut pandangan akademik adalah: i) Kesempurnaan, ii) Praktikal dan iii) Kebolehgunaan. Kriteria untuk penilaian industri adalah 'kebolehgunaan amalan RE yang disyorkan untuk menangani isu yang berkaitan dengan proses RE untuk SDO dalam kes punca masing-masing. Model REP membentangkan isu-isu proses SDO RE yang kerap berlaku, menyediakan Kategori-bijak dan kedudukan keseluruhan isu-isu tersebut, mengkelaskan kategori isu-isu, menyatakan punca bagi isu-isu tersebut dan dengan itu memetakan isu kepada punca dan amalan RE terbaik yang relevan untuk menangani isu-isu berkenaan. Oleh yang demikian, Model REP menyokong proses RE untuk SDO, dan membantu untuk mengelakkan penggunaan amalan RE rawak dan ad-hoc untuk berurusan dengan isu-isu yang biasa daripada proses ini.

ACKNOWLEDGEMENTS

First of all, I am humbly indebted to Allah Almighty for the supreme blessings with which the learning I under took in mission to seek knowledge. I would like to offer special appreciations to my supervisor Dr. Rodina Binti Ahmad for her invaluable guidance, supervision, sympathetic attitude and encouragement throughout this research work. Dr. Rodina Binti Ahmad not only provided helpful suggestions, but also magnificently fulfilled the responsibility to oversee this research, and guided me towards the efficacious completion of this thesis. She provided me the chance to expand my professional knowledge and prepared me for the future challenges.

I would like to express my gratitude to my family for their endless love and support during my entire life. The prayers and the nerve of my gracious parents in spite of their adverse physical condition and illness, the affection and sacrifice of my lovely wife, the endurance of Hassan and Abdullah in my absence, and the unconditional support of my sisters are my most precious assets. Without the moral patronage of my family, this dissertation would never have been completed. No words can express my real feelings, so I dedicate this achievement as a small gift to my family.

I am really thankful to Dr. Mahmood Niazi , Dr. Muhammad Asim Noor and Dr. Mohd Hairul Nizam Bin Md Nasir for their timely and continuing help, which can never be paid back. I would like to thank my colleagues at the Faculty of Computer Science & Information Technology especially Muhammad Ahsan Qureshi who provided much support and encouragement throughout this research process. I wish them all the best in their future undertakings. I am also grateful to all my friends for providing cooperation and assistance that enabled me to continue this long and fruitful journey.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

APPENDIX A: QUESTIONNAIRE

CHAPTER 1: INTRODUCTION

This chapter introduces the research work by summarizing the background, problem statement, research objectives, research methodology, scope and the significance of this research. The organization of this thesis is also provided.

1.1 Background

Information Technology (IT) market is changing and growing at a fast pace. The demand for developing new, complex and special purpose software for the specific markets, various types of businesses, governmental or private organizations and domestic usage is increasing day by day. Owing to the tremendous growth in size of the IT market and the complications involved, many challenges have risen on the IT horizon and the IT industry is looking for new avenues worldwide to satisfy the versatile, changing and large-scale needs of the clients. This phenomenon has paved the way to Information Technology Outsourcing (ITO).

ITO is the process of transferring some or all of the IT related activities to an external service provider or vendor who performs these activities according to the agreed upon contract (Dhar & Balakrishnan, 2006). The volume of IT outsourcing is increasing day by day. As per a 2012 report published by the USA based IT research company 'Gartner', international ITO revenue has increased from $228.7 billion (2010) to $246.6 billion (2011) in a span of one year, with a growth of 7.8% ("Market share analysis: IT outsourcing services, worldwide, 2011," 2012). However, it reached $288 billion in 2013 ("Market share analysis: IT outsourcing services, worldwide, 2013," 2013) and touched $3.8 trillion in 2014 ("Market share analysis: IT outsourcing services, worldwide," 2014), which was a big leap.

Software Development Outsourcing (SDO) is a type of ITO in which some or all activities of the software development are contracted out by a client to the vendor(s) (Babar, Verner, & Nguyen, 2007; S. U. Khan, Niazi, & Ahmad, 2011). The idea of SDO is becoming prevalent rapidly (Islam, 2009). It creates a state which is a win-win situation for both the developed and developing countries (Perera, 2011). European firms are outsourcing the software development projects to India, Russia and China (Niazi, El-Attar, Usma, & Ikram, 2012). Outsourcing drivers can be divided into the two main categories (Bush, Tiwana, & Tsuji, 2008; Holmström, Ågerfalk, & Fitzgerald, 2006; Ishenko, 2005): i) Outsourcing provides advantages such as cost reduction, utilizing better capabilities, access to state of the art technologies, reduction in completion time and time required to market, process improvement, innovation, mitigation of risks and the optimal use of internal resources, ii) Organizations have many limitations such as improper management, incompetent staff and scarcity of the resources. The vendor side is also benefited from the SDO as vendors enhance their expertise and services, and also learn how to fulfill the needs of clients (S. U. Khan, Niazi, & Ahmad, 2009). It is also acknowledged that by gaining the experience of dealing with the outsourced projects, vendors can add substantial value to clients' supply chains (Shao & David, 2007).

SDO is performed in many different forms that can be summed up in four scenarios (Gibbs, 2006; Iqbal, Ahmad, Nizam, Nasir, & Noor, 2013):

i) When a contractor provides services at the location of the outsourcing organization.

ii) In case of Onshoring or Domestic Outsourcing, services are not provided at the outsourcing location but the contractor operates from the same country (Kehal, 2006; Oshri, Kotlarsky, & Willcocks, 2015).

iii) Contractor provides services from another country (Oshri, et al., 2015):

If services are provided from the same region or nearby country, it is called Nearshoring (Kehal, 2006). If a vendor supplies services from a far off country, it is called Offshoring (Kehal, 2006).

iv) When multiple contractors or vendors are involved:

When stakeholders are geographically dispersed, it is called Distributed Software Development (DSD) (Layman, Williams, Damian, & Bures, 2006; Rafael Prikladnicki, Audy, Damian, & De Oliveira, 2007). When distances among the stakeholders become global, it is called Global Software Development (GSD) (Layman, et al., 2006; Lopes, Prikladnicki, Audy, & Majdenbaum, 2005; Rafael Prikladnicki, et al., 2007).

These various scenarios exhibit that stakeholders are physically distributed in most of the cases of SDO. This dispersion affects the Requirements Engineering (RE) process for SDO and introduces many challenges for it (D. E. Damian & Zowghi, 2003b; Lopes, et al., 2005).

RE is the most important phase of the software development life cycle (Bhat, Gupta, & Murthy, 2006; Edwards & Sridhar, 2005). The success of a project depends on the success of the RE process (Bhat, et al., 2006). A good RE process contributes to reduce the development cost and time, and improves the software quality (Sadraei, Aurum, Beydoun, & Paech, 2007). The RE process is a multifaceted and complex course of technical activities that is aimed at producing requirements for software intensive systems (Azadegan, Cheng, Niederman, & Yin, 2013). A comprehensively performed RE process serves as a backbone for the successful projects (Khalid, ul Haq, & Khan, 2013). RE consists of all the activities that are required to discover, document and maintain the requirements to be fulfilled by a computer-based system (Nuseibeh & Easterbrook, 2000; Sommerville & Kotonya, 1998; Sommerville & Sawyer, 1997).

According to IEEE definition (Radatz, Geraci, & Katki, 1990) a 'Requirement' is:

1. A condition or capability needed by a user to solve a problem or achieve an objective.
2. A condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed document.
3. A documented representation of a condition or capability as in definition 1 or 2.

There is no standard RE process that is fit for all the organizations (Belsis, Koutoumanos, & Sgouropoulou, 2014). This process varies depending on the type of system to be developed, the culture of the organization and expertise of the practitioners that are involved in the RE process (R Prikladnicki, Evaristo, Gallagher, Lopes, & Audy, 2005; Sommerville & Kotonya, 1998). According to Paetsch et al. (2003) and Prikladnicki et al. (2005) RE activities include:

i) Requirement Elicitation.
ii) Requirement Analysis and Negotiation.
iii) Requirements Documentation.
iv) Requirements Validation.
v) Requirements Management.

According to Sommerville and Sawyer (1997), and Lopes et al. (2004) there are following six activities for the RE process:

i) Requirements Elicitation.
ii) Requirements Analysis and negotiations.
iii) Describing requirements.
iv) System Modeling.
v) Requirements Validation.

vi) Requirements Management.

Figure 1.1 shows common inputs and output of the RE process (Sommerville & Kotonya, 1998):

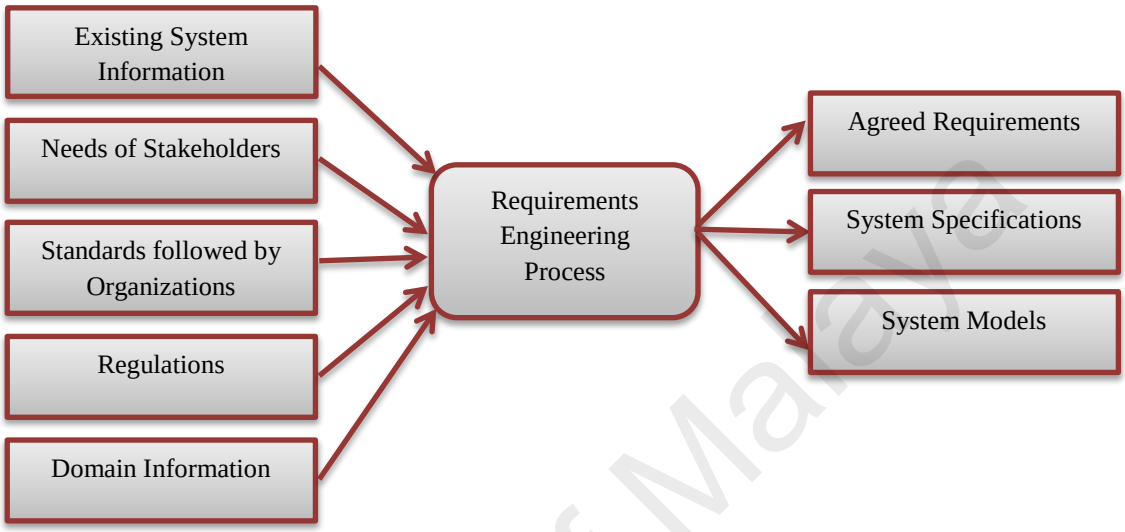

Figure 1.1: Inputs and outputs of the Requirements Engineering process

The studies show that RE errors are the most frequent in the software development life cycle (Sadraei, et al., 2007). A study, of the RE problems confronted by 12 software development companies, shows that out of 268 reported software development problems, 48% (128) are RE problems (Sommerville & Ransom, 2005). These problems are amplified, and new ones are also introduced when projects are outsourced for software development (Bhat, et al., 2006; Hanisch & Corbitt, 2004; Lopes, et al., 2005) as stakeholders are physically disseminated, face communication problems, belong to various social and cultural backgrounds, have temporal distances, utilize diverse development practices and tools, and are not at the same level of the technical knowledge. There are many valuable studies on the RE issues in the case of SDO. Based on case studies' experiences Bhat et al. (2006) have described the RE challenges in the case of outsourced offshore software development and also have presented a framework for the solution of the challenges. According to Damian (2007), stakeholders should acquire and

share the relevant knowledge, and should also build a relationship to overcome the global RE challenges caused by cultural, organizational and time zone differences. Another study focuses on the SDO scenario when there are multiple software development sites and describes the RE challenges that arise because of the lack of communication, inappropriate knowledge management, cultural diversities and time zone differences (D. E. Damian & Zowghi, 2003b). Edwards and Sridhar (2005) explore that trust and planned task allocation have a positive influence on the efficiency and satisfaction of global virtual teams dealing with the RE process. According to Lopes et al. (2005), the RE process for DSD is affected by communication, culture, technical and knowledge management issues. Prikladnicki et al. (2007) describe the RE and other challenges for the offshore and onshore SDO. Another study formulates the factors, which can generate risks during the RE process for GSD, into 8 categories which are communication and distance, cultural and organizational differences, knowledge management and awareness, management, tools and technologies, stakeholders, project and process, and requirements (H. H. Khan, Naz'ri bin Mahrin, & bt Chuprat, 2014). According to Lopez et al. (2009), the 7 categories of risks for the RE process in GSD are: communication and distance, knowledge management and awareness, cultural differences, management and project coordination, tools which support the processes, client, and miscellany. Aranda et al. (2010) have proposed a framework for improving the communication during the requirements elicitation in the case of GSD. A subsequent study (A. A. Khan, Basri, & Dominic, 2012) introduces a framework for the requirements change management in the GSD whereas another framework to deal with the requirements change management in the GSD is presented in (Minhas & Zulfiqar, 2014). Furthermore, Niazi et al. (2012) have proposed a framework GlobReq, to improve the RE process for GSD.

In brief, RE is a difficult and complex process for co-located software development projects as requirements elicitation, analysis and negotiations, description, modeling, validation and management phases involve many problems (D. E. Damian & Zowghi, 2003b; Sommerville & Sawyer, 1997; Walia & Carver, 2009). The same is true for the distributed projects as most of the software development problems in such scenarios occur because of shortcomings in the RE process (Šmite, 2006). The distance among the stakeholders, various cultural backgrounds and time zone differences introduce new issues during the RE process for SDO and differentiate it from the traditional RE process.

1.2 Statement of the problem

Software development projects are outsourced keeping in view anticipated benefits, however, many risks are involved in this process (S. U. Khan, et al., 2009). The failure rate of SDO projects is high as 40% of offshore projects did not manage to achieve the expected benefits (Meyer, 2005) and half of the companies that tried GSD failed to attain the anticipated results (Iqbal, et al., 2013; Niazi, et al., 2012). Industry surveys show that although SDO is becoming popular, but only half of the software development outsourcing projects are successful (Gefen, Wyss, & Lichtenstein, 2008). The studies show that RE related problems are one of the basic reasons for the failure of SDO projects as most of the factors contributing to such failures are related to the requirements (Lopes, et al., 2005; Niazi, et al., 2012; Šmite, 2006). According to Verner and Abdullah (2012), the requirements cause the outsourced software development project to fail. Meeting clients' requirements is a challenge in the case of offshore software development outsourcing (Kannabiran & Sankaran, 2011). Compromising on the quality of requirements can cause project failure (Mikulovic & Heiss, 2006). The requirements

errors are common for the offshore outsourced software development projects (Islam, 2009). RE problems are the main reasons for the inefficient and failed software projects (Sadraei, et al., 2007). This is not surprising as RE is the most critical phase of the software development life cycle that affects the other software development activities significantly (Edwards & Sridhar, 2005; Sommerville & Ransom, 2005). The reason behind this fact is that errors which are left uncorrected during the RE phase often cascade into other phases. According to a study, planning and control issues are the result of poor requirements definition (Verner & Abdullah, 2012). Previous research also shows that the removal of a RE error at the later stages of the software development life cycle could be up to 100 times more expensive than removing a coding error (Sommerville & Kotonya, 1998). Thus a well-defined RE process is essential for the success of the outsourced software development projects in terms of cost, time and quality (Edwards & Sridhar, 2005).

There are evidences that the RE problems have adverse effects on the success of software development projects (Sommerville & Ransom, 2005; T. Hall, 2002). For the software development outsourced projects, where stakeholders are dispersed at different locations, the RE problems become more complex (Bhat, et al., 2006; D. E. Damian & Zowghi, 2003b; Lopes, et al., 2005). The lack of communication or improper communication, inappropriate knowledge management, cultural diversities, differences about tools and technologies, different working hours and rare head to head meetings are some of the reasons that cause and augment the issues of the RE process in case of SDO (D. E. Damian & Zowghi, 2003b; Iqbal, et al., 2013; Lopes, et al., 2005). Delayed responses, unawareness from the effects of new system implementation, difficulties in achieving consensus on requirements, lack of participation in RE process, use of dissimilar processes and incomplete requirements are some of such issues.

The traditional RE process is somehow unable to deal with the difficulties of the RE process caused by the dispersion among the stakeholders of SDO (Lopes, et al., 2005). Also, the software industry's globalization demands for an investigation of the RE process when stakeholders are distributed at multiple sites (D. E. Damian & Zowghi, 2003b). To the best of knowledge, there is no such model in the existing literature that covers all aspects of complex and multifaceted nature of the SDO RE process and recommends the practices to address the commonly or frequently occurring issues of the RE process for SDO. Therefore, to acquire the anticipated benefits of SDO, the frequently occurring issues of the RE process for SDO need to be addressed. For this purpose, this research work intends to propose a literature and empirically-based model, called the Requirements Engineering Practices (REP) Model, for addressing the frequently occurring issues of the RE process for SDO. In this context, three research objectives and nine associated research questions have been defined to achieve the aim.

1.3 Research objectives and questions

This research work is intended to develop a model in order to address the frequently occurring issues of the RE process in case of SDO. The research objectives and the related Research Questions (RQs) to guide the research work are:

Research Objective 1: To identify the literature-based issues of the RE process for SDO and to identify the relevant literature-based RE practices to address those issues.

To attend this objective, the first goal is to identify the RE process issues for SDO which have been pointed out in the literature. Therefore, the first research question is:

RQ1: Which are the literature-based issues of the RE process for SDO?

RQ1.1: Which are the categories of the issues of RE process for SDO?

RQ1 has been answered through a Systematic Literature Review whereas RQ1.1 has been answered through a questionnaire survey with SDO practitioners to find the categories of the issues of RE process for SDO.

After identifying the RE process issues for SDO from the literature and finding the categories of such issues, the next target is to identify which are the literature-based RE practices that can be used to address those issues. So the second research question is:

RQ2: Which are the literature-based RE practices to address the literature-based issues of the RE process for SDO?

RQ2 has been answered through the Systematic Literature Review.

A sufficient number of RE practices have been proposed by Sommerville and Sawyer for addressing the issues of the traditional RE process (Sommerville & Sawyer, 1997). Keeping in view the objectives of this research work, this is important to investigate empirically how significant these RE practices are for the SDO RE process. The research question to address this matter is as follows:

RQ3: Which of the RE practices recommended by Sommerville and Sawyer (1997) are significant to address the issues of the RE process for SDO?

RQ3 has been answered through a questionnaire survey with SDO industry practitioners.

This is equally important to investigate the SDO practitioners' take on the RE issues and the practices to address those issues. Therefore, the next objective of the research work is to find out the RE issues that SDO practitioners encounter and the practices they use to address those issues. This establishes the second research objective:

Research Objective 2: To identify the additional issues, other than those reported in the literature, of the RE process for SDO and identify the relevant RE practices to address those identified issues.

To address this objective, the first step is to identify the RE issues that SDO practitioners face while working on the outsourcing projects, as defined in the following research question:

RQ4: Which are the SDO RE process issues, other than those reported in the literature, faced by SDO practitioners?

The second step to meet objective 2 is to identify the RE practices adopted by SDO practitioners to address the RE issues they face. This helps to define the next research question as:

RQ5: Which are the RE practices adopted by SDO practitioners to address the RE process issues they face?

RQ4 and RQ5 have been answered through a questionnaire survey with the SDO practitioners.

Having identified the SDO RE process issues and the practices to address those issues, from the literature and the SDO industry, the formation of the REP Model can be initiated. This helps to define the third objective of the research:

Research Objective 3: To propose and evaluate the REP Model for addressing the issues of RE process for SDO.

To achieve this objective, intention is to rationalize and structure the results obtained by answering the research questions 1 to 5. To propose a workable model, this is imperative to identify those issues that occur frequently during the RE process for SDO. So the next research question is:

RQ6: Which are the frequently occurring issues of the RE process for SDO?

RQ6 has been answered by conducting a questionnaire survey with the SDO practitioners and by employing the Delphi method. The Cut-off value method is employed to extract the frequently occurring issues of the RE process for SDO.

The second important step for the formation of an applicable model is to rank the frequently occurring SDO RE process issues and to rank the categories of those issues. This leads to another research question.

RQ7: What is the ranking of each:

i) Frequently occurring issue of the RE process for SDO within the respective category of the issue (Category-wise ranking) and with respect to all the categories (Overall ranking)?

ii) Category of the issues of RE process for SDO?

Frequently occurring issues and their categories have been ranked based on the means of response values obtained through the Delphi method. The Top 10 issues have also been identified.

Having identified and ranked the frequently occurring issues of the RE process for SDO, the causes of those issues must be explored, and also the relevant RE practices must be recommended and mapped to corresponding issues to address those issues. Thus, the next research question for the formation of the model is:

RQ8: Which are the root causes for the frequently occurring issues of the RE process for SDO, and which are the relevant RE practices to address those issues?

The Root Cause Analysis (RCA) has been performed to find the root causes for the frequently occurring issues of the SDO RE process, and to recommend the relevant practices to the corresponding issues to address those issues.

After formation, a model needs to be evaluated. So the next target is to evaluate the REP Model to check its effectiveness for the researchers, academicians and SDO industry practitioners. This target leads to the last research question of this research work.

RQ9: How to evaluate the proposed REP Model?

The proposed REP model has been evaluated in two ways. First, from the academics point of view through the expert panel of academicians and researchers, and second, from the industrial perspective by employing experienced practitioners from SDO industry.

1.4 Research methodology

Keeping in view the objectives of the research, the constructive research approach has been employed. Applying this methodology, a practical or theoretical artifact or an artifact of both types is developed for finding a solution to the problem (Crnkovic, 2010). This approach supports the production of knowledge through industry practitioners and researcher collaboration (Oyegoke, 2011). The results produced through the constructive research approach have practical as well as theoretical applications (Sommerville & Ransom, 2005). Figure 1.2 shows different stages of the research**:**

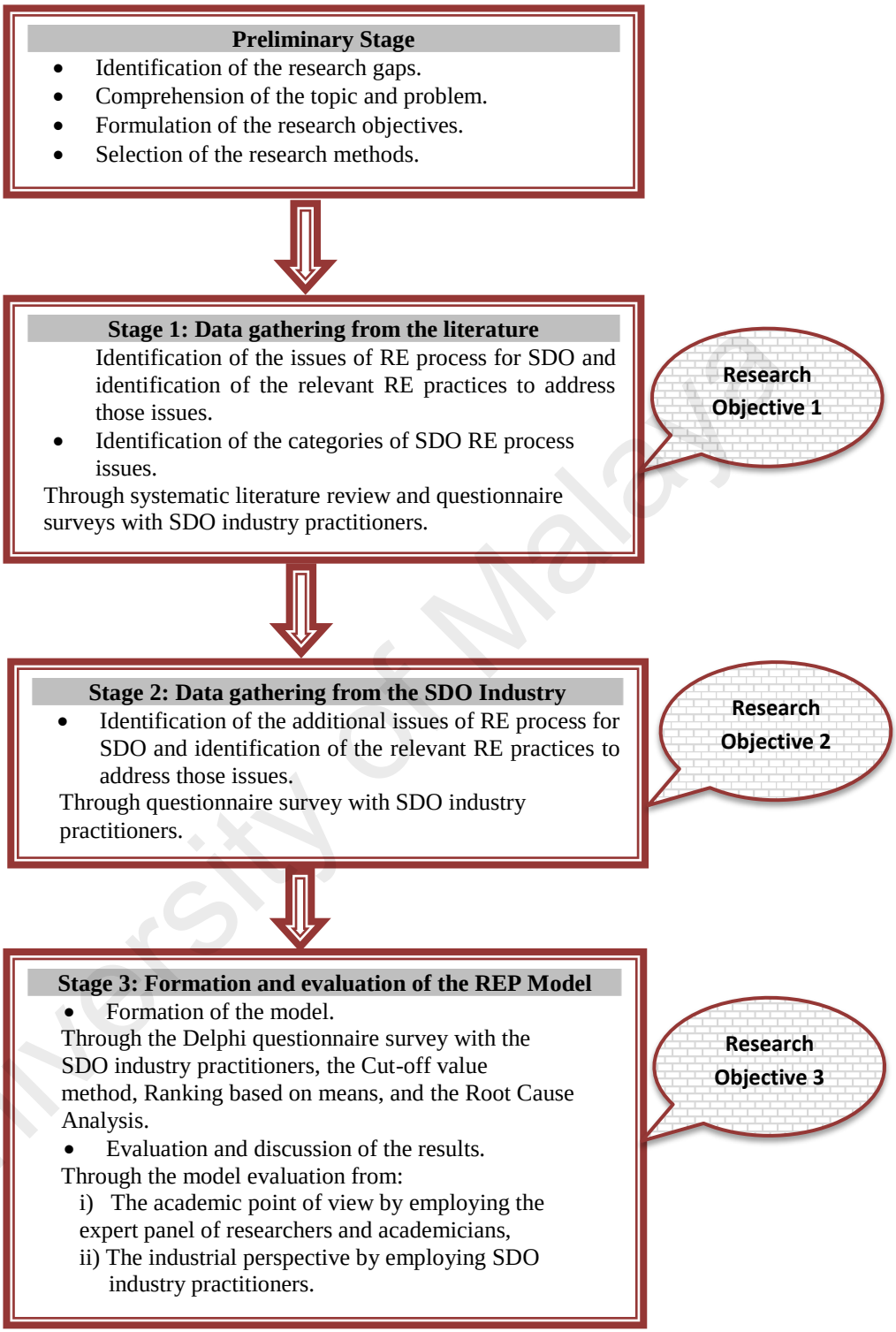

Figure 1.2: Research stages

1.5 Scope of research

This research work covers:

i) The RE process issues in the case of SDO. It does not deal with the RE process issues for insourcing that is very close to outsourcing in some scenarios. For example, a multinational company can send development work to its own overseas office, although development work has been sent to an overseas country but this is not the case of Offshore SDO. This work in not intended for such scenarios.

ii) The SDO RE process scenarios when stakeholders are located at different places.

iii) Seven categories of the SDO RE process issues that are Communication, Knowledge management and awareness, Cultural diversities, Management and coordination, Processes and tools, Relationship among stakeholders and Requirements centric.

1.6 Significance of research

This research work has implications for researchers as well as for practitioners. The proposed model not only assists the SDO industry practitioners to avoid from adopting inappropriate RE practices in the case of SDO but also provides hands-on recommendations to address the common issues of the RE process for SDO. Thus, the model leads to such SDO RE process that contributes to the successful completion of SDO projects in terms of schedule, cost and quality. The model also increases the likelihood of materializing the anticipated benefits of SDO by addressing common issues of the SDO RE process as a considerable number of SDO projects failures stem from the RE issues. On the other hand, the proposed model extends knowledge in SDO, enables researchers to conduct further studies and to support or enhance the findings with more empirical data.

1.7 Organization of thesis

This thesis has been structured into seven chapters as explained below:

Chapter 1- Introduction- Introduces the research topic and provides an overview of the research work by describing the research problem, research questions and objectives, research methodology, research scope and the significance of research. Chapter 1 also presents the structure of the thesis.

Chapter 2- Literature Review- Provides related work from the existing literature and also introduces the work that has already been done to address the issues of the SDO RE process. The review of the related work helps to identify research gaps.

Chapter 3- Research Methodology- Presents the research methodology employed to conduct this research. This chapter outlines the employed research methods, the research objectives and the research questions.

Chapter 4- Identification of the RE process issues for Software Development Outsourcing and exploration of the RE practices to address the issues- Deals with the identification of the SDO RE process issues and the RE practices to address those issues. This chapter describes the results of the systematic literature review which has been performed to explore the SDO RE process issues and the RE practices to address those issues. Somerville and Sawyer have proposed the RE practices for resolving the issues of the traditional RE process. Results of the questionnaire survey, conducted to find out which of those RE practices are significant to address the issues of the RE process for SDO, have been presented in Chapter 4. Another questionnaire survey has been conducted with SDO industry professionals to find out the RE process issues they have to face and the practices they follow to address those issues. Chapter 4 also presents the results of this survey.

Chapter 5- Formation of the REP Model- Gives a profound insight into the formation of the REP Model by showing the rationalization and structuring of obtained results. This chapter deals with the extraction of the frequently occurring issues of the RE process for SDO, ranking of the issues, ranking of the categories of the issues, discovering the root causes for the issues, and mapping the RE practices to the corresponding issues for addressing the issues.

Chapter 6 – REP Model evaluation results and discussions- Presents the results of the REP Model evaluation from: i) The academic point of view through the expert panel of academicians and researchers, ii) The industrial perspective by employing experienced practitioners from the SDO industry. This chapter also provides in detail discussion about the evaluation results.

Chapter 7- Conclusion- Concludes the research work described in this thesis by summarizing the research conducted. This is followed by the research contributions, limitations of the research and some recommendations for future work.

CHAPTER 2: LITERATURE REVIEW

This chapter introduces the importance of Requirements Engineering (RE) process for Software Development Outsourcing (SDO) and summarizes the related work from existing literature. The chapter also presents previous work on addressing the issues of RE process for SDO and analyzes the research gaps to justify this research work.

2.1 Significance of the RE process for SDO

Software projects are outsourced owing to the associated benefits like cost reduction, availability of the specialized and high-class capabilities, process improvement, outsourcing no-core activities and freeing the internal resources. However, a considerable proportion of such projects fails to materialize the anticipated benefits (Gefen, et al., 2008; Iqbal, et al., 2013; Meyer, 2005; Niazi, et al., 2012). The reasons for failure are often traced back to the RE process for SDO (Lopes, et al., 2005; Niazi, et al., 2012; Šmite, 2006; Verner & Abdullah, 2012). RE is the most important phase of the software development life cycle (Edwards & Sridhar, 2005). It affects the other software development phases as well (Sommerville & Ransom, 2005). Many issues arise during the RE process. In the case of SDO, stakeholders are geographically distributed, therefore, the RE process issues are increased many times (D. E. Damian & Zowghi, 2003b; Lopes, et al., 2005; Ramzan, Batool, Minhas, Ul-Qayyum, & Jaffar, 2011). The geographical dispersion among the stakeholders affects the various activities of the RE process and causes communication, knowledge management, cultural and coordination issues. Therefore, to achieve the anticipated benefits of the SDO, the issues of the RE process for SDO must be addressed.

RE process, in the scenarios when stakeholders are dispersed to different locations, has been focused in the literature from different aspects. The relevant studies in this context

can be divided into these 5 categories: i) Requirements elicitation, ii) Requirements prioritization, iii) Requirements management, iv) Requirements engineering process when stakeholders are geographically distributed, and v) Addressing requirements engineering process issues when stakeholders are geographically distributed. The related studies are presented category-wise.

2.2 Requirements elicitation

Requirements elicitation is the activity of discovering possible or raw system requirements by consulting all the stakeholders, studying the available documents, observing the target environment, utilizing the domain knowledge and conducting the market studies (Sommerville & Sawyer, 1997). A number of useful studies regarding requirements elicitation in the case of geographically distributed stakeholders are:

(a) An iterative approach for global requirements elicitation: A case study analysis

The limitations of applying the current requirements elicitation techniques during the GSD have been identified in (Sabahat, Iqbal, Azam, & Javed, 2010). By using survey research method numerous challenges for the global requirements elicitation have been highlighted which include poor communication, cost overrun, time constraints, technique and tool selection, domain knowledge and identification of the stakeholders. The survey results have revealed that prototyping, interviews, questionnaire and use case scenarios are the most useful requirement elicitation techniques in the case of GSD.

The study lists several requirements related issues in the case of GSD like incompleteness, ambiguity, instability, inconsistency and difficulties in requirements understanding. The rationales behind these issues have also been mentioned.

Keeping in view the constraints of the exiting elicitation techniques in the case of GSD, an Iterative Requirements Elicitation (IRE) framework has been proposed. According to IRE framework the elicitation and, analysis and negotiation activities are repeated until the ambiguities are removed and the consensus is developed. An application of the proposed IRE framework through a case study has exhibited that it is useful to satisfy the requirements of the greater number of customers as compared to existing elicitation approaches.

(b) A survey on global requirements elicitation issues and proposed research framework

The issues which affect the effectiveness of the requirements elicitation techniques in the case of GSD are: i) Scope management, ii) Poor understanding of requirements, and iii) Requirements' volatility (Neetu Kumari & Pillai, 2013). To address such issues, a RE elicitation approach has been proposed for the GSD. Further, qualitative research methods like surveys, interviews and examining documents have been recommended to propose a research framework to reveal the state-of-the-art and the state-of-the-practice current requirements elicitation issues.

Through the consultation with practitioners, the study also illustrates the activities which are performed during the GSD RE process. The issues that come up during this process are:

i) Lack of domain knowledge,

ii) Misapprehending requirements,

iii) Inappropriate requirements,

iv) Incomplete requirements,

v) Poor communication,

v) Identifying and involving stakeholders.

The study does not provide any solution for addressing these issues but emphasizes the need for sharing experiences and lessons learned during requirements elicitation in the case of GSD by creating an inter-organizational repository.

(c) Automated requirements elicitation for Global Software Development (GSD) environment

Motivation towards the value based requirements elicitation in GSD has been highlighted in (Ramzan, et al., 2011). The study discusses that how value based requirement elicitation can be improved and made easy. For this purpose, a framework has been proposed to elicit the requirements based on the stakeholder's importance. A few steps have been adopted from the existing literature to improve the performance. The Analytic Hierarchy Process (AHP) has been used to identify the valued stakeholders. The framework helps to determine the final set of requirements in the GSD scenario when different stakeholders have conflicting expectations. The five steps, which may involve iterations, of the proposed framework are:

i) Identifying the valued-stakeholders,

ii) Gathering initial requirements from the valued-stakeholders,

iii) Refining the project requirements and sending to the stakeholders in the form of questionnaire,

iv) Taking feedback from the stakeholders up to the specified threshold (threshold limit can be changed if the earlier threshold is not reached),

v) Preparing the final set of requirements.

Although this work emphasizes on the need for the value based RE during GSD and claims to present an enhanced framework for this purpose but it lacks the validation.

(d) A P2P toolset for distributed requirements elicitation

To support the distributed requirements elicitation, an integrated toolset has been introduced in (Lanubile, 2003). This toolset has been developed on a peer-to-peer infrastructure platform named as Groove (Lanubile, 2003). The toolset comprises of stakeholders' tool, interviewing tool, requirements tool, workshop tool and vote tool. The basic aim is to comprehend how a decentralized system, based on the peer-to-peer architecture, can be utilized to facilitate various important activities of GSD. The study has targeted the requirements elicitation first because it involves substantial communication among the stakeholders.

For performance analysis, the tool needs to be tested in a real world environment.

(e) Computer-mediated communication to support distributed requirements elicitations and negotiations tasks

RE is significantly impacted by the geographical dispersion among the stakeholders (Calefato, Damian, & Lanubile, 2012). The teams have to face the challenges during the requirements elicitation and negotiation in such scenarios. An important question is to decide that out of the face to face communication and the synchronous text-based communication which communication medium should be adopted for the effective communication during the requirements elicitation and negotiation. A framework has been developed to analyze the effectiveness of the communication mediums. Based on this framework, an empirical study has been conducted. The study has investigated the usefulness of both communication mediums by observing the performance of the six groups of undergraduate students (totally 38 students) that were assigned to six real life projects. The results have revealed that the face to face communication is not a

preferable medium in all the circumstances. In some situations, the text-based communication produces better results.

Although, there are certain threats to validity like the participants are not professionals and the environment is not real life DSD environment but the study produces valuable results which are in contrast to the common belief.

(f) A framework to improve communication during the requirements elicitation process in GSD projects

The requirements elicitation in the case of GSD is affected by insufficient communication, time zone differences, cultural diversities and improper knowledge management (Aranda, et al., 2010). For addressing such problems, a framework called RE-GSD (Requirement Elicitation for Global Software Development) has been proposed which is based on two already proposed models. RE-GSD analyzes the potential problems during the requirements elicitation process for GSD and recommends strategies for avoiding or mitigating the impact of such problems. The three phases of RE-GSD are: i) Collecting preliminary data, ii) Defining virtual teams, detecting problems and suggesting solutions, and iii) Gathering requirements.

For partial evaluation of the proposed framework, some strategies have been applied through a controlled experiment. The results exhibit that:

i) The process for selection of groupware tools, which is based on the cognitive characteristics of the stakeholders, positively affects the satisfaction of stakeholders during the communication for requirements elicitation.

ii) The usage of domain ontology positively affects the quality of software requirements specification document.

Although the study provides suggestions for improving communication during requirements elicitation in the case of GSD but it lacks evaluation from the industrial perspective.

(g) Effectiveness of elicitation techniques in distributed requirements engineering

An empirical study has been conducted by performing RE activities in a distributed environment (Lloyd, Rosson, & Arthur, 2002). The goals of the study are: i) Identification of the factors which affect the quality of Software Requirements Specification (SRS) document in a distributed environment, ii) Evaluation of the usefulness of groupware tools for the distributed RE, iii) Assessment of the different requirements elicitation techniques. For this purpose, 46 graduate students with computer science background have been divided into six groups to play the roles of customers and requirements engineers during the RE process conducted in a distributed environment. The requirements elicitation and analysis have been performed, and SRS document has been produced. The study has exhibited that:

i) Active participation of the stakeholders and richness of the synchronous collaboration media is required for an effective distributed RE process,

ii) Usage of the groupware tools supports the RE process in a distributed environment,

iii) Questioning and Answering method, Brainstorming and Uses Cases are the most beneficial elicitation techniques for the distributed RE process.

For the generalization of results, this study requires further investigations by:

i) Involving more groups,

ii) Comparing the results of the RE analysis conducted by a co-located team with those of RE analysis conducted by distributed teams,

iii) Allowing distributed teams to use the elicitation technique of their choice and then observing the effects on the quality of SRS document.

2.3 Requirements prioritization

Requirements prioritization helps to determine which requirements or set of requirements, out of all the candidate requirements, of a software product should be included in a certain release (Pitangueira, Maciel, de Oliveira Barros, & Andrade, 2013). Requirements are prioritized based on many criteria like time to release, customer satisfaction, core requirements, available resources, cost vs benefits and importance of stakeholders (Wohlin & Aurum, 2006). Some studies that focus on requirements prioritization in the case of dispersed stakeholders are:

(a) Requirements prioritization with respect to geographically distributed stakeholders

The success of software products depends on the selection of requirements, to be included in a software release, which is carried out by applying numerous requirements prioritization techniques (Ahmad, Shahzad, et al., 2011). This study presents the limitations of the two requirements prioritization techniques: i) 100 Dollar Method, and ii) Binary Search Tree, when they are applied in the scenarios where stakeholders are geographically dispersed. These two techniques have been modified to support the requirements prioritization in the case of geographically distributed stakeholders.

Two experiments have been conducted for analyzing the effects of modifications. First experiment has been carried out by applying already exiting 100 Dollar method and Binary Search Tree techniques and the second experiment has been conducted with modified 100 Dollar method and Binary Search Tree techniques. The results prove that

modification in requirements prioritization techniques help in achieving desired results during the distributed RE process.

The modified prioritization techniques do not produce correct results in some situations as high priorities are assigned to less important requirements referring to include such requirements in the earlier releases whereas low priorities are assigned to more important requirements. This limitation demands for more research work on the modified prioritization techniques.

(b) Agile requirements prioritization in large-scale outsourced system projects: An empirical Study

This work (Daneva et al., 2013) presents results of an exploratory study. This study, which has been conducted with the help of a large size and matured software company, is based on the understanding developed from three projects. It reveals the concepts and the practices which are utilized by professionals for the prioritizing requirements, while working in a large size software development organization. In-depth interviews have been conducted for the collection of data and grounded theory has been employed for the data analysis. The research investigations have produced findings that:

i) Dependencies among the requirements must be discovered for applying agile approaches successfully in the case when large projects are outsourced,

ii) After the business value, risk is the second most important criterion for prioritization in the case of large outsourced projects which are handled by following agile approaches,

iii) 'Delivery stories' that complement user stories play an important role for prioritizing requirements,

iv) Knowledge of the vendor about the domain is very crucial for establishing a successful relationship between client and vendor,

v) The agile prioritization practices can be applied keeping in view outsourcing arrangements of a project.

These outcomes are an important contribution to the empirical software engineering literature as they provide a rich analysis of the application of agile practices in the distributed scenario, from the vendor's perception.

The study also discusses possible implications for the research and the practical usage. First implication is based upon the rich analysis presented by this study which is helpful for the researchers in the situations where enough knowledge is not available regarding the phenomena.

Second implication has been achieved by comparing the results of this research with the results of another empirical research which is based on small or medium size projects. It has been observed that large projects are more implicated to balance the forces which oppose the interests of clients and vendors. Further, it has been found that there are no detailed requirements in case of the most of small projects and also there are no committed teams for delivery.

Another implication is based on uncovering the fact that new roles, for example Domain Owners, are required for applying agile RE approaches in the case of large scale projects. All the roles do not suit to all the organizations. Detecting which roles are better for which context helps in implementing agile approaches, results become foreseeable and the chances of success are increased.

2.4 Requirements management

Requirements management focuses on managing the system requirements and requirements change management policies (Sommerville & Sawyer, 1997). Managing the requirements becomes complex when involved parties are disseminated to various distinct locations. Some studies related to the requirements management in such scenarios are:

(a) Requirements management infrastructures in global software development - towards application lifecycle management with role-oriented in-time notification

Matthias et al. (2007) have: i) Mentioned the needs that should be fulfilled for managing requirements during GSD, ii) Described approaches that are used for managing requirements in case of GSD, iii) Introduced an approach for addressing the deficiencies of the approaches that are used for requirements management in the case of GSD (M Heindl, Reinisch, & Biffl, 2007).

Necessities for managing requirements during GSD include effective information exchange within an appropriate period of time, inexpensive requirements traceability and integration of tools. Timely exchange of information is significantly important as delayed information delivery may result in the wasted effort or even redesigning. For example, requirements changes occur frequently during the software development lifecycle. However, if information about the suggested changes is not delivered within time then developers may implement outdated requirements which can lead to wastage of effort and exhaustive redesign. Furthermore, this exchange of information must be effective as well so that every role gets the sufficient information related to allocated work. Requirements traceability is equally important as it helps in understanding the origins and the meanings of requirements. The traceability facilitates project managers

for monitoring projects, moreover the traceability information is crucial for change impact analysis. Lastly, these needs must be supported by an appropriate set of tools and their tight integration.

By analyzing requirements management approaches for GSD, it has been observed that needs for managing requirements during GSD are not fulfilled properly. Therefore, a plug-in (to provide interface between tools) for requirements tracing has been proposed that aims at the systematic improvement of the information exchange, traceability and notification mechanisms. The plug-in approach can be enhanced further by facilitating standard data exchange format and introducing a role-oriented notification (defining which notification, about an event, is relevant to whom) system.

(b) Managing evolving requirements in an outsourcing context: An industrial experience report

Problems that affect the management of evolving requirements in outsourcing context have been described through an industrial experience report in (Lormans, Van Dijk, Van Deursen, Nocker, & De Zeeuw, 2004). Such problems are related to control, assurance, ownership, development paradigms, and system decomposition. The evolving requirements may bring inconsistency issues to the requirements document and overall system functionality. Requirement management activity is aimed at controlling these requirement changes. This study focuses on requirement management techniques that can be employed by solution providers while dealing with the outsourcing contracts. In this context, different methods have been evaluated to analyze their suitability for managing the evolving requirements.

After mentioning the features, which a traditional requirements management system should provide, the study also describes the aspects that should be given special

attention in the outsourcing context. These aspects are: i) Change management, ii) Quality assurance, iii) Issue tracking, iv) Test reporting, v) Status reporting, and vi) Flexible modularization.

The study is concluded by proposing a conceptual framework for Requirement Engineering Systems (RES). The framework aims at bridging the gap between evolving requirements and impediments associated with the implementation of these requirements. This framework comprises of a requirements model accompanied by a traceability model. Traceability links, generation of multiple views, structured analysis and dynamic modularization are important aspects of the proposed framework.

The study provides valuable results for industry as well as for researcher as discussing requirements management issues in the industrial perspective helps practitioners in understanding requirements management issues in case of their own projects.

Secondly, the study analyzes various requirements management techniques by describing when they are suitable to be used and when they are not suitable to be used. The analysis provides practitioners and researchers a deeper insight into these techniques.

(c) An improved framework for requirement change management in global software development

An improved framework named as RCM-GSD has been introduced to facilitate the Requirement Change Management (RCM) activities during GSD in (Minhas & Zulfiqar, 2014). Through a systematic literature review many existing frameworks for RCM have been discussed along with the limitations to pave the way for proposing a new framework. The proposed framework comprises of the three main steps which are: i) Change initiation (for initiating change request), ii) Change evaluation (for evaluating requested change),

and iii) Voting process (for getting the opinion of the members of change control board about the requested change).

The framework has been evaluated by two different methods:

i) Through case study by applying the framework on two GSD projects in two different companies,

ii) By comparing proposed framework with existing frameworks using two criteria: covering the activities of RCM, and addressing issues of GSD.

The evaluation results exhibit that the proposed framework provides suitable solution for addressing the issues of RCM during GSD.

(d) A proposed framework for requirement change management in global software development

Another study on the RCM in GSD (A. A. Khan, et al., 2012) aims at proposing a framework to address the RCM challenges. This framework mainly focuses on the communication issues related to the RCM during GSD. The RCM process starts when a Request for Change (RFC) emerges from any stakeholder at any geographically distributed site. This is regarded as Change Initiation phase. The requested change is evaluated in the second phase called Change Evaluation phase. Evaluation phase is followed by the Change Decision phase and Change Implementation phase. After implementation phase, change is accommodated within the system. Then change moderator (CM) is informed and data about the change is sent to the central repository.

Although the proposed framework recommends steps for a systematic RCM in GSD but it needs to be validated through the real life scenarios for determining its practicality. Moreover, the framework should be improved further to address the communication issues.

(e) A requirement change management framework for distributed software environment

Various RCM frameworks have been briefly presented and an ontology based RCM framework ORCM (Ontological Requirement Change Management) have been described in (Hafeez et al., 2012). ORCM framework aims at enhancing the efficacy of change management process in the GSD context. This framework utilizes ontology for creating knowledge management mechanism which develops common requirements understanding among the distributed stakeholders and presents requirements in a formal, agreed and unambiguous way. Defect Tracking System (DTS) has been used for impact analysis and estimation of the cost associated with each change requested by any stakeholder.

Evaluation of ORCM framework has been performed through a case study by implementing it in a company and using two criteria: i) User satisfaction, and ii) Ease of learning. The responses have been collected from ten experienced practitioners by using a three point Likert Scale: 'Agreed', 'Partially agreed' and 'Not present'. According to the opinion of the practitioners, the proposed framework is quite understandable and can manage the RCM process well in the case of GSD.

For the wider acceptability, ORCM framework needs to be evaluated through implementation in more companies. Secondly, this study does not provide any detailed description of the ontology being used. Thirdly, own ontology should be developed. These factors can hinder the motivational factor to adopt this framework for RCM during GSD.

(f) Managing requirements in globally distributed COTS customization

Although the global RE has received significant attention from software engineering researchers but an important context of the customization of Commercial Off-The-Shelf (COTS) products is still neglected (Hussain, Buchan, & Clear, 2014). The COTS products need to be reconfigured and customized to meet specific customer requirements. In some cases, extensive source code changes need to be accommodated. Then, RE processes become more important. Empirical studies have shown that COTS customization usually does not follow the traditional RE processes. Recursive and volatile nature of COTS development can be attributed as the reason for this trend. As global RE in the context of COTS customization has received a little attention, therefore, an exploratory case study aimed at understanding the RE activities in this context has been conducted. A COTS customization process model has been developed by conducting semi-structured interviews of the stakeholders, and performing thematic content analysis of the related artifacts and transcribed interviews.

Some important RE issues have been highlighted as a result of this case study. The issues linked to discovering matches and mismatches include: lack of COTS product documentation, difficulties in verification of non-functional requirements, unavailability of timely expert knowledge, conceptually distant product features and system requirements, variable degree of certainty of a match or mismatch. A significant scope checking issue is the prolonged time frame for scope negotiation. Issues related to the specification and prioritization include the formalization and elaboration of a consistent view of the requirements, and translating customization to vendor specific spreadsheet templates. Analysis and negotiation phase also encompasses some issues including the difficulty in synchronous communication due to differences in time zones, credibility of

vendor claims, and technology shortcomings. Project management issues are related to iterative boundaries, product knowledge and quality control.

After identifying the issues related to different phases of COTS customization, this study provides a set of recommendations for vendor to address some of the issues. The suggestions are:

i) Aligning project management with the activities of client team,

ii) Documenting COTS products to serve as customization baseline,

iii) Getting clear idea of the project scope and avoiding traps,

iv) Increasing clients' accessibility to product experts,

v) Focusing on functional requirements and clearing the non-functional requirements in the beginning of project.

Although this research work provides a deep insight into the global RE process in the case of COTS customization but it lacks validation.

(g) Requirements management in distributed projects

Another exploratory study (Šmite, 2006) identifies and addresses the threats to requirements management in the context of globally distributed software development projects. Data has been collected through interviews, surveys and relevant literature review. Grounded theory has been applied for data analysis. To validate and investigate the results, an online survey has been conducted. Respondents include 28 project managers from 3 Latvian software houses that have been involved in the globally distributed projects. The top 5 identified threats include:

i) Diverse or poorly defined requirement specifications,

ii) Faulty estimates about efforts involved,

iii) Varied working practices or maturity levels,

iv) Poorly defined and unstructured tasks, and

v) Poor distribution of development related activities.

Results of the survey reveal that threats related to requirements management have been attributed as the most significant source of risks. Reasons for poor requirements management include discrepancies in the levels of process maturity, different working practices, poor version control, affiliation with more than one supplier, insufficient language skills, usage of different terminologies and reluctance for the collaboration.

For successful requirements management in distributed environment, the study enlists a set of the practices which are: involving representatives of all important stakeholders during requirements analysis, reducing diversities in the working practices, agreeing on the requirements specification template, developing glossary for the terminology to be used, clearly defined responsibilities and maintaining the continuous communication.

This set of practices has been derived from the field studies and is meant to address the specific threats of global projects.

Survey for validating the study has been conducted by involving 28 project managers only from 3 software houses which belong to the same country. This fact creates threat to validity and emphasizes the need for broadening the scope.

2.5 Requirements engineering process when stakeholders are geographically distributed

Distributed Software Development (DSD) and Global Software Development (GSD) constitute a large segment of the literature on SDO. Some important studies which highlight RE process during DSD and GSD are:

(a) Requirements understanding: A challenge in global software development

In the study (Alnuem, Ahmad, & Khan, 2012), prime focus is Requirements Understanding in GSD. Mohammed et al. (2012) intend to identify: i) Different factors which create challenges for Requirements Understanding in GSD context, and ii) Solutions to handle those challenges. There are two motives behind this study. First, there is no study focusing on Requirements Understanding issue during GSD with respect to Kingdom of Saudi Arabia (KSA) software industry. This study would help practitioners to handle Requirements Understanding issue in the relevant context. Second motive is to explore the environment of KSA software companies to know how they tackle requirements communication and coordination issues for understanding requirements in GSD scenario.

Interviewing method has been used to survey the KSA software companies involved in GSD. For this purpose, questionnaires containing closed-ended questions as well as open-ended questions have been designed. Additionally, grounded theory approach has been employed to analyze the data.

Totally, four practitioners have been interviewed, out of those two belong to same company and other two belong to the two different companies. Business Development Manager, Principal Architect, Requirements Coordinator and Technical Engineer employed for interviewing have been directly involved in RE activities in global context and possess more than 9 years of field experience on average.

According to the findings, all of the interviewees agree that Requirements Understanding is a serious challenge for KSA software development companies which deal with GSD. The interviewees recommend that every software company, which deals with GSD, should take measures to handle this challenge. It has also been identified that cultural diversity and poor communication are the most prominent challenges for the

Requirements Understanding. All interviewees have claimed that time zone differences, culture diversities, lack of face-to-face communication, language, trust, motivation and distributed multicultural teams are the factors owing to which challenges are created for Requirements Understanding during GSD.

While conducting interviews, interviewees have been provided with a checklist of some valuable tools and practices. They have been requested to choose those tools or practices which could be beneficial for handling Requirements Understanding issues. The main motive behind selection of these tools or practices is to get companies' perceptions and recommendations regarding each tool or practice and their usage for resolving Requirements Understanding problems. The study also reveals that companies are unacquainted with the use of modern technologies. The interviewees have endorsed adoption of many tools and practices along with using commonly defined terminology, following standards, and maintaining motivation and trust to address Requirements Understanding issues during GSD. They have claimed that it is important to meet with all stakeholders at least once for understanding the requirements.

Although, study provides a deep insight into Requirements Understanding issues during GSD in KSA context but it requires investigations on large scale by involving more software development companies.

(b) An empirical study of requirements engineering in distributed software projects: Is distance negotiation more effective?

DSD demands complete understanding of the various activities which involve combined efforts from the distributed stakeholders (D. Damian, 2001). RE is one of such activities. RE conflicts occur during DSD and affect the performance of the professional groups involved. The effects of technology on the efficiency of such groups need to be

investigated for producing better results. This exploratory study presents the results of RE meetings conducted with the geographically distributed stakeholders.

Evidences show that distributed RE process is enhanced through the use of NetMeeting Web-based tool which has been employed to facilitate the requirements communication between two the distant locations. The results have also disclosed the facts which encourage distributed communication. Further, these results can be used to make distributed communication more productive and for achieving a requirements consensus keeping in view the needs of all the stakeholders.

The empirical investigations of the distributed requirements communication by using NetMeeting Web-based tool, have disclosed the following facts:

i) Efficiency of the groups during the face to face RE meetings is not better as compared to their efficiency during the distributed RE meetings,

ii) Requirements negotiations among two stakeholders is productive even when they collaborate remotely,

iii) When two stakeholders negotiate being co-located, it is supportive but not really advantageous,

iv) Usage of a common electronic workspace proves really beneficial during the distributed negotiation about the requirements,

v) Usage of the video channel is also beneficial during the requirements negotiations among the distributed stakeholders,

vi) Human facilitator can play an important role during the requirements negotiation among the distributed stakeholders,

vii) Early face to face interaction is significant prior to the computer mediated meeting.

There are practical implications of this study for the industry. The results facilitate to resolve requirements contradictions in the distributed paradigm that may prove more effective than the traditional face to face requirements meetings.

Although this research work has revealed the possibilities of distributed web-based requirements negotiations and has reported its benefits for requirements conflict resolution but it is objected to controlled laboratory settings and a small sample size of participants. Therefore, experiments performed during study should be repeated with a large sample size and in real environment to investigate that whether same results are produced or not.

(c) PBURC: A patterns-based, unsupervised requirements clustering framework for distributed agile software development

Multi-national projects that engage a large number of associates, target groups of users and developers, are characterized by the diverse backgrounds and skills (Belsis, et al., 2014). In this diverse environment, data gathering and validation during the RE require effective processing techniques for dealing with bulk of data and managing discrepancies during online data collection. For this purpose, a framework called PBURC (Pattern-Based Unsupervised Requirements Clustering) has been presented which is based on machine-learning methods for requirements validation, processing and classification.

In fact, PBURC defines a mechanism to integrate machine-learning based algorithms for a pattern-based and unsupervised requirements clustering in the case of distributed agile software development. It presents a combination of well recognized methods along with the use of clustering algorithms in order to prioritize requirements, group them and drive agile software process.

The distributed collaboration is achieved mainly by following steps:

Initially, a number of key features are identified after a careful examination of relevant system. In addition, many value-adding features and services may be recorded during distributed developers' workshops. The minutes of these activities serve as a basis for the creation of a more sophisticated questionnaire-based survey. Further, several workshops at different locations may be conducted for validation and prioritization of the identified requirements. During the workshops, the conflicting requirements are carefully opinionated to address the contradictions. To take care of the possible inconsistencies, the PBURC framework adopts different ways ranging from the formation of process able data to the final identification of the requirements clusters.

After identification of the set of requirements, next step is validation of the requirements and identifying the most important requirements through online questionnaire in which system users are requested for grading the requirements with respect to the importance.

Data are classified after tackling null values or free spaces by using a method that makes data available for the clustering. Proposed approach focuses not only on the preparation phase but also on identifying the optimal number, k, of clusters (by using the Ward's algorithm) before applying appropriate clustering algorithms. The clusters are identified using the k-means algorithm.

To deal with challenges of distance, tools for web-based development have been utilized. A software requirements tracking tool and a wiki have been used to collaborate and for mutual communication. Distributed coordination has been achieved by mind maps and quality procedures such as workflow diagrams, and other established cost and time-scheduling monitoring tools. Communication and knowledge sharing have been made possible by using the different forums and online discussion tools.

The effectiveness of the proposed framework has been tested through application in a real-world large scale software project. Partners from 11 different countries of Europe have been involved in this project which is aimed at providing social services to the researchers and academicians along with facilitating open access to a group of repositories. This study has encountered several problems like cultural diversities, technical background differences, lack of mutual trust, competitiveness among different stakeholders, maintaining quality and cost of the coordination meetings.

PBURC should be expanded to make it applicable to other development scenarios. Furthermore, for better results clustering algorithms based on Fuzzy logic can be used for dealing with the data discrepancies.

(d) Requirements engineering for distributed development using software agents

In another study (Sayão, Haendchen Filho, & do Prado, 2008), use of MAS (Multi Agent System) architecture has been articulated to minimize the difficulties that arise during the distributed RE process specifically during Verification and Validation (V&V) activities. A goal-driven approach has been followed for defining high-level verification and validation goals. After refinement, this approach helps in requirements derivation and assignment of responsibilities to the different actors like humans, software agents, devices and programs.

It has been argued that agents based approaches provide natural solution for addressing the inherent problems of the distributed RE like distributed stakeholders, poor communication among the stakeholders and time zone differences. Requirements verification and validation in case of software having medium or high complexity may have to deal with hundreds or in some cases even thousands of requirements. Keeping in view such complexity level, software engineers performing quality assurance

activities must be provided computational support. For this purpose, a strategy has been proposed which combines Natural Language Processing (NLP) techniques and software agents. Through the proposed approach, authors have explored autonomy and flexibility of the agents. Communication among the agents, and between agents and humans has also been explored. Goal oriented techniques have been adopted for identifying the targets of the software agents.

As described earlier, the proposed approach primarily stresses upon the verification and validation activities during which stakeholders interact for verifying quality of requirements and to make sure that requirements fulfill needs of the customers and users. In order to represent the proposed approach, a model has been proposed. The model demonstrates goals of every agent and the dependencies which exist among agents for achieving goals. After specifying the model of strategic dependency, goals are refined in the next step. Every goal is divided into sub-goals and commitments. The commitments are allocated the responsibility of an agent.

The Software Requirements Specification (SRS) verification goal has been divided into two sub-goals in such a way that satisfying these sub-goals causes the satisfaction of the parent goal. These sub-goals are decomposed into tasks and further sub-tasks. These sub-tasks deal with the direct commitment of the four agents: Inspector, Lexical, Verifier and Requirements Engineer. Throughout the process of requirements verification, the developers, testing engineers, requirements engineer and customers perform evaluation of SRS and interact with each other to guarantee that the requirements in the SRS meet the standards and rules, and they have been modeled correctly. On the next level, decomposition of the tasks occurs and they are divided into actions. Next step is defining the actions which agent should perform. The agent which is committed to a task or sub-task is liable for implementing all the actions which are

decomposed from that task. To do this, that agent can request for collaboration with other agents.

The Lexical agent is committed for examining various documents and to extract, sort and organize information for sake of producing an initial requirements document and an artifact report. The function of Verifier agent is to check duplicity of requirements and errors regarding the non-functional requirements. In order to perform these duties, Verifier agent has to collaborate with Lexical, Statistics and Communicator agents. In brief, the Verifier agent is liable for inspecting the overall quality of requirements.

After identification of the agents and respective actions which must be performed by those agents, the design of MAS can be established. By using the 'roles model', the rights and responsibilities of the agents are represented along with the actions which must be performed. The traditional UML (Unified Modeling Language) tools can be employed for modeling the lifecycle of agents, internal behavior and interaction.

A prototype has been built to prove that it is possible to automate verification and validation activities partially with the help of software agents. This aspect also demonstrates that personal software agents can be used to assist stakeholders as an agent can represent a stakeholder and perform its role while following the established plan.

(e) Analysis of software requirements engineering exercises in a global virtual team setup

To understand complexities involved in the RE process for GSD projects, an exploratory study (Edwards & Sridhar, 2005) has been conducted by analyzing the working of 24 virtual teams who took part in the exercises of defining requirements in case of software development projects for duration of five weeks. The virtual teams

have been formed by selecting students from the two educational institutions based in Canada and India.

Global Virtual Teams (GVTs) are geographically distributed, they have rare face to face meetings and communicate through communication technology to coordinate and manage the development tasks. During software development process, RE is considered as the most critical phase as it affects the latter development phases as well. This phase could be even more critical and complicated in the case of globally distributed virtual teams because of the distance based temporal, communication and cultural issues. For the evaluation purpose, the virtual teams have been formulated from two different and distinct countries which are India and Canada. Indian student teams (having 5 to 6 members) have performed the requirements elicitation whereas Canadian teams (having 3 to 4 members) have performed the requirements analysis and negotiations, and the requirements documentation. Teams from both the cultures have been involved in requirements validation. The virtual teams have communicated through a web-based application. The objective of the study is to analyze: i) Effectiveness of the virtual teams, ii) Factors which affect the quality of requirements artifacts. For this purpose, a model has been developed that incorporated four outcome variables and seven predictor variables. Upon finding correlation among the outcome variables, correlation matrix has disclosed that there are significant positive associations between learning effectiveness, virtual team project experience, and the software engineering process outcome.

It has also been observed that:

i) Trust between the peer teams has significant positive association with the quality of the projects,

ii) Structure of the project and trust between peer teams have significant positive association with virtual team project experience, the learning effectiveness and efficiency of the software engineering process.

To analyze whether there are any significant differences in the perception of outcome and predictor variables across the teams, the ANOVA test has been performed. Significant differences have been found in the case of:

i) Structure of the project tasks, trust, difference in academic orientation and difference in cultural orientation (predictor variables),

ii) Learning effectiveness and virtual team project experience (outcome variables).

Although, the study produces many valuable results that can be used for managing global virtual teams but there are certain limitations of this research work:

i) Environment in which the exercises have been conducted is academic instead of real-world environment and it is rather controlled,

ii) The study duration is only 5 weeks, therefore, transformation of the results to the projects having lengthier duration, requires a lot of care,

iii) For most of the times, the virtual teams have used asynchronous communication medium like email. Video conferencing technology, configuration management tools etc. have not been employed. Therefore, this study does not depict the effects of such technologies and tools.

(f) The study of requirements engineering in global software development: As challenging as important

By conducting a field study in a multi-site development organization, the RE process for DSD has been studied in (D. Damian, 2002). The research work aims at investigating the effects of stakeholders' geographical dispersion on the RE process with stakeholders

like customers, developers, product managers and analyst distributed to five continents. Data has been collected by inspecting the relevant documents, observing requirements negotiations in the form of requirements related emails and meetings, face to face meetings and telephonic interviews.

After spending seven months for investigation on an Australian site, the findings of this study have revealed that poor communication, cultural diversities, improper knowledge management and temporal differences affect collaborative activities of the RE process particularly requirements negotiation and prioritization. Temporal differences provide advantages as well as disadvantages. If synchronous RE meetings are held in the case of temporal differences among the stakeholders then at least one of the involved parties has to compromise on schedule to attend the meetings. Time zone differences offer certain benefits like facility of operating 'around-the-clock' to respond the queries and complete tasks quickly. It has also been noted during the study that political, human, social and organizational factors cause lack of mutual trust, informal communication and awareness about the working context which hampers the common requirements understanding.

The study has faced various challenges like convincing certain stakeholders for allowing to attend the requirements negotiations, accessing sensitive information, collecting accurate information from the distributed stakeholders, gaining trust of the remote stakeholders and tendency of non-reporting the problems to avoid any negative consequences.

(g) Process support for requirements engineering activities in global software development: A literature based evaluation

Various RE process models for GSD have been described and evaluated based on the coverage of: i) RE process activities, and ii) GSD issues in (Javed & Minhas, 2010).

RE activities like elicitation, analysis and negotiation, specification, validation, management and traceability have been discussed in this work. Communication, strategic, cultural, technical, knowledge management and time zone differences issues have also been considered.

The evaluation results have underlined insufficiencies in the current RE process models for GSD. The results have proved that the existing RE process models for GSD do not deal with all the activities of RE process and major issues of GSD. Because of the significance and role of a well-defined RE process model for GSD scenario, this study emphasizes on developing a new comprehensive RE process model which should support all the activities of the RE process in case of GSD and address main GSD issues.

(h) Requirements development life cycle with respect to geographically distributed stakeholders: The 'V' model

A model named as V model has been proposed in (Ahmad, Goransson, et al., 2011), for developing and selecting requirements of a software product release when stakeholders are geographically distributed. This model has introduced some additional RE activities for dealing with the geographically distributed stakeholders. The activities are:

i) Determining the target market,

ii) Determining the needs of current market, and

iii) Identifying the stakeholders with respect to particular needs.

Although RE activities recommended by V model can play vital role in the success of a software product release but this work lacks model validation in the real world environment.

(i) Reusing requirements in global software engineering

Sharing of knowledge and reusability in the global RE context have been discussed in (Juan Manuel Carrillo de Gea et al., 2013). Knowledge sharing is affected by distance among the stakeholders and cultural diversities. Distrust and protectionism result in the inadequate reuse during RE. This study is aimed at improving the knowledge sharing and requirements reusability when stakeholders are globally distributed. For this purpose, a lightweight and reusability based global RE method PANGEA (Process for globAl requiremeNts enGinEering and quAlity) has been presented. PANGEA is based on requirements of natural language and the software engineering standards. For providing automated support to the method, a prototyping tool named as PANTALASA (PANgea Tool And Lightweight Automated Support Architecture) has also been developed based on Semantic MediaWiki and Facebook. For validation of the prototype, a hotel management case study has been performed. There are two threats to validity.

First, validation has been conducted in the academic environment by involving only 2 students for time of 2 weeks. Therefore, prototyping tool should be validated through a real life case study by involving more participants for a longer duration. Secondly, the validation involves the scattered participants but not globally distributed participants.

(j) Involving end users in distributed requirements engineering

Involving the end users during interactive systems' development is recommended vastly (Lohmann, Ziegler, & Heim, 2008). This becomes challenging when end users are large in the number and they are distributed geographically. To incorporate the needs of end users in such situations, a unified web-based approach has been introduced. By using this approach, distributed end users can present their views about improving interaction with the system. Input of the end users about requirements is contextualized which can be used for accessing, exploring and analyzing the requirements.

Presented approach provides certain advantages like improving the distributed requirements elicitation, facilitating end users and reducing efforts for developers. Although, initial evaluation results exhibit that approach is easy to understand and use for end users but it requires validation through a case study in the larger context. For making this approach more effective, certain mechanisms are needed to be introduced for:

i) Requirements tracking,

ii) Users' feedback and satisfaction,

iii) Discussion and reformulation of the requirements,

iv) Voting for the requirements.

(k) An exploratory study of facilitation in distributed requirements engineering

Results of an exploratory study about the role and importance of the human facilitator during the distributed RE have been presented in (D. E. Damian, Eberlein, Shaw, & Gaines, 2003). In the simulated distributed RE environment, three persons have played the roles of facilitators for five sessions while mediating among the fifteen groups

whereas each group contained three persons. Role of facilitator in the case of face to face meetings has been analyzed by involving four groups.

Study has employed multiple data collection methods like questionnaire, interviewing and video recording of group conversations. Proceedings of the various groups have been analyzed by performing the behavioral analysis through SYMLOG methodology. The study describes that a good human facilitator for the distributed RE should be able to:

i) Communicate well,

ii) Isolate ideas from the personalities,

iii) Listen and observe well,

iv) Keep authority,

v) Help groups(s) for innovation, evaluation and reformulation.

Results exhibit that:

i) Sense of physical separation among the participants helps to maintain impartiality and leads to consistent context,

ii) Slow computer-mediated conversation enhances the ability of following group proceedings.

The results also show that during the distributed RE facilitation, there are hindrances in understanding group dynamics, perceiving interpersonal behaviors, determining level of agreement among participants, and sustaining equality and authority. Although this study provides a deep understanding of the group facilitation during the distributed RE but there are certain threats to validity:

i) The study has been conducted in laboratory settings,

ii) Tasks to be performed have been structured which minimizes need for facilitation,

iii) Sessions have been held for short durations.

To deal with these limitations, a real life case study should be conducted by involving more facilitators for the longer sessions. The participating facilitators have given several recommendations for improving the human facilitation during the distributed RE:

i) Establishing rules for participation in the distributed RE activities,

ii) Discouraging personal discussions among the participants,

iii) Using commonly agreed upon applications for writing and editing agenda or proceedings,

iv) Meeting participants face to face, if possible, before the official meetings,

v) Clearly defining the meeting agendas and group tasks.

(l) Impact of poor requirement engineering in software outsourcing: A study on software developers' experience

In the case of outsourced software projects, the effects of poor RE have been investigated in (Hanisch, Corbitt, & Thanasankit, 2005) from the developers' perspective. For this purpose, a questionnaire survey has been conducted with 57 developers who have experience of dealing with SDO and belong to 8 small and medium software enterprises. Questionnaires have been sent and received back through emails. Data analysis has revealed that developers have to deal with too many requirements changes, shortened design, stretching of development phases and unexpected number of deliverables.

Although, the study presents problems faced by developers as a result of poor RE in case of SDO but it has many limitations like differences among the skill levels of participating developers and gathering of accurate data. The study also lacks in presenting how social life, economy and health of software developers are affected as a result of poor RE. Therefore, further studies are required in this dimension to remove these shortcomings.

(m) Differentiating local and global systems requirements gathering processes in IS software development projects

In case of SDO, there are differences between requirements gathering processes of a uniform cultural team and a multicultural team. Such differences have been highlighted in (Hanisch, et al., 2005). For this purpose, two case studies have been performed. Informal, in-depth and semi-structured interviews of practitioners have been conducted during these case studies.

The results show that in the case of local or uniform cultural team, usually formal processes are avoided. But in the case of globalized and multicultural teams, formal processes are followed. Cultural aspect also impacts communication during RE. In case of uniform culture or local case, culture affects the behavior of system analyst and relationship between client and analyst. In globalized context, cultural diversities cause derivation of different meanings and interpretations from same the information about requirements. The study suggests that extra budget should be allocated for dealing with the effects of cultural differences during SDO.

(n) Does global software development need a different requirements engineering process

Certain conclusions about the distributed RE process in GSD have been drawn in (Zowghi, 2002). The conclusions are based on a field study that has been conducted on the geographically distributed stakeholders during GSD.

Some core problems of the RE process are aggravated when stakeholders are located at distinct locations. This is because of the fact that distributed environment possesses some unique features like distance among stakeholders, time zone differences and cultural diversities which directly affect the RE process. This study presents a brief

description of the impacts of these challenges over the distributed RE process and suggests devising a separate RE process for supporting the distributed environment.

RE is a communication intensive activity which establishes the stakeholders' needs by analyzing, documenting and finally validating needs whereas geographical distance among stakeholders has a direct impact on communication. Usually communication among stakeholders becomes infrequent and constrained because of adopting asynchronous mode of communication and less tool support for the RE process.

Distributed teams' coordination and control is also affected by the geographical distance that not only decelerates RE process but also averts congruence which could have been achieved through the agreement and consultation. Knowledge management is another important aspect of the distributed development which is also severely affected because of the distance as there is no or less informal communication among the geographically distributed stakeholders. As a result, they cannot pass on the tacit knowledge to one another.

Temporal distance among the stakeholders worsens and intensifies the communication problems particularly in the absence of the overlapping of stakeholders' business hours. This hampers the appropriate input from the stakeholders and leads to compromises by at least one of the parties involved.

Another challenge is the cultural difference among the stakeholders which impacts relationship between customer and supplier because of the variances in ethical values, traditions, precision levels, behaviors and languages etc. Furthermore, disparities in organizational functional culture also create problems during the RE process when the stakeholders are geographically distributed.

Author has concluded that while developing the requirements there is a need to incorporate commercially available tool support in the distributed RE process which

will facilitate the traceability and record keeping functionality. Most importantly, certainly there is a need for the new RE process for GSD which must handle challenges of the distributed environment in such a way that managers could then capitalize on the information provided regarding the RE process.

2.6 Addressing requirements engineering process issues when stakeholders are geographically distributed

Several studies in the existing literature deal with the issues that come up during the RE process when stakeholders are geographically distributed. This section analyzes such studies.

(a) Impediments to requirements engineering during global software development

An important study reports the results of case study regarding a large scale project outsourced for software development with the stakeholders distributed to two distinct countries (Hanisch & Corbitt, 2007). Data has been collected by conducting in-depth and semi-structured interviews of 6 practitioners who have experience of gathering the requirements from users. The interviews have been transcribed, and clarifications have been done through follow-up telephone calls and emails. The study argues that:

i) Electronic communication medium is required for achieving the economic benefits of GSD, ii) For an effective RE process and maintaining the long term relationship with client during GSD, the cultural aspects of the RE should be addressed.

The study results further reveal that the main obstacles during the RE process for GSD are related to communication, and are based on differences on meanings and explanations of the information about requirements. Communication in case of GSD is constrained as:

i) Members of the development teams are geographically distributed,

ii) There is also a geographical distribution between the client and members of development teams,

iii) Members of development teams belong to the diverse cultural backgrounds, and

iv) There are cultural differences between the client and members of development teams.

This physical and cultural dispersion among the stakeholders creates many issues for GSD. There are:

i) Difficulties in identifying and accessing the key users which hinder the reduction of requirements changes,

ii) Misinterpretation of the requirements,

iii) Short overlapping development time,

iv) Failures in meeting the deadlines.

To address such issues, the study provides several suggestions:

i) Social exchanges among the stakeholders,

ii) Providing awareness about cultural diversities,

iii) Alleviating time pressure from developers,

iv) Providing access to the key users, and

v) Appointing communication coordinators.

Although, the study highlights the issues resulting from ineffective communication, cultural diversities and geographical dispersion among the stakeholders during the RE for GSD but it does not present the users' perspective as data has been gathered only from practitioners. This aspect necessitates further research work to know about the users' perception.

(b) Requirements specification in distributed software development – A process proposal

An iterative requirements specification process has been proposed in (Lopes, et al., 2005) to address the issues that arise during the RE process in a distributed environment. The issues belong to the four categories of: i) Communication, ii) Culture, iii) Knowledge management, and iv) Technical aspects.

The steps of the proposed process are:

i) Sending the first version of Software Requirements Specification (SRS) to the development team,

ii) Analysis and adaption of SRS document by the development team and sending back to specification team iteratively, if needed,

iii) Completion of the SRS adaption (by development team) and sending back to specification team,

iv) Validation of the SRS document by specification team, and

v) Approval of the final version of SRS document.

The recommended iterative process partially addresses the communication issues through the SRS document adaption. Time zone differences may hamper the SRS document adaption but this difficulty is reduced with the passage of time as the requirements comprehension is increased when the SRS document is sent back and forth between specification and development teams. Similarly, the cultural issues are also resolved during the SRS document adaption. The knowledge management and technical issues are addressed through the usage of commonly agreed upon processes and the SRS document. The study introduces the four categories of the RE issues which arise when stakeholders are geographically distributed but it lacks the empirical validation. The effectiveness of

the proposed process during the distributed RE process should be investigated by applying it during the globally developed software projects.

(c) The challenges of distributed software engineering and requirements engineering: Results of an online survey

The issues of the DSD and the distributed RE along with the countermeasures to address those issues have been presented in (Illes-Seifert, Herrmann, Geisser, & Hildenbrand, 2007). For this purpose an online questionnaire survey has been conducted with practitioners having DSD experience. Finally 744 questionnaires, containing open- ended as well as close-ended questions, have been selected for data analysis.

According to the results, the issues of the distributed RE process are ambiguous requirements specification, using inconsistent terminologies or notations for requirements specification, incomplete requirements, changing requirements, incorrect requirements, inefficient RE processes, requirements prioritization, and a high number of stakeholders to elicit the requirements. The most frequently recommended solution to RE issues is the face to face communication. The other suggested countermeasures are frequent communication, training, defining and using a common glossary, testing requirements specification early, following standardized formats and defining the minimum standards to be followed.

Findings of the study are consistent with other studies but there are many validity threats like most of the participating practitioners are not senior practitioners but developers and designers, and the recommended countermeasures have not been tested practically.

(d) Challenges and solutions in global requirements engineering – A literature survey

The study (Schmid, 2014) focuses on the global requirements engineering. The issues related to the customer interaction, organizational structure, cultural diversities, law, educational background and climate have been discussed in the context of GSD. The impact of GSD on requirements negotiation and prioritization is also presented. Furthermore, three important issues of the RE process in a distributed environment have also been highlighted and practices have been suggested to deal with those issues.

The first issue is requirements elicitation when stakeholders are distributed. The recommended practices to address this issue are following common processes, encouraging shared responsibilities and maintaining trust.

Second issue mentioned in the study is improper communication during the RE process. The approaches to deal with the issue of inadequate communication in a distributed context are:

i) A well-defined organizational structure with clearly defined communication responsibilities,

ii) All the distinct sites should have peer to peer linkages at the management level, project level and teams' level,

iii) Inter-organizational processes should be synchronized to a possible extent, and contacts and deliverables should also be frequent,

iv) Cultural liaisons should also be appointed,

v) Maintaining open communication lines among the main stakeholders,

vi) Informing and monitoring progress on agreed upon artifacts.

The third issue is creating and maintaining an intense cooperation among stakeholders. The suggestions to deal with this issue are:

i) Creating communication links at earlier stages of the project,

ii) Using a standard language for communication like English,

iii) Appointing cultural liaisons, and

iv) Establishing peer to peer linkages at all possible levels.

Most of the recommended solutions lack the supporting evidence and have not been validated. Therefore, further studies are needed to be performed at a detailed level for producing the reliable results.

(e) Stakeholders in global requirements engineering: Lessons learned from practice

According to Daniela Damian, the three challenges that arise when stakeholders interact during the global RE are:

i) Attainment and sharing of the relevant knowledge,

ii) Alignment of the RE processes and supporting tools, and

iii) Enabling useful communication and coordination among the distributed teams (D. Damian, 2007).

The relevant strategies to deal with these challenges are:

i) A well-defined organizational structure with clearly defined communication responsibilities,

ii) All the distinct sites should have peer to peer linkages at the management level, project level and teams' level,

iii) Inter-organizational processes should be synchronized to a possible extent, and contacts and deliverables should also be frequent,

iv) Cultural liaisons should be appointed,

v) Maintaining open communication lines among the main stakeholders,

vi) Informing and monitoring progress on the agreed upon artifacts.

The study introduces common challenges that come up during the global RE and presents suggestions to deal with those challenges. More studies should be carried out to provide the concrete recommendations for enabling the effective interaction among the distributed stakeholders during the global RE process.

(f) Overcoming requirements engineering challenges: Lessons from offshore outsourcing

Practitioners have shared their experiences about the challenges encountered during the RE process for the offshore SDO in (Bhat, et al., 2006). Based on the 9 industrial case-studies, 9 challenges have been mentioned: i) Client and vendor have conflicting interests, ii) Lack of involvement from client side, iii) Client and vendor follow conflicting RE approaches, iv) Client does not fulfill commitments, v) Conflicts on selection of the tools, vi) Communication lapses, vii) Vendor disowns responsibilities, viii) Signing-off issues regarding the RE deliverables, and ix) Selected tools are different from the expectations. On the basis of the Root Cause Analysis, the 5 success factors have been identified to deal with these challenges: i) Setting the common goals, ii) Adopting the shared culture, iii) Following the shared processes, iv) Sharing the responsibilities, and v) Maintaining trust.

To realize these success factors, a framework has been proposed based on the RE practices extracted from the relevant literature. Although, the framework recommends RE practices with respect to three dimensions of people, process and technology but it entails more RE practices suggested by researchers and practitioners.

(g) Requirements engineering challenges in multi-site software development organizations

The challenges of the RE process during software development among multiple sites and the practices to deal with those challenges have been presented in (D. E. Damian & Zowghi, 2003b). The study is based on a seven month long field study during which multiple data collection methods have been used like examining the relevant documents, attending RE meetings and conducting semi-structured interviews with 24 stakeholders. The grounded theory has also been applied for analyzing the data and producing the results.

According to the findings, the RE challenges in multi-site software development organizations include cultural diversities among stakeholders, inappropriate involvement of the stakeholders, unawareness from working context, maintaining trust, managing conflicts, common requirements understanding, arranging result oriented RE meetings and delays in responses. The recommended practices to overcome these challenges are:

i) Enabling effective and frequent contacts with the field personnel,

ii) Arranging more and more visits,

iii) Scheduling the face to face meetings among the stakeholders at the start of the project,

iv) Appointing facilitators during the RE meetings, and

v) Creating a repository to store information about the requirements.

Although, the study findings are significant but an apparent threat to validity is that conclusions are based on a single case study conducted only in one multi-site software development organization. This fact emphasizes the need for conducting more industrial studies to produce more reliable results.

(h) Risks and safeguards for the requirements engineering process in global software development

A plan to identify the risks of the RE process for GSD and the safeguards to handle those risks, has been described in (Lopez, et al., 2009). To achieve the study objectives, a systematic literature review has been conducted. Some results have also been discussed. A total of 106 risks have been identified for the RE process in the case of GSD. The risks belong to the 7 categories: i) Communication and distance, ii) Knowledge management and awareness, iii) Cultural differences, iv) Management and project coordination, v) Tools which support the processes, vi) Clients, and vii) Miscellany. The study also recommends 52 safeguards to overcome 106 identified risks.

The RE risks related to GSD and corresponding safeguards for dealing with those risks have been presented in the form of a repository. This repository provides a basis for an effective RE process in the situation when the stakeholders are globally distributed and practitioners have no or a little experience of dealing the with GSD projects. But for the sake of improvement, the repository needs to be validated by GSD practitioners or through implementation during the GSD projects.

(i) Situational requirement engineering framework for global software development

A situational RE framework has been proposed in (H. H. Khan & bin Mahrin, 2014) for identification of the situational factors and the most influential situational factors which affect the different activities of the RE process for GSD. The study focuses on the activities of requirements elicitation, analysis, specification, validation and management. By sending questionnaires through emails, a questionnaire survey has

been conducted with requirements engineers having GSD experience. During the survey, by providing a list of the situational factors for each RE activity separately, the respondents have been requested to rank the influence of each situational factor on each RE activity. For ranking the influence of situational factors, a five point Likert Scale has been used: strongly influential=5, influential=4, moderate=3, weakly influential=2, not influential=1. Out of the 114 responses received, 83 have been selected for the data analysis keeping in view the quality criteria. A statistical analysis has been performed based on the mean values and composite mean values in the case of each situational factor for each RE activity. According to the results, the most influential situational factors for the various RE activities are: understanding and stating requirements, clients, teams, stakeholders' mode of interaction, culture, characteristics of project, resources, evolution of requirements, estimations about requirements, technical maturity level, problem domain, standards, occurrence of defects and testing.

The situational RE framework for GSD presents the situational factors and the most influential situational factors which affect the various RE activities during GSD. Thus the situational RE framework contributes to the RE body of knowledge but it lacks validation that can be performed either by GSD practitioners or through implementation during GSD.

(j) Factors generating risks during requirement engineering process in global software development environment

The factors and the risks which can be generated from those factors during the RE process for GSD, have been identified in (H. H. Khan, et al., 2014) by performing a systematic literature review and applying the grounded theory. The 74 discovered factors have been grouped into 8 categories: i) Communication and distance, ii)

Cultural, organizational and time zone differences, iii) Knowledge management and awareness, iv) Management, v) Tools, technologies and standards, vi) Stakeholders, vii) Project and process, and viii) Requirements.

The study provides a comprehensive list of the factors and the risks that may spawn from those factors during the RE process for GSD. Therefore, this work is beneficial for the inexperienced GSD practitioners to overcome the risks of the RE process and avoid the GSD projects' failures. A threat to validity is that the study is based only on the state-of-knowledge and not on the state-of-practice. Therefore, industrial surveys should be conducted with the experienced GSD practitioners to include the industry perspective and generate more comprehensive and practicable results.

(k) GlobReq: A framework for improving requirements engineering in global software development projects: Preliminary results

Another study on GSD (Niazi, et al., 2012) describes the methodology and the preliminary results for the development of GlobReq which is a framework to improve the RE process for GSD.

GlobReq is based on the 66 RE practices recommended by Sommerville & Sawyer, and empirical studies with the organizations which deal with GSD. Initially, 5 experienced practitioners have been selected from 5 GSD organizations. These practitioners have been rigorously involved in the RE process for GSD. During the in-depth interviews with practitioners, they have been solicited to rank the Sommerville & Sawyer's 66 RE practices against the four categories of the perceived benefits of the RE practices for GSD. The four categories of the perceived benefits are: High (if an RE practices is always followed), Medium (widely followed), Low (followed sometimes), and Zero (Never or rarely followed). The RE practices for which most of the GSD practitioners

have suggested ‘High’ and ‘Medium’ categories, are considered as useful for the GSD RE process. The results show that all the 66 RE practices are not suitable for the GSD RE process and hence cannot be incorporated in GlobReq.

Authors have plan to evaluate the GlobReq framework through the ‘Experts Panel’ against the three criteria of ‘User satisfaction’, ‘Ease of use’ and ‘Better requirements’.

2.7 Research gap analysis

By reviewing the relevant literature, this becomes evident that there are many issues of the RE process for SDO. The issues belong to various categories. Projects are outsourced for the software development to achieve certain benefits but a large proportion of such projects cannot attain the estimated benefits because of the RE process issues (Gefen, et al., 2008; Iqbal, et al., 2013; Meyer, 2005; Niazi, et al., 2012) (Lopes, et al., 2005; Niazi, et al., 2012; Šmite, 2006; Verner & Abdullah, 2012). Therefore, to realize the anticipated benefits of SDO, there is a need to propose a model to address the issues of the RE process for SDO. The development of such model requires the identification of the SDO RE process issues from the literature and industry, and needs the categorization of such issues. The formation of a workable model to address the SDO RE process issues also entails the extraction of the issues which occur frequently or commonly during this process. The development of the model further requires the ranking of the common issues and the ranking of the categories of those issues. The ranking of the common issues and that of the categories of those issues facilitates the planning of proactive strategy to deal with the SDO RE process issues. To present a model, which provides the effective solutions to address the common issues of the SDO RE process, the root causes for the occurrences of such issues must be discovered. Discovery of the root causes requires the

Root Cause Analysis of the commonly or frequently issues of the SDO RE process. The detection of the root causes enables to recommend the best RE practices (solutions) to address the corresponding issues of the RE process for SDO. Keeping in view all these aspects, a fruitful model, for addressing the SDO RE process issues, needs to provide:

i) The common issues of the RE process for SDO and the categorization of those issues,

ii) The Ranking of the common issues of the RE process for SDO, and the ranking of the categories of those issues,

iii) Root causes for the commonly or frequently occurring issues of the RE process for SDO, and

iv) Suitable RE practices to address the frequently occurring issues of the RE process for SDO.

Based on these features, the closely related studies, presented in the Section 2.6, have been analyzed with respect to the following parameters:

i) Focus of study, ii) Issues/ Risks/ Challenges mentioned, iii) Solution provided, iv) Providing frequently occurring issues of the RE process for SDO, v) Categorization of the frequently occurring issues, vi) Ranking of the frequently occurring issues and ranking of the categories of such issues, vii) Root Cause Analysis.

Table 2.1 presents the analysis of the closely related studies.

Table 2. 1: Analysis of the closely related studies

Sr. #	Title and year of the Study	Focus	Issues/ Risks/Challenges mentioned	Solution Provided	Providing Frequently Occurring Issues of RE Process for SDO	Categorization of Issues/ Risks	Ranking of Frequently Occurring Issues and Issues' Categories	Root Cause Analysis
1	Factors Generating Risks during Requirement Engineering Process in Global Software Development Environment (2014).	Factors which cause risks during the RE process in case of Global Software Development (GSD).	Risks caused by communication and distance, culture, knowledge management and awareness, tools, management, stakeholders, project and process, requirements.	Identification of the situational factors which generate risks during the RE process for SDO.	X	√	X	X
2	Challenges and solutions in global requirements engineering–A literature survey (2014).	Global Requirements Engineering.	Issues related to customer interaction, organizational structure, culture, law, education, climate, communication, coordination, requirements negotiation and prioritization in global requirements engineering context.	Practices for dealing with issues.	X	X	X	X
3	Situational Requirement Engineering Framework for Global Software Development (2014).	Requirements elicitation, analysis, specification, validation and management during GSD.	Situational factors and most influential situational factors which influence RE process in case of GSD.	Situational RE framework.	X	X	Ranking of most influential factors for various RE activities	X

Table 2.1, Continued

Sr. #	Title and year of the Study	Focus	Issues/ Risks/Challenges mentioned	Solution Provided	Providing Frequently Occurring Issues of RE Process for SDO	Categorization of Issues/ Risks	Ranking of Frequently Occurring Issues and Issues' Categories	Root Cause Analysis
4	GlobReq: A framework for improving requirements engineering in global software development projects: Preliminary results (2012).	RE process in the case of GSD.	X	Based on RE practices, GlobReq framework to improve RE process for GSD.	X	X	X	X
5	Risks and Safeguards for the Requirements Engineering Process in Global Software Development (2009).	RE process in the case of GSD.	Risks related to communication and distance, knowledge management and awareness, culture, management and coordination, tools to support processes, clients and miscellany.	Safeguards to address risks.	X	√	X	X
6	Stakeholders in Global Requirements Engineering: Lessons Learned from Practice (2007).	Global requirements engineering challenges.	Challenges related to knowledge acquirement and sharing, alignment of processes and tools, and communication and coordination.	Strategies to deal with challenges.	X	X	X	X
7	Impediments to requirements engineering during global software development (2007).	Main obstacles to the RE process for GSD.	Issues resulting from ineffective communication, cultural diversities and geographical dispersion.	Strategies for dealing with issues.	X	X	X	X

Table 2.1, Continued

Sr. #	Title and year of the Study	Focus	Issues/ Risks/Challenges mentioned	Solution Provided	Providing Frequently Occurring Issues of RE Process for SDO	Categorization of Issues/ Risks	Ranking of Frequently Occurring Issues and Issues' Categories	Root Cause Analysis
8	The Challenges of Distributed Software Engineering and Requirements Engineering: Results of an Online Survey (2007).	Distributed Software Engineering and RE.	Issues like ambiguous requirements, incomplete requirements, changing requirements, incorrect requirements, inefficient RE processes, requirements prioritization, and high number of stakeholders to elicit requirements.	Countermeasures to address the issues.	X	X	X	X
9	Overcoming Requirements Engineering Challenges: Lessons from Offshore Outsourcing (2006).	RE challenges during offshore SDO by presenting nine case studies.	Challenges related to communication and conflicts among stakeholders regarding goals, approaches, tools and signing-off.	Partial framework, based on best RE practices, to deal with three dimensions of people, process and technology.	X	X	X	√
10	Requirements specification in distributed software development- a process proposal (2005).	Building consensus on requirements specification during distributed RE process.	Issues associated to communication, culture, knowledge management and technical aspects.	An iterative requirements specification process for DSD.	X	√	X	X

Table 2.1, Continued

Sr. #	Title and year of the Study	Focus	Issues/ Risks/Challenges mentioned	Solution Provided	Providing Frequently Occurring Issues of RE Process for SDO	Categorization of Issues/ Risks	Ranking of Frequently Occurring Issues and Issues' Categories	Root Cause Analysis
11	Requirements Engineering challenges in multi-site software development Organizations (2003).	RE challenges during outsourced software development on the multiple sites.	Challenges related to communication, knowledge management, cultural diversities and time zone differences.	Recommendations for dealing with challenges.	X	√	X	X

2.8 Research gaps and justification for the model development to address the frequently occurring issues of SDO RE process

The RE process for SDO involves various types of issues which belong to the different categories like communication, knowledge management, cultural diversities, tools, coordination, and relationship among the stakeholders. The analysis of the related studies shows that the studies partly deal with such issues and their solutions. Moreover, no study collects a comprehensive list of the SDO RE process issues. Most of the studies do not mention which are the frequently or commonly occurring issues of the RE process for SDO.

The frequently occurring issues of the RE process for SDO and the categories of such issues have not been ranked based on the 'frequency of occurrence' of the issues. This deficiency of the existing literature hinders the proactive project planning in the case of SDO. Most of the relevant studies do not present the root causes for the occurrences of the common issues of RE process for SDO.

Besides, the studies only partially present the RE practices to address the common or frequently occurring issues of the RE process for SDO.

This research work presents a model for addressing the commonly occurring issues of the RE process for SDO by digging out the frequently or commonly occurring issues of the RE process for SDO, ranking those issues and their categories, discovering the root causes for such issues, and identifying and mapping the best RE practices to the corresponding issues for addressing those issues.

2.9 Summary

In this chapter, literature review is presented by dividing the related work into five categories: i) Requirements elicitation, ii) Requirements prioritization, iii) Requirements

management, iv) Requirements engineering process when stakeholders are geographically distributed, and v) Addressing requirements engineering process issues when stakeholders are geographically distributed. A total of 41 studies are discussed and analyzed. Research gaps are also identified justifying the development of a model to address the frequently occurring issues of the RE process for SDO.

CHAPTER 3: RESEARCH METHODOLOGY

This chapter presents the research objectives, research questions and describes the research methods employed to achieve the identified research objectives.

3.1 Research objectives and research questions

This research work intends to develop Requirements Engineering Process (REP) Model in order to address issues that occur commonly during the Requirements Engineering (RE) process for Software Development Outsourcing (SDO). To achieve this aim, three research objectives and a set of nine associated research questions guide the research.

For the formation of REP Model, the first step of this research work is to explore the existing literature to identify which issues of RE process for SDO have been reported and which are relevant practices to address those issues. So the first research objective is:

Research Objective 1: To identify the literature-based issues of RE process for SDO and to identify the relevant literature-based RE practices to address those issues.

Keeping in view objective 1, literature-based issues of RE process for SDO should be identified. So first Research Question (RQ) is:

RQ1: Which are the literature-based issues of the RE process for SDO?

While identifying issues of RE process for SDO, categories of such issues should also be found. So next research question is:

RQ1.1: Which are categories of the issues of RE process for SDO?

After identifying issues of RE process for SDO from literature and finding categories of such issues, next step is to identify literature-based practices that can be used to address those issues. This leads to second research question:

RQ2: Which are the literature-based RE practices to address the literature-based issues of the RE process for SDO?

Sommerville and Sawyer has proposed a pool of RE practices to resolve the issues of traditional RE process (Sommerville & Sawyer, 1997). To utilize those practices for the SDO RE process, there is a need to empirically investigate that whether those practices are significant in case of the SDO RE process or not. The research question to deal with this matter is as follows:

RQ3: Which of the RE practices recommended by Sommerville and Sawyer (1997) are significant to address the issues of RE process for SDO?

Incorporating the industry perspective is required for a complete and effective research. Therefore, second objective of this research work is to identify the RE issues that are faced by SDO practitioners and the practices they follow to address those issues. So the second objective of research is:

Research Objective 2: To identify additional issues, other than those reported in the literature, of the RE process for SDO and identify the relevant RE practices to address those identified issues.

To fulfill this objective, SDO practitioners need to be approached to find out that what are the issues they encounter during the RE process for SDO, and what are the practices they adopt to address those issues. This perspective helps to define research questions no. 4 and 5:

RQ4: Which are the SDO RE process issues, other than those reported in the literature, faced by SDO practitioners?

The research question no. 5 is:

RQ5: Which are the RE practices adopted by SDO practitioners to address the RE process issues they face?

After exploring existing literature and SDO industry to identify issues of RE process for SDO and relevant practices to address those issues, next step is formation of the REP Model. Therefore, third research objective is:

Research Objective 3: To propose and evaluate the REP Model for addressing the issues of RE process for SDO.

To achieve this objective, four research questions have been designed. To help SDO practitioners for adopting proactive strategy, frequently or commonly occurring issues of RE process for SDO need to be filtered out. So next research question is:

RQ6: Which are the frequently occurring issues of the RE process for SDO?

Ranking the frequently occurring SDO RE process issues and their categories is necessary to develop a workable model. Therefore, research question no. 7 is:

RQ7: What is the ranking of each:

i) Frequently occurring issue of the RE process for SDO within the respective category of the issue (category-wise ranking) and with respect to all categories (overall ranking)?

ii) Category of the issues of RE process for SDO?

After identifying and ranking the frequently occurring issues of RE process for SDO, root causes for those issues need to be explored and then relevant practices should be recommended and mapped to corresponding issues to address those issues. This leads to research question no. 8.

RQ8: Which are the root causes for the frequently occurring issues of the RE process for SDO, and which are the relevant RE practices to address those issues?

After proposing a model, next target is to evaluate the model. This intention points to the last research question.

RQ9: How to evaluate the proposed REP Model?

3.2 Criteria for development of the REP Model

The main purpose of this research work is development of a: i) Comprehensive (complete), ii) Practical (easy to adopt), and iii) Useful (beneficial to address issues) model to address the frequently occurring issues of SDO RE process for assisting the academicians, researchers and SDO practitioners.

By 'Complete' means that the model covers almost all the relevant categories of the frequently occurring issues of RE process for SDO, almost all the frequently occurring issues, sufficient root causes for occurrence of corresponding frequently occurring issues and sufficient RE practices to address corresponding frequently occurring issues.

By 'Practical' means that for each frequently occurring issue of RE process for SDO, corresponding root causes and RE practices have been clearly defined and are unambiguous that is they have only one interpretation. Further in case of each frequently occurring issue, recommended set of RE practices is easy to adapt in most of scenarios without any special arrangements.

By 'Useful' means that for each frequently occurring issue of RE process for SDO, given set of root causes is beneficial enough to explore RE practices for addressing corresponding issue, and recommended set of RE practices is beneficial enough to address corresponding issue. Additionally, proposed model is beneficial enough to support RE process for SDO. By 'Useful' also means that in case of each root cause, recommended set of RE practices is beneficial enough to address corresponding frequently occurring issue of RE process for SDO.

Particularly from the industrial perspective, the criterion for the development of the REP Model is 'usefulness of the recommended RE practice(s) to address the corresponding issue of the SDO RE process in the case of the respective root cause'.

3.3 Research approach and research methods

To fulfill research objectives and answer research questions, mixed-methods approach has been adopted that comprises of Systematic Literature Review (SLR), Questionnaire-based surveys, Computer-Assisted Telephone Interviewing, Delphi method, Cut-off value method , Root Cause Analysis and evaluation from the academic as well as industrial perspective. The mixed-methods approach is combination of qualitative research methods and quantitative research methods (Driscoll, Appiah-Yeboah, Salib, & Rupert, 2007).

(a) Qualitative, Quantitative and Mixed-Methods approaches

Qualitative research approach is exploratory or investigative in nature. It is used for getting insight into problem, for developing ideas and for understanding underlying reasons. Group discussions, in-depth interviews and observations are some common methods for qualitative research approach. Quantitative research is for quantification of opinions, attitudes and behaviors. It is based on numerical data. Questionnaire surveys are common methods for quantitative research (Creswell, 2013; Sale, Lohfeld, & Brazil, 2002). In the mixed-methods approach, qualitative methods and quantitative methods are mixed in one study (Driscoll, et al., 2007). For example, observations and interviews (qualitative approach) are combined with questionnaire surveys (quantitative approach) (Creswell, 2013).

There are three general strategies for following mixed-methods approach: i) Sequential Procedures, iii) Concurrent Procedures, and iii) Transformative Procedures (Creswell, 2013). In the Sequential Procedures strategy, results found by employing one research method are elaborated or expanded by using another research method. While following Sequential Procedures strategy, a study may begin with qualitative method followed by

quantitative method(s). Alternatively, study can be started by using quantitative method that can be followed by qualitative method(s) (Creswell, 2013).

In this research work, Sequential Procedures strategy has been adopted to follow mixed-methods approach keeping in view problem to be addressed and to meet research objectives. The main aim of the research is to develop REP Model for addressing common issues of RE process for SDO. For identifying the common issues of SDO RE process and recommending RE practices to address those issues the research work requires:

A) Exploring relevant literature for finding reported SDO RE process issues and RE practices to address those issues,

B) Taking opinions of SDO industry practitioners, through closed ended and open ended questions, to: i) Categorize SDO RE process issues, ii) Identify Sommerville and Sawyer's significant RE practices for SDO RE process, iii) Identify SDO RE process issues faced by SDO practitioners and practices they follow to address those issues, iv) Extract common issues of SDO RE process, rank those issues and rank categories of issues,

C) Discussions and brainstorming to discover the root causes for occurrence of the common issues of SDO RE process and to recommend RE practices to address those issues,

D) Model evaluation through: i) Expert panel of researchers and academicians, and ii) SDO industry practitioners, by conducting questionnaire surveys.

Therefore, this research work employs mix-methods approach by following Sequential Procedures strategy. A step-wise approach to accomplish research objectives and answer the designed RQs has been depicted in Figure 3.1. The various questionnaire surveys have been identified as 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th} and 6^{th}.

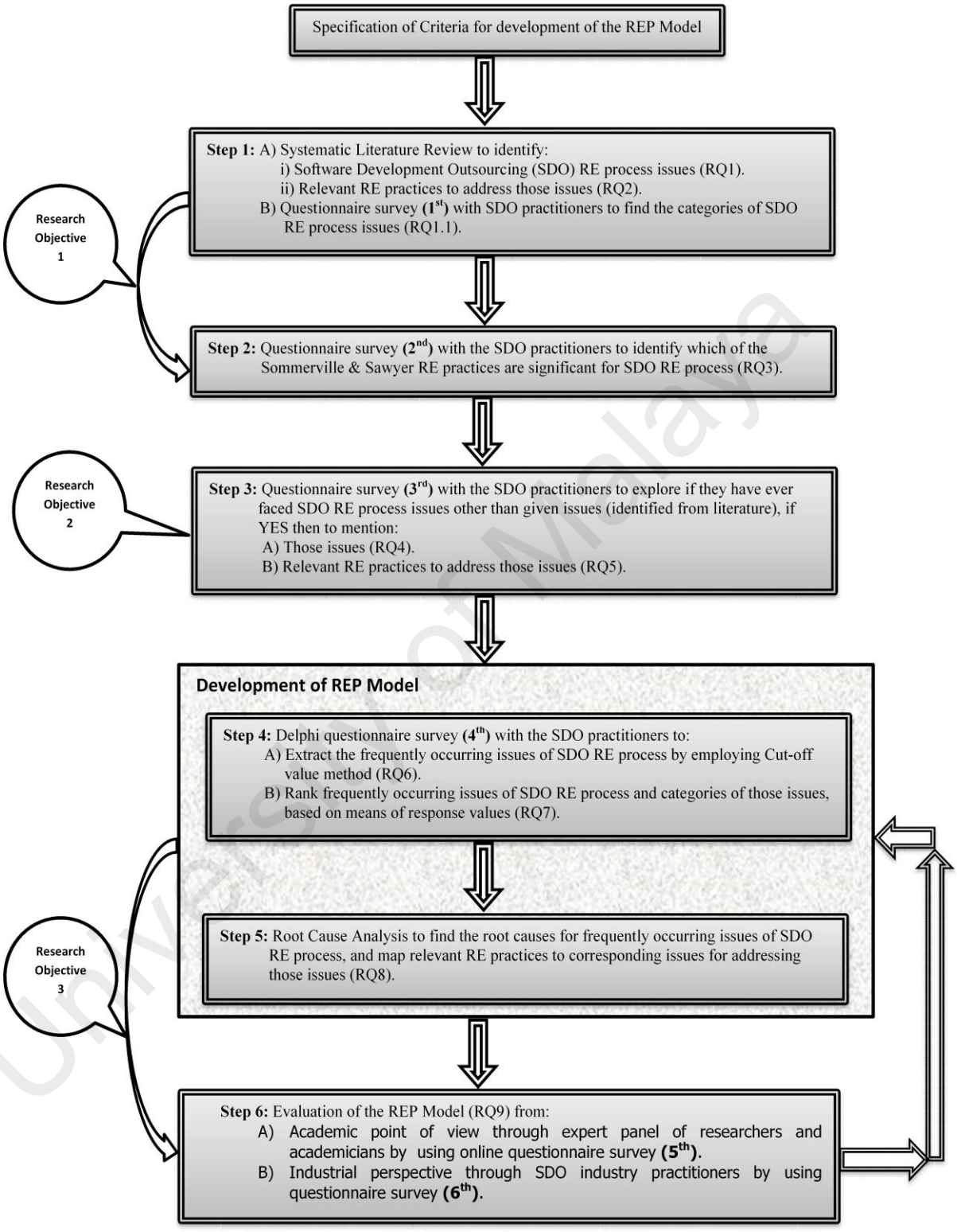

Figure 3. 1: Steps to develop the REP Model

3.3.1 Employing Systematic Literature Review and Questionnaire Surveys

RQ1 is about the identification of RE process issues for SDO from literature. This research question has been answered through Step 1-A (i). RQ1.1 deals with the categories of the issues of RE process for SDO. Step 1-B helps to answer RQ1.1. Step 1-A (i) has been completed through SLR and Step 1-B has been completed through a questionnaire survey (1st questionnaire survey of the research work) with SDO practitioners.

Literature-based RE practices to address SDO RE process issues (RQ2) are identified in Step 1-A (ii). Step 1-A (ii) has also been completed through SLR.

Next target is to investigate which of the RE practices in (Sommerville & Sawyer, 1997) are significant for SDO RE process (RQ3). The Sommerville and Sawyer's significant RE practices for SDO RE process are explored in Step 2. Step 2 has been completed through questionnaire survey (2nd questionnaire survey of the research work) with SDO practitioners.

To develop an effective model, the industry perspective is also incorporated. For this purpose, SDO practitioners have been solicited for reporting additional issues and relevant RE practices to address those issues. SDO RE issues faced by SDO practitioners (RQ4) are found through Step 3-A. The RE practices adopted by SDO practitioners to address the SDO RE issues they face (RQ5), are discovered in Step

3-B. Step 3-A and Step 3-B have been completed through a questionnaire survey (3rd questionnaire survey of the research work) with SDO practitioners.

(a) Systematic Literature Review

The purpose of SLR is to identify, analyze and interpret all the existing research regarding specific research question(s) or topic or area of interest (Keele, 2007). A SLR is performed by using a well-defined methodology that ensures complete, unbiased,

repeatable and assessable research (Keele, 2007). The SLR in this research work has been carried out by using Barbara Kitchenham's methodology (B. Kitchenham, 2004).

(b) Questionnaire Surveys

Questionnaire survey is one of the two basic forms of survey research. A questionnaire is like a form which is filled by respondents by selecting given options and/or answering questions, and is returned back (Creswell, 2002). Personally Administered Questionnaires, Mailed Questionnaires and Web-Based Questionnaires are three types of questionnaires which are used during survey research (Creswell, 2002; Sekaran, 2006). Questionnaires consist of two categories of questions: i) Open-ended questions, ii) Closed-ended questions. While answering closed-ended questions respondents can select one of the given options whereas in case of open-ended questions choices are not fixed and respondents are free to write the answer whatever they like (Sekaran, 2006).

This research involves six questionnaire surveys. All the surveys have been conducted by using semi-supervised approach in which objectives of the survey, questionnaire format and various queries regarding the questionnaire are made clear to respondents by researcher. After that, respondents are given suitable time to fill the questionnaires on their own (Pfleeger & Kitchenham, 2001). During this research semi-supervised approach has been adopted either through face-to-face meetings with respondents or through Computer-Assisted Telephone Interviewing (CATI) technique. CATI technique which contributes toward rapid, cost effective and resulted oriented surveys is based on joint use of interviewing, computer and telephone system (Choi, 2004).

This research work has employed various methods for distribution of questionnaires like Drop-Off/Pick-Up method (Steele et al., 2001), email and online questionnaires. Questionnaire surveys no. 1, 3 and 4 (Section 3.3.2) are drop-off surveys as respondents

for these surveys were busy. Because of the busy schedule, the respondents are not available at a fix time for interviewing or filling questionnaire during face-to-face meetings. Also response rate is high in case of drop-off questionnaires (Allred & Ross-Davis, 2011). Therefore, for these surveys questionnaires have been handed over to participants or their representatives at the working places of participants. The respondents have been given suitable time for filling questionnaires, after that questionnaires have been collected. The 5th questionnaire survey (Section 3.4.1) and 6th questionnaire survey (Section 3.4.2) are web-based questionnaire surveys. For these surveys, the research has targeted physically distributed respondents. Reaching to each respondent individually in such situation is not possible as it requires considerable time, resources and respondents' consent and availability. Whereas web-based questionnaire surveys are cost-effective, opinion of a large no of distributed respondents can be gathered in comparatively short time, and respondents can fill out questionnaires at the time of their choice (Lethbridge, Sim, & Singer, 2005). In the case of the 2nd questionnaire survey, some of the questionnaires have been distributed and filled out during face-to-face meetings, and a number of questionnaires have been sent through email.

(c) Pilot Study

In case of all the six questionnaire surveys, pilot studies (Creswell, 2013) have been conducted. To improve the questionnaire layout, assess the language comprehension and estimate the time required to complete the questionnaires, two rounds of pilot study have been performed for each survey. Recommendations have been incorporated after the first round. The second round has been carried out to ensure that the changes made are according to the given suggestions.

3.3.2 Employing Delphi method

The frequently occurring issues of SDO RE process have been extracted (RQ6) through Step 4-A. Ranking of the frequently occurring issues of SDO RE process and that of their categories (RQ7) has been performed in Step 4-B. This research work completes Step 4-A and Step 4-B by employing Delphi method through two rounds of questionnaire survey (4^{th} questionnaire survey of research work) with SDO practitioners. This research work employs Delphi method through drop-off questionnaire survey because of two reasons: i) To get high response rate, and ii) To develop consensus among SDO practitioners regarding 'frequency of occurrence' of SDO RE process issues, to extract frequently occurring issues, rank such issues and categories of issues.

(a) Delphi method.

Delphi method is an iterative process that is used to build the consensus or to converge the opinion of experts on certain issue(s). A group of experts, from a particular area, is employed for two or three rounds of study (or even more). After each round, every expert is provided with a summary of overall results of that round and his or her own response in that round. The experts are suggested to modify or review their responses given during last round, if they feel it appropriate, keeping in view the combined response of other experts in that round. This process is continued till the achievement of a pre-decided criterion like number of rounds or consensus on a specific achievement (Okoli & Pawlowski, 2004; R. C. Schmidt, 1997; Skulmoski, Hartman, & Krahn, 2007). This research work employs three rounds of Delphi method.

3.3.3 Employing Root Cause Analysis

RQ8 is about exploring root causes for the frequently occurring issues of RE process for SDO and relevant RE practices to address those issues. RQ8 has been answered by performing Root Cause Analysis through Step 5.

(a) Root Cause Analysis

In this research Root Cause Analysis (RCA) has been performed to discover the root causes for occurrence of the common SDO RE process issues as RCA method is employed for preventing or solving problems by investigating the root causes of problems and recommending actions to correct or avoid those problems (Lehtinen, Mäntylä, & Vanhanen, 2011; Sandeep Dalal, 2013). Thus RCA can provide support for process improvement (Lehtinen, et al., 2011). Software development can be improved if causes of the software development problems are analyzed and controlled (Lehtinen, Mäntylä, Vanhanen, Itkonen, & Lassenius, 2014). RCA method comprises of three steps:

i) Detecting Problem, ii) Detecting Root Cause, and iii) Recommending Corrective Actions (Lehtinen, et al., 2011).

For performing RCA, workshops have been conducted during which '5 Whys' and 'Brainstorming' techniques have been used.

3.4 Model evaluation

Finally the REP Model has been evaluated (RQ9) in Step 6 by performing evaluation through: i) Expert panel of researchers and academicians, and ii) Practitioners from SDO industry. Evaluation through human experts is fairly common (Abramson et al., 2014; Beecham, Hall, Britton, Cottee, & Rainer, 2005; Bertolino, De Angelis, Di Sandro, & Sabetta, 2011; Carpio, Martín-Morales, & Zamorano, 2015; Dyba, 2000; Pelly, Meyer, Pearce, Burkhart, & Burke, 2014; Rosqvist, Koskela, & Harju, 2003; Ruiz, Segura, & Sirvent, 2015). The utility of evaluation by experts, in a particular field, is widely acknowledged (B. Kitchenham, Pfleeger, McColl, & Eagan, 2002; Lauesen & Vinter, 2001) as experts with relevant background and expertise are believed to provide fruitful and valuable feedback (Mathew, Field, & French, 2011). Evaluation of the model has been carried out from:

A) The academic perspective through expert panel of researchers and academicians (Step 6-A).

B) The industrial perspective through practitioners from SDO industry (Step 6-B).

3.4.1 Model evaluation from the academic perspective through expert panel of researchers and academicians

For evaluation of the REP Model from researchers and academicians, 'Completeness', 'Practicality' and 'Usefulness' are three criteria. For the evaluation three experts, having research and academic experience, have been involved and an online questionnaire survey (5^{th} questionnaire survey of research work) has been conducted. Experts have evaluated the model against three given criteria by using a 7-point Likert Scale. The results have been examined by performing: i) Inter-Rater Reliability Analysis through calculation of Cohen's kappa coefficient (k), and ii) Analysis of Means (ANOM).

3.4.2 Model evaluation from the industrial perspective through practitioners from SDO industry

To evaluate the REP Model from the industrial standpoint, criterion is 'usefulness of recommended RE practice(s) for addressing the corresponding issue in case of respective root cause'. For this purpose, 11 experienced SDO practitioners have been involved and a questionnaire survey (6^{th} questionnaire survey of research work) has been conducted. Practitioners have evaluated the model against given criterion by using a 4-point Likert Scale. Results have been analyzed through three different methods:

i) By applying 50% rule,

ii) By analysis of responses through Content Validity Index (CVI),

iii) By analysis of responses through Confidence Interval (CI).

3.5 Summary

This chapter narrates the 3 research objectives, related research questions and criteria for the development of the REP Model. Further, the overall research approach is presented along with the introduction of research methods that are used subsequently for completing this research work. In the end, particulars of the REP Model evaluation are presented. Table 3.1 shows the research methods that are used to fulfill the Research Objectives (ROs) and answer the Research Questions (RQs). Relevant chapter numbers and surveys' numbers are also mentioned.

Table 3. 1 : Research methods employed to achieve research objectives and relevant chapter numbers.

ROs	RQs	Research Methods	Chapter No.
RO1	RQ1	Systematic Literature Review	Chapter 4
	RQ1.1	Questionnaire Survey (1^{st} questionnaire survey of research work)	
	RQ2	Systematic Literature Review	
	RQ3	Questionnaire Survey (2^{nd} questionnaire survey of research work)	
RO2	RQ4	Questionnaire Survey (3^{rd} questionnaire survey of research work)	
	RQ5	Questionnaire Survey (3^{rd} questionnaire survey of research work)	
RO3	RQ6	Delphi method, Cut-off value method (4^{th} questionnaire survey of research work)	Chapter 5
	RQ7	Delphi method, Ranking based on means of response values. (4^{th} questionnaire survey of research work)	
	RQ8	Root Cause Analysis, 5 Whys and Brainstorming techniques	
	RQ9	Online questionnaire survey with expert panel consisting of academicians and researchers (5^{th} questionnaire survey of research work)	Chapter 6
		Questionnaire survey with SDO industry practitioners (6^{th} questionnaire survey of research work)	

CHAPTER 4: IDENTIFICATION OF THE RE PROCESS ISSUES FOR SOFTWARE DEVELOPMENT OUTSOURCING AND EXPLORATION OF THE RE PRACTICES TO ADDRESS THE ISSUES

This chapter deals with the identification of the literature-based issues of Requirements Engineering (RE) process for Software Development Outsourcing (SDO) and the exploration of the literature-based RE practices that are followed to address those issues. The categories of such issues are also identified. Afterwards, the details are provided to find the Sommerville and Sawyer's significant RE practices to address the issues of the RE process for SDO. The next step is the identification of the SDO RE process issues faced by SDO practitioners and the exploration of RE practices that the practitioners adopt to address those issues. Table 4.1 shows the association of the research objectives and research questions with the contents of Chapter 4.

Table 4. 1 : Relationship between research objectives and contents of chapter 4

Research Objectives (ROs)	Research Questions (RQ)	Research Methods	Output
RO1	RQ1	Systematic Literature Review	Table [4.6]
	RQ1.1	Questionnaire Survey (1st questionnaire survey of research work)	Table [4.5]
	RQ2	Systematic Literature Review	Table [4.7]
	RQ3	Questionnaire Survey (2nd questionnaire survey of research work)	Table [4.16]
RO2	RQ4	Questionnaire Survey (3rd questionnaire survey of research work)	Table [4.6]
	RQ5	Questionnaire Survey (3rd questionnaire survey of research work)	Table [4.18]

4.1 Systematic Literature Review

Systematic Literature Review (SLR) has been conducted to identify the issues of RE process for SDO and to explore the relevant RE practices that can be used to address

those issues. This SLR has been carried out by using guidelines as given in the study (Keele, 2007; B. Kitchenham, 2004).

(a) Research Questions

The aim of this SLR is to explore the existing literature to identify the issues of RE process for SDO and related RE practices to address those issues. The primary research question for this SLR is "*Which are literature-based issues of RE process in case of SDO and which are literature-based relevant RE practices to address those issues?"* This primary research question has been decomposed into two research questions:

RQ1: Which are literature-based issues of RE process for SDO?

RQ2: Which are the relevant RE practices, reported in the literature, to address literature-based issues of RE process for SDO?

(b) Data Sources

Five electronic databases have been employed as data sources to find potentially relevant studies. The selected electronic databases have been listed in Table 4.2.

Table 4.2: Electronic databases (ED) searched for systematic literature review

Identifier	Database	URL
ED1	IEEE Xplore	http://ieeexplore.ieee.org/
ED2	ACM	http://dl.acm.org/
ED3	Science Direct	http://sciencedirect.com/
ED4	Springer Link	http://link.springer.com/
ED5	Web of Science	http://webofknowledge.com/

(c) Search String

The following search terms have been used to define search string for searching the electronic databases. These search terms have been derived keeping in view the research questions and relevant literature.

i) Requirements

ii) Issues OR problems OR risks OR errors OR challenges OR barriers

iii) Practice OR lesson OR solution OR strategy OR strategies

iv) Outsource OR outsourced OR outsourcing

v) Domestic OR onshore OR onshoring OR “on shore” OR nearshore OR nearshoring OR nearshored OR “multi-site” OR offshore OR offshoring OR offshored OR “off shore” OR global OR distributed

vi) “Software development”

The search string has been derived by combining these search terms, using conjunction (AND) and disjunction (OR) operators, and wildcard *. The resulting search string is:

((Requirements)

AND

(Issues OR problems OR risks OR errors OR challenges OR barriers OR practice OR lesson OR solution OR strateg)*

AND

(outsourc OR domestic OR onshor* OR "on shore" OR nearshor* OR "multi-site" OR offshor* OR "off shore" OR global OR distributed)*

AND

("Software development"))

This basic search string has been applied in different forms to search the selected electronic databases. For example, to find the relevant studies from IEEE Xplore, the basic search string has been decomposed in to five sub-strings. These sub-strings have been applied one by one through the Command Search option. The sub-strings have been shown in Figure 4.1.

i) *((Requirements)*
AND
(Issues OR problems OR risks OR errors OR challenges OR barriers OR practice OR lesson OR solution OR strateg)*
AND
(outsourc)*
AND
("Software development"))
ii) *((Requirements)*
AND
(Issues OR problems OR risks OR errors OR challenges OR barriers OR practice OR lesson OR solution OR strateg)*
AND
(Domestic OR onshor OR "on shore")*
AND
("Software development"))
iii) *((Requirements)*
AND
(Issues OR problems OR risks OR errors OR challenges OR barriers OR practice OR lesson OR solution OR strateg)*
AND
(nearshor OR "multi-site")*
AND
("Software development"))
iv) *((Requirements)*
AND
(Issues OR problems OR risks OR errors OR challenges OR barriers OR practice OR lesson OR solution OR strateg)*
AND
(Offshor OR "Off Shore")*
AND
("Software development"))
v) *((Requirements)*
AND
(Issues OR problems OR risks OR errors OR challenges OR barriers OR practice OR lesson OR solution OR strateg)*
AND
(Global OR distributed)
AND
("Software development"))

Figure 4. 1: Sub-strings for searching from IEEEXplore

(d) Selection of Studies

The studies' selection procedure for SLR has been presented in Figure 4.2. This procedure encompasses three phases which are: i) Identification of studies, ii) Screening of studies on the basis of title and abstract, and iii) Screening of studies on the basis of full-text. To avoid biasedness, two fellow researchers have been involved during all the phases and each phase has been completed after developing consensus.

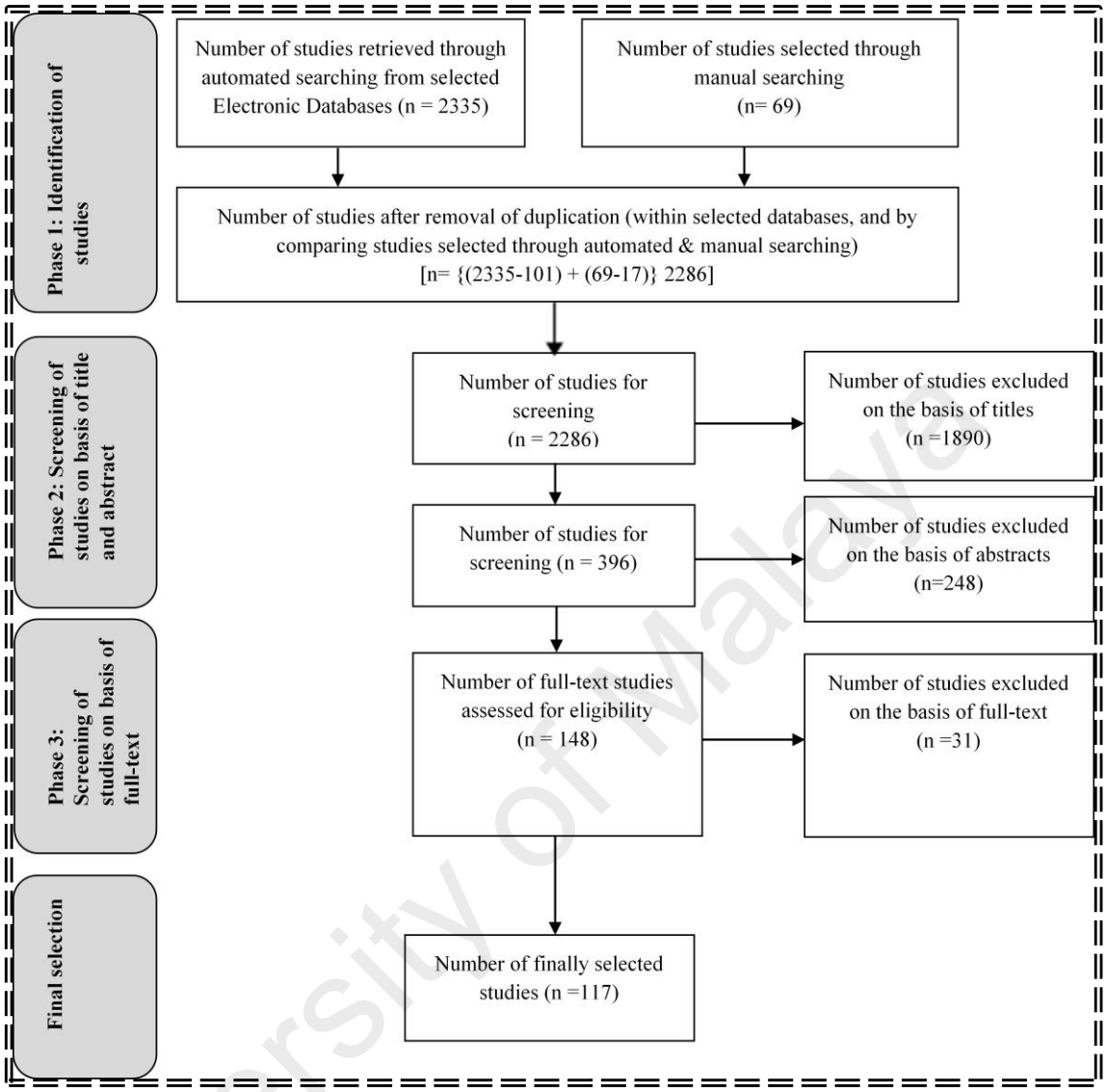

Figure 4. 2: Studies selection procedure

(e) Inclusion and Exclusion Criteria

The inclusion and exclusion criteria have been applied during the studies' selection procedure to choose the potentially relevant studies that are suitable to answer the research questions. Time period for automated searching from selected electronic databases is from 2000 to June 2014. The inclusion and exclusion criteria employed for this SLR are:

- **Inclusion Criteria (IC)**

IC1: Studies that are related to the issues of RE process for SDO.

IC2: Studies that are related to the practices that can be used to address the issues of RE process for SDO.

- **Exclusion Criteria (EC)**

EC1: Studies that are duplicated in more than one electronic databases or duplicated in automated and manual search.

EC2: Studies other than English language.

EC3: Studies that are not related to the issues of RE process for SDO or are not related to the practices that can be used to address the issues of RE process for SDO.

EC4: Studies with ambiguous findings.

(f) Quality Assessment Criteria

The Quality Assessment (QA) criteria for this SLR are:

QA1: Are the inclusion and exclusion criteria appropriate?

QA2: Has impartiality been ensured during the selection of studies?

QA3: Are the studies context specific?

QA4: Is evidence in support of findings?

The inclusion and exclusion criteria have been defined and reviewed carefully keeping in view the research questions. To guarantee neutrality during studies selection procedure, two fellow researchers have been involved during all the three phases of this procedure. Furthermore, only those studies have been selected for data extractions that are relevant to the context. For example, studies regarding insourced offshoring or insourced near shoring have been excluded. Lastly, only those studies have been considered for final selection in which evidences support the results and there are no contradictions.

Keeping in view inclusion & exclusion, and quality assessment criteria, each study has been reviewed by three reviewers. After passing through an arduous review process and screening, finally 117 studies have been selected for data extraction. These 117 studies include 77 studies from automated searching and 40 studies from manual searching. Database-wise details of 77 studies, selected through automated searching, have been provided in Table 4.3.

Table 4. 3 : No. of retrieved studies and finally selected studied from the different electronic databases

Identifier	Database	No. of retrieved studies	No. of finally selected studies	Percentages to total no. of finally selected studies
ED1	IEEE Xplore	431	39	50.65≈51%
ED2	ACM	310	10	12.99≈13%
ED3	Science Direct	679	08	10.39≈10%
ED4	Springer Link	662	12	15.58≈16%
ED5	Web of Science	253	08	10.39≈10%
	Total	**2335**	77	**100%**

Figure 4.3 represents the percentages of the finally studies selected from different databases.

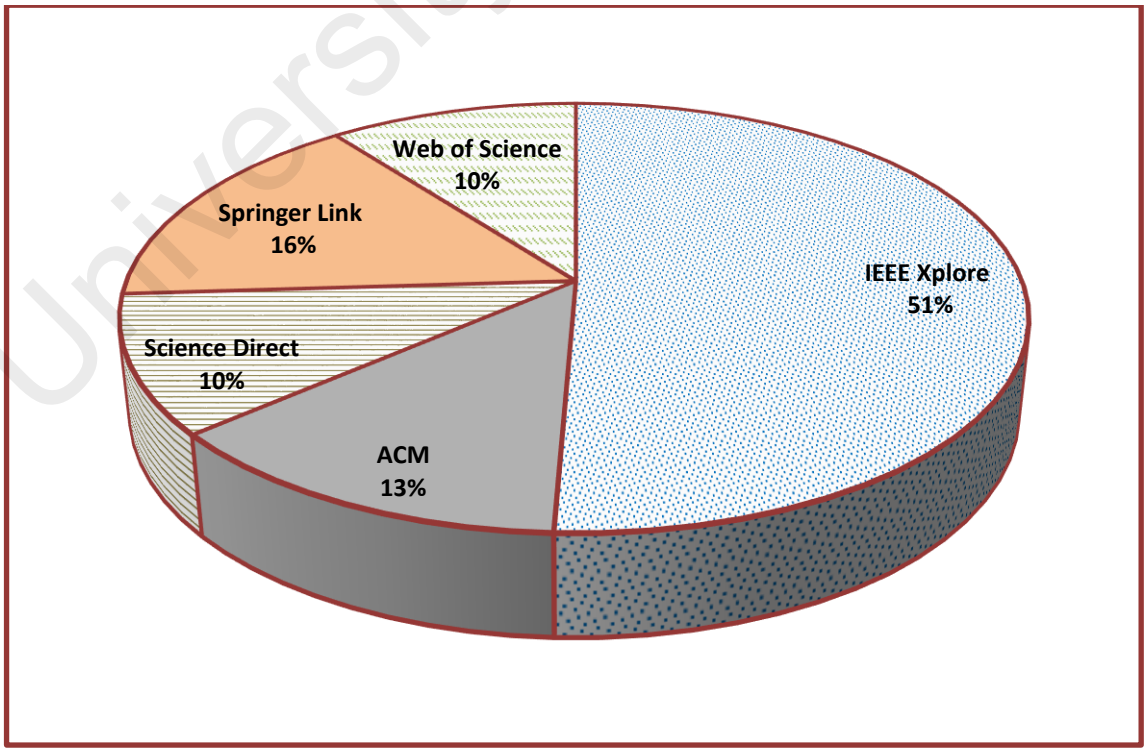

Figure 4. 3: Database-wise percentages of finally selected studies

The 40 studies have been selected through the manual search that is based on searching the issues of RE process for SDO and practices to address those issues, publications of specific authors and references of the studies retrieved through automated searching.

These 117(77+40) studies have been investigated thoroughly to find the issues of RE process for SDO and to explore the relevant RE practices to address those issues. The issues are related to different categories like communication, knowledge management, culture etc. A questionnaire survey has been conducted along with the SLR to find the categories of those issues according to the perception of SDO practitioners.

4.2 Identifying the categories of RE process issues for Software Development Outsourcing

A questionnaire survey (1st questionnaire survey of research work) has been employed to find the categories of SDO RE process issues. The survey respondents are SDO practitioners. The 50% rule has been used for data analysis. Guidelines provided in study (B. A. Kitchenham & Pfleeger, 2008) have been used to design and conduct the survey.

(a) Data Collection: This survey is a cross sectional study. The questionnaire, provided in Appendix A as questionnaire 1, has been used for the study. The 200 questionnaires have been distributed through drop-off/pick-up method. The survey has been conducted by using semi-supervised approach (Pfleeger & Kitchenham, 2001). Respondents have been guided and their queries have been answered through Computer-Assisted Telephone Interviewing technique (Anie, Jones, Hilton, & Anderson, 1996).

(b) Questionnaire Format: The questionnaire contains two parts. The purpose of the first part is to collect data about the respondents' experience, job nature and respective companies. The second part is meant for data collection about the categories of the RE

process issues for SDO. To improve the questionnaire layout, assess the language comprehension and estimate the time required to complete the questionnaire, two rounds of pilot study have been conducted. Recommendations have been incorporated after the first round. The second round has been carried out to ensure that the changes made are according to the given suggestions.

The nine possible categories of RE process issues for SDO have been mentioned in the questionnaire. The SDO practitioners have been inquired, by providing 'YES' or 'NO' option, which of these categories should be considered as categories of RE process issues for SDO. The practitioners have also been requested to mention categories, if there are, other than nine given categories.

(c) Sampling and population: The Convenience Sampling method has been employed for obtaining a valid sample of respondents. The respondents are project managers, software engineers, team leaders, quality assurance managers, programmers, designers, requirements engineers, analysts and manager operations having at least 5 years SDO experience.

(d) Response rate: The total responses have been received back are 115 (57.50%).

Out of a total of 115 responses, the 105 responses (52.50%) have been selected for analysis based on the respondent's company profile, job title and relevant experience. Table 4.4 shows details about the first questionnaire survey of this research work.

Table 4. 4 : Details about the first questionnaire survey of research work

		No. of Questionnaires			
	Survey Medium	**Distributed**	**Received Back**	**Selected for Data analysis**	**Percentages**
	Questionnaire Drop-Off/Pick-Up	200	115	----	57.50%
Total	----	200	----	105	52.50%

e) Criterion for the selection of categories: If at least 50% of respondents select 'YES' option in case of a potential category then that category is considered as a

category for the RE process issues in case of SDO. A similar method, using the criterion of considering the opinion of 50% or more respondents for decision making, has already been employed effectively in preceding studies (Cox, Niazi, & Verner, 2009; Niazi, Wilson, & Zowghi, 2005; Rainer & Hall, 2002). In the study (Rainer & Hall, 2002), key or important factors for software process improvement have been identified by using the principle that if 50% or more respondents believe that a factor has a major impact then that factor is treated as important.

f) Survey results: Out of the nine possible categories, in case of seven categories 50% or more respondents have selected 'YES' option. Therefore, those categories have been selected as the categories of RE process issues for SDO. The selected categories are : i) Communication, ii) Knowledge management and awareness, iii) Cultural diversities, iv) Management and coordination, v) Processes and tools, vi) Relationship among stakeholders, and vii) Requirements centric. The 'Trust' and 'Organizational structure' do not fulfill selection criterion, therefore, have not been considered as issues' categories. This helps to answer RQ1.1. Table 4.5 shows the survey results.

Table 4. 5 : Results of the survey to identify the categories of the issues of RE process for SDO

Sr. #	Possible Categories of Issues	Respondents				
		Total	Selecting 'YES'		Selecting 'NO'	
			Number	Percentage	Number	Percentage
1.	Communication	105	105	100%	0	0%
2.	Knowledge management and awareness	105	98	93.33%	7	6.67%
3.	Cultural diversities	105	70	66.67%	35	33.33%
4.	Trust	105	50	47.62%	55	52.38%
5.	Management and coordination	105	90	85.71%	15	14.29%
6.	Organizational structure	105	34	32.38%	71	67.62%
7.	Processes and tools	105	85	80.95%	20	19.05%
8.	Relationship among stakeholders	105	80	76.19%	25	23.81%
9.	Requirements centric	105	100	95.24%	5	4.76%

4.2.1 Categories of the RE process issues for SDO

Thus, seven categories of the issues have been selected for proposing the REP Model to address the issues of RE process for SDO. These categories can be defined as:

i) Communication issues: The issues associated with communication among the various stakeholders that are scattered across different countries and times zones.

ii) Knowledge management and awareness issues: The issues that are resulted from improper management of the required knowledge and unawareness of the stakeholders from this knowledge at right time.

iii) Cultural diversities issues: The issues that are originated from diverse cultural backgrounds of stakeholders.

iv) Management and coordination issues: The issues that are initiated because of the poor management of RE process and poor coordination among the stakeholders.

v) Processes and tools issues: The issues that arise because of the inappropriate use of tools and processes.

vi) Relationship among stakeholders issues: The issues that are concerned with requirements engineering related interactions among the distant stakeholders.

vii) **Requirements centric issues:** The issues that are generated because of the improper requirements elicitation, analysis, specification, modeling, validation and management.

4.3 Literature-based issues of RE process for SDO

Through the SLR, details provided in Section 4.1, 129 issues have been identified in case of RE process for SDO. Out of those 129 issues, 21 issues belong to 'Communication' category that have been represented as Issue1, Issue2, …, Issue21. Similarly, 21 issues belong to 'Knowledge management and awareness' that have been

represented by Issue23, Issue24, …, Issue43. 'Cultural diversities' category causes 19 issues that have been denoted by Issue47, Issue48, …, Issue65. Furthermore, 19 issues belong to 'Management and coordination' that have been represented by Issue69, Issue70, …, Issue87. 'Processes and tools' category has 16 issues that have been represented by Issue91, Issue92, ..., Issue106. Similarly, 14 issues are related to 'Relationship among stakeholders' that have been denoted by Issue110, Issue111, …, Issue123 whereas 19 issues are 'Requirements centric' that have been symbolized by Issue124, Issue125, …, and Issue142. All the 129 issues have been given in Table 4.6. This provides the answer to RQ1.

Note: To present a complete list of issues, the additional issues (identified through 3rd questionnaire survey of this research work) have also been presented in Table 4.6.

Table 4. 6 : Literature-based and additional issues of RE process for SDO

IDs	Literature-based Communication issues of RE process for SDO
Issue1	Infrequent and constrained communication among the stakeholders during RE process (Zowghi, 2002).
Issue2	Lack of informal communication among the stakeholders during RE process (Calefato, et al., 2012; D. Damian, 2007; D. E. Damian & Zowghi, 2002; de Farias Junior, de Azevedo, de Moura, & Silva, 2012).
Issue3	For clarification and resolution of misunderstandings about requirements, face to face communication is required (R Prikladnicki, et al., 2005).
Issue4	Lack of face to face communication (Avritzer, Ostrand, & Weyuker, 2006; de Farias Junior, et al., 2012; Moe & Šmite, 2007).
Issue5	Lack of synchronous communication (Casey & Richardson, 2008; Nidhra, Yanamadala, Afzal, & Torkar, 2013).
Issue6	Even through the videoconferencing, it is hard to conduct long and productive negotiations in particular when many stakeholders are involved (D. Damian, Lanubile, & Mallardo, 2008).
Issue7	Delayed responses (de Farias Junior, et al., 2012; Holmstrom, Conchúir, Ågerfalk, & Fitzgerald, 2006; Noll, Beecham, & Richardson, 2010).
Issue8	Arrangement of collocated meetings among stakeholders is unfeasible in most of cases because of the distance involved (Christiansen, 2007; Mallardo, Calefato, Lanubile, & Damian, 2007).
Issue9	Poor client-vendor communication (Nakatsu & Iacovou, 2009).
Issue10	Arranging the face-to-face gatherings escalates cost (Christiansen, 2007; Nidhra, et al., 2013; Šmite, 2006).

Table 4.6, Continued

Issue11	Stakeholders do not use synchronous Internet communication technologies to communicate about the requirements and depend on formal means like scheduled meetings, emails and documents (D. Damian, 2007).
Issue12	Meetings to take decisions about the requirements are unproductive (D. E. Damian & Zowghi, 2002, 2003b).
Issue13	Asynchronous communication causes delay in propagation and solution of issues (D. E. Damian & Zowghi, 2003a).
Issue14	When there is synchronous meeting among the sites having considerable time differences, the stakeholders at least from one site are quite disturbed since either it is too late or too early with respect to daily working schedule(D. E. Damian & Zowghi, 2003a) (D. Damian, 2002) (Zowghi, 2002).
Issue15	Stakeholders are not fluent in the communication language (D. E. Damian & Zowghi, 2002).
Issue16	Electronic communication like email allows covert communication that creates challenges for resolving requirements conflicts (D. E. Damian & Zowghi, 2002).
Issue17	Stakeholders do not communicate with each other effectively, and look for exerting power and using influence on each other(D. E. Damian & Zowghi, 2003a).
Issue18	For clarification and resolution of issues, any team member can communicate with any other stakeholder that can result in repetitive discussions and demands for extra controlling efforts (Babar & Zahedi, 2013).
Issue19	Communication gaps or delays during RE due to personality clashes(Berenbach, 2006).
Issue20	Online communication for clarification of requirements leads to problematic requirements as such requirements are ambiguous, change frequently or are incomplete (Knauss & Damian, 2013).
Issue21	Attaining the consent of distant stakeholders for interviewing and scheduling it (Rafael Prikladnicki, Boden, Avram, de Souza, & Wulf, 2014).
IDs	**Additional Communication Issues of RE process for SDO Reported by SDO Practitioners**
Issue22	Usually non recording of commitments made during videoconferencing or telephonic conversation, therefore, it cannot be referred if required [Proposed].
IDs	**Literature-based Knowledge management and awareness issues of RE process for SDO**
Issue23	Hindrance in circulation of requirements knowledge from/to organizations (Schmid, 2014).
Issue24	Incapability of tracing the stakeholders, and related information, that are affected by introducing new requirements (Lormans, et al., 2004).
Issue25	Stakeholders are incapable of seeking relevant knowledge, procedures are integrated inappropriately to synthesize the knowledge, and knowledge transfer is delayed or blocked (Desouza, Awazu, & Baloh, 2006).
Issue26	Unawareness of the stakeholders from current/latest information about requirements (Kwan, Damian, & Marczak, 2007).
Issue27	Requirements information obtained by multiple distant sources is not shared with all the stakeholders (D. Damian, 2002) (D. E. Damian & Zowghi, 2003b; Zowghi, 2002) .
Issue28	Geographically distributed stakeholders cannot get the advantages of social mechanisms and processes that are present in case of co-located workspace, therefore, need for awareness about the requirements is intensified (D. Damian, Chisan, Allen, & Corrie, 2003).
Issue29	Reopening of the already discussed and seemingly settled issues (D. Damian, et al., 2003) (Chisan & Damian, 2004).
Issue30	Organizational structure, which does not match with the task assignments, can hinder the flow of knowledge (D. Damian, Helms, Kwan, Marczak, & Koelewijn, 2013).
Issue31	Propagation of the information about requirements changes is ineffective (D. Damian, 2007).
Issue32	Practitioners forget to inform relevant stakeholders about the requirements changes.
Issue33	The groups that are working on the same or associated requirements are not aware of the stakeholders affected by alterations in the requirements or stakeholders who affect the requirement changes (D. Damian, 2007).
Issue34	Poor requirements change management (Nakatsu & Iacovou, 2009) (Mathrani, Parsons, & Mathrani, 2012).

Table 4.6, Continued

Issue35	The various teams/groups that are working on the identical or associated requirements are not aware of the expertise of practitioners from remote groups (D. Damian, 2007).
Issue36	Formal means of communication like documents cannot exhibit requirements' changes as rapidly as it is required (D. Damian, et al., 2003) (Herbsleb, Mockus, Finholt, & Grinter, 2000).
Issue37	Working on obsolete requirements (M Heindl, et al., 2007) (Kwan, et al., 2007).
Issue38	Availability of the consistent information, as sources are distributed, is difficult (Illes-Seifert, et al., 2007).
Issue39	Lack of the awareness, about the environment in which system is to be deployed, may lead to ambiguous requirements (R Prikladnicki, et al., 2005).
Issue40	Unawareness from the context and importance of requirements that lead to project delays and quality compromises (Matthias Heindl & Biffl, 2006).
Issue41	Requirements clarifications are conveyed late that cause delay in project (Kwan, et al., 2007).
Issue42	Inability of sharing knowledge or best practices(D. E. Damian & Zowghi, 2003b) (Levina & Vaast, 2008) .
Issue43	Unawareness of requirements engineers from the effects of new system implementation on the client organization (Goguen, 1993).
	Additional Knowledge management and awareness Issues of RE process for SDO Reported by SDO Practitioners
Issue44	The groups that are working on the same or associated requirements are not aware of the fact that who is dealing with which requirement [Proposed].
Issue45	Unawareness from or not accessing all requirements sources [Proposed].
Issue46	Improper requirements traceability [Proposed].
IDs	**Literature-based Cultural diversities' issues of RE process for SDO**
Issue47	Distance causes cultural differences among the various functional units of an organization that creates hindrance in attaining the common understanding of requirements (D. E. Damian & Zowghi, 2003a) (D. E. Damian & Zowghi, 2002) (D. E. Damian & Zowghi, 2003a).
Issue48	Creating trust is challenging (D. E. Damian & Zowghi, 2002) (Rafael Prikladnicki, et al., 2014) (Al-Ani et al., 2013; Jalali, Gencel, & Šmite, 2010; Niazi, Ikram, Bano, Imtiaz, & Khan, 2013) (Oza, Hall, Rainer, & Grey, 2006).
Issue49	Maintaining trust is challenging (Jalali, et al., 2010) (Oza, et al., 2006).
Issue50	Lack of trust (Rafael Prikladnicki, et al., 2014) (Al-Ani, et al., 2013) (de Farias Junior, et al., 2012; Jalali, et al., 2010) (Moe & Šmite, 2007; Rafael Prikladnicki, et al., 2007) .
Issue51	Avoidance of the commitments from the stakeholders (R Prikladnicki, et al., 2005).
Issue52	Loss of cohesion among stakeholders because of geographical dispersion (Helén, 2004).
Issue53	Difficulties in achieving consensus on requirements (D. Damian, 2001; Decker, Ras, Rech, Jaubert, & Rieth, 2007; R Prikladnicki, et al., 2005) (Zowghi, 2002).
Issue54	Stakeholders belonging to diverse cultural backgrounds and have different ethical values about hierarchies, handling risks, following schedules and punctuality that may escalate conflicts (R Prikladnicki, et al., 2005).
Issue55	Different cultures have different ethics regarding precision of work and improvisation ability (Illes-Seifert, et al., 2007).
Issue56	Practitioners from diverse cultural backgrounds have inexplicit and unstated meanings and explanations of the information about the requirements (Hanisch & Corbitt, 2007; Hanisch, et al., 2005).
Issue57	Practitioners from various cultural backgrounds draw/deduce varied meanings from messages (Boden, Avram, Bannon, & Wulf, 2009).
Issue58	Some practitioners, because of their cultural backgrounds, cannot disagree with the clients, therefore, 'nice to have' requirements and key requirements have equal priorities (Illes-Seifert, et al., 2007).
Issue59	Customer requirements are not well-understood and delivered because of dissimilar culture and language (Xiong & Wu, 2009).

Table 4.6, Continued

Issue60	Participants of remote requirements engineering meetings are not expert in single common language (Calefato, Lanubile, & Prikladnicki, 2011; Nidhra, et al., 2013).
Issue61	Stakeholders are at different proficiency level of communication language, therefore, stakeholder at higher level dominates and affects the requirements communication (Noll, et al., 2010).
Issue62	Same words are used to convey the different meanings in different organizations that creates misunderstandings for specifying and validating requirements (D. E. Damian & Zowghi, 2002).
Issue63	The individuals, who are not proficient in communication language, are reluctant in asking questions for clarifications (Noll, et al., 2010).
Issue64	Shyness of the stakeholders, for example avoidance from making phone calls to unfamiliar persons, causes delayed communication (Christiansen, 2007).
Issue65	The requirements comprehension is reduced if requirements are stated in the non-native language (R Prikladnicki, et al., 2005).
IDs	**Additional Cultural diversities' Issues of RE process for SDO Reported by SDO Practitioners**
Issue66	Nonparticipation or exclusion of stakeholders from RE activities [Proposed].
Issue67	Some of the stakeholders do not participate or contribute in the conversation because of their non-fluency in the communication language [Proposed].
Issue68	Difficulties in setting realistic expectations about response time [Proposed].
IDs	**Literature-based Management and coordination issues of RE process for SDO**
Issue69	Difficulties in comprehending information, reasons and activities that are required for common Requirements Understanding (RU) among the dispersed stakeholders (D. E. Damian & Zowghi, 2003a) (D. E. Damian & Zowghi, 2002, 2003a) (Alnuem, et al., 2012).
Issue70	Time zone differences cause problems for coordination (Begel & Nagappan, 2008; Rafael Prikladnicki & Carmel, 2013) .
Issue71	Hindrance for appropriate involvement of stakeholders in RE activities because of time differences (Zowghi, 2002).
Issue72	Delay in clarifications about requirements and decision making (R Prikladnicki, et al., 2005).
Issue73	Propensity of less or non-reporting of the problems because of distance (D. Damian, 2002).
Issue74	Even the skilled professionals can become nervous and inactive because of being distant (Berenbach, 2006).
Issue75	Poorly defined or undefined responsibilities (Illes-Seifert, et al., 2007) (Gumm, 2007).
Issue76	Absence of central and trusted management in area of requirements engineering causing poor coordination (Berenbach, 2006).
Issue77	Absence of a firm, skilled and central analyst role (Berenbach, 2006).
Issue78	Underestimation of the time required for conducting requirements review (Berenbach, 2006).
Issue79	Unfair allocation of workload to various teams (Rafael Prikladnicki, Audy, & Evaristo, 2003).
Issue80	No assessment of the effect of stakeholders' distribution on different RE activities (Rafael Prikladnicki, et al., 2003).
Issue81	Conflicting interests of different stakeholders (D. E. Damian & Zowghi, 2002) (D. Damian, 2001).
Issue82	The requirements are elicited from the stakeholders that are spread over various organizational units and thus requirements have to bundle or pack (Gumm, 2007).
Issue83	High number of stakeholders as sources of requirements (Illes-Seifert, et al., 2007).
Issue84	Need for adjustment of actual requirements to interact with other software(s) (Gumm, 2007).

Table 4.6, Continued

Issue85	Analysts change requirements by ignoring the change management process (Berenbach, 2006).
Issue86	In case of temporal dispersion, synchronized coordination is required to build the trust (Rafael Prikladnicki & Carmel, 2013).
Issue87	Remote teams or RE teams work with tight schedules to meet deadlines (Hashmi, Ishikawa, & Richardson, 2013) (Perera, 2011).
IDs	**Additional Management and coordination Issues of RE process for SDO Reported by SDO Practitioners**
Issue88	Team member(s) assume that other team member(s) have same duties to perform [Proposed].
Issue89	Nonperformance of a Requirements Engineering related task as everybody presumes that this is the responsibility of somebody else [Proposed].
Issue90	Unrealistic resource allocation for RE [Proposed].
IDs	**Literature-based Processes and tools' issues of RE process for SDO**
Issue91	Lack of clearly defined RE process (R Prikladnicki, et al., 2005) (Rafael Prikladnicki, et al., 2003).
Issue92	The stakeholders employ dissimilar processes for analyzing and documenting requirements (D. Damian, 2007).
Issue93	Stakeholders employ different processes to manage changes in requirements (D. Damian, 2007).
Issue94	The documented processes are not applied (Berenbach, 2006) (Illes-Seifert, et al., 2007).
Issue95	Use of different RE processes, resulting in different templates and methodologies, at the different locations of client (Rafael Prikladnicki, et al., 2003) (Bhat, et al., 2006).
Issue96	Use of unsuitable RE processes (Illes-Seifert, et al., 2007).
Issue97	Some team members do not attend the requirements engineering meetings as they are not familiar with the tools and technologies being used (Dubé & Paré, 2001).
Issue98	The tools cannot be integrated with other tools (Illes-Seifert, et al., 2007).
Issue99	RE rework or data loss during transfer from one tool to other (Bhat, et al., 2006).
Issue100	Need of the tools that provide permanent access to the requirements related information (M Heindl, et al., 2007).
Issue101	Tools do not convey requirements change information to the relevant stakeholders at the appropriate time (Sinha, Sengupta, & Chandra, 2006).
Issue102	Need of the tools that facilitate traceability of requirements across borders of tools (M Heindl, et al., 2007).
Issue103	Need of the tools that support requirements negotiations among the remote stakeholders (Calefato & Lanubile, 2005).
Issue104	Tools lack the facility of requirements document evolution through the collaboration among remote stakeholders (Sinha, et al., 2006).
Issue105	Selection of inappropriate RE tool(s) (Illes-Seifert, et al., 2007) (Bhat, et al., 2006).
Issue106	Lack of training for using groupware tools (Helén, 2004).
	Additional Processes and tools Issues of RE process for SDO Reported by SDO Practitioners
Issue107	Use of unsuitable requirements elicitation technique [Proposed].
Issue108	Tools and technologies do not meet expectations [Proposed]
Issue109	The tools are not secure and also have scalability issues [Proposed].
IDs	**Literature-based issues originated from Relationship among stakeholders**
Issue110	Lack of firm relationship among stakeholders (Heeks, Krishna, Nicholsen, & Sahay, 2001) (de Farias Junior, et al., 2012).
Issue111	Information about the identifications or resolutions of requirements' issues is not conveyed to other sites for a long time (D. Damian, 2007).
Issue112	Intermittency of informal contacts causes less opportunity of building relationships (Noll, et al., 2010).
Issue113	Use of different requirements documentation standards by customer and vendor (Bhat, et al., 2006).
Issue114	Formation of customer and/or vendor teams on ad hoc basis (Bhat, et al., 2006).

Table 4.6, Continued

Issue115	Different priorities of client and vendor for collecting and finalizing requirements (Bhat, et al., 2006).
Issue116	Lack of participation, in RE process, from client side (D. E. Damian & Zowghi, 2002) (Bhat, et al., 2006).
Issue117	Misconceptions of the vendor teams about client's working practices (Bhat, et al., 2006).
Issue118	Client and vendor follow conflicting requirements engineering approaches (Bhat, et al., 2006).
Issue119	Failure in meeting deadlines and fulfilling commitments about requirements by vendor (Bhat, et al., 2006).
Issue120	Issues in signing-off requirements engineering deliverables (Bhat, et al., 2006).
Issue121	Differences on selection of requirements engineering tools (Bhat, et al., 2006).
Issue122	Customers think that performing requirements related work from remote locations is not possible (Šmite, 2006).
Issue123	Client and vendor rely on oral agreement (Berenbach, 2006).
IDs	**Literature-based Requirements centric issues of RE process for SDO**
Issue124	Finalizing requirements for all stakeholders based on the requirements gathered or information obtained from the available stakeholders (Hanisch & Corbitt, 2007).
Issue125	Requirements (specifications) are misinterpreted (Nakatsu & Iacovou, 2009) (Mikulovic, Heiss, & Herbsleb, 2006).
Issue126	Incorrect or false requirements (Sabahat, et al., 2010).
Issue127	Requirements are not based upon appropriate/ sound business case (Abdullah & Verner, 2012).
Issu128	Gold plating or extra requirements (Abdullah & Verner, 2012).
Issu129	Incomplete requirements (Lormans, et al., 2004) (Hashmi, et al., 2013) (Sabahat, et al., 2010).
Issue130	Requirements documentation without following any standard (Minhas & Zulfiqar, 2014).
Issue131	Requirements are out of the scope of project (Gumm, 2007).
Issue132	Poor or ambiguous requirements specification (Lormans, et al., 2004) (Illes-Seifert, et al., 2007) (Perera, 2011) (Šmite, 2006) ((Islam, Joarder, & Houmb, 2009; Nakatsu & Iacovou, 2009) (Islam, et al., 2009).
Issue133	Not providing information or providing intentionally ambiguous information about requirements (D. E. Damian & Zowghi, 2002) (D. E. Damian & Zowghi, 2003a).
Issue134	How prioritization of requirements should be done (Illes-Seifert, et al., 2007).
Issue135	Requirements change frequently (Nakatsu & Iacovou, 2009) (Lormans, et al., 2004) (Perera, 2011) (Islam, et al., 2009).
Issue136	Requirements document becomes inconsistent (Lormans, et al., 2004).
Issue137	Requirements are stretched resulting in scope creeping (Perera, 2011).
Issue138	Requirements elicitation through fragmentation, that is requirements related to different parts of system are elicited by different people who work independently, leads to customer dissatisfaction (Šmite & Galviņa, 2012).
Issue139	Analysts are familiar with the domestic projects but do not possess the skills required for dealing with requirements specification in case of outsourcing (Berenbach, 2006).
Issue140	Only selected stakeholders are consulted during the requirements elicitation that results in biased elicitation (Lim, Damian, & Finkelstein, 2011).
Issue141	System users and people who interact with the requirements engineering team are different (Goguen, 1993).
Issue142	Pressure on Requirements Engineers to hide certain information about requirements, resulting in compromised requirements elicitation and specification (Goguen, 1993).
IDs	**Additional Requirements centric Issues of RE process for SDO Reported by SDO Practitioners**
Issue143	Users are not clear about their requirements [Proposed].
Issue144	Requirements Engineers assume, based on their experience, that they know requirements of users [Proposed].
Issue145	Users are fascinated by the features of other systems and want to have in their system but actually those features are not required [Proposed].

Table 4.6, Continued

Issue146	Client's insistence on adding new requirements after settlement of cost and time [Proposed].
Issue147	There are no actual users presently [Proposed].
Issue148	Using a requirements elicitation technique without exploring its suitability [Proposed].
Issue149	Selecting overall solution of problem wrongly [Proposed].
Issue150	Applying suppositions for finalizing requirements [Proposed].

4.4 Literature-based RE practices to address the issues of RE process for SDO

Through SLR, details provided in Section 4.1, 90 RE practices have been identified that can be used to address the issues of RE process for SDO. These practices have been shown in Table 4.7. This provides answer to RQ2.

Table 4.7 : Literature-based RE practices to address the SDO RE process issues

Sr. #	Literature-based Practices to address the issues of RE process issues for SDO
1.	Establishing proper infrastructure to facilitate communication and ensuring that it works properly (Christiansen, 2007).
2.	Encouraging Synchronous communication in form of chatting, telephone calls, and videoconferencing (Christiansen, 2007).
3.	Adapting and understanding the culture of other stakeholders (Christiansen, 2007) means knowing about the traditions, beliefs, ethos and native language (Babar, et al., 2007).
4.	Deciding and using a standard language for communication (Illes-Seifert, et al., 2007).
5.	Focusing on improving the communication language, for example, offering English language courses (Christiansen, 2007) (Carmel & Agarwal, 2001; Dubé & Paré, 2001).
6.	Appointing cultural liaisons (Boden, et al., 2009; Braun, 2007; Carmel & Agarwal, 2001; Christiansen, 2007; Deshpande, Richardson, Casey, & Beecham, 2010; Schmid, 2014) or Proxies (individuals who are familiar with the culture of client and vendor) (Brockmann & Thaumüller, 2009).
7.	Establishing 'proximity development center' in the region having no or a little time zone difference from the region of client (Abbott & Jones, 2003).
8.	Trying to find natural overlapping of working hours (D. Damian, 2002).
9.	Assessing 'around-the-clock' capability of working (D. Damian, 2002).
10.	Achieving time zone proximity through time-shifting (changing one's working hours in order to overlap with other's working hours) for which different approaches are: i) Flextime (working at flexible timings to overlap). ii) Overtime (working for extra time to overlap). iii) Telework (working with flexible schedules from residence to overlap). iv) Long working days (availing working time overlap either at start of day or at end of the day). v) Unrestricted working hours (there are no restricted working hours and employees set their own working hours to overlap) (Rafael Prikladnicki & Carmel, 2013).
11.	Equipping remote practitioners' rooms with electronic message "drop in", remote calling and artifacts sharing facilities (D. E. Damian & Zowghi, 2002).
12.	Facilitating socialization among the practitioners from the beginning of the project, like arranging face-to-face start-off meetings to establish personal relationships (D. E. Damian & Zowghi, 2003b) (Noll, et al., 2010).
13.	Arranging traveling to remote sites frequently in order to build trust (Oshri, Kotlarsky, & Willcocks, 2007) (Edwards & Sridhar, 2005) (Holmstrom, et al., 2006) (Moe & Šmite, 2007).

Table 4.7, Continued

Sr. #	Literature-based Practices to address the issues of RE process issues for SDO
14.	Facilitating direct communication among the stakeholders (Herbsleb, Paulish, & Bass, 2005).
15.	Ensuring that stakeholders introduce themselves to one another right from beginning of the project (Rusman, Van Bruggen, Cörvers, Sloep, & Koper, 2009).
16.	Encouraging communication in the native language of client (Babar, et al., 2007).
17.	Promoting the use of groupware tools (Moe & Šmite, 2007).
18.	Persuading the stakeholders that revealing the issues or providing information will not have negative fallouts instead will have positive consequences (D. Damian, 2002).
19.	Scheduling video conferences or teleconferences (D. Damian, 2007) daily, weekly, bimonthly, monthly so that there are no or minimal inconvenient hours for all the stakeholders (Holmstrom, et al., 2006).
20.	Arranging requirements engineering meetings by: i) Engaging a human facilitator and using a rich communication media that supports integration of data, videos and audios. ii) Preparing agenda and following it. iii) Selecting relevant participant and informing them timely to take part in requirements meetings. iv) Timely exchanging supporting documents to give participants enough time to read the relevant material. v) Enabling participants of requirements meetings to access the resources (like emails, relevant documents, work artifacts etc.) that contain information about the requirements (D. E. Damian & Zowghi, 2003b).
21.	Establishing authoritative leadership at the level of project managers and team heads (Berenbach, 2006).
22.	Maintaining explicit sequence of commands (Berenbach, 2006).
23.	Having clearly defined and agreed responsibilities for each individual and group (Berenbach, 2006).
24.	Having clearly delineated and comprehended requirements engineering processes (Berenbach, 2006).
25.	Using email as communication medium for verification as it keeps written record of communication (D. E. Damian & Zowghi, 2002) (D. E. Damian & Zowghi, 2003b) (Carmel & Agarwal, 2001).
26.	Reaching written and properly documented agreements (Krishna, Sahay, & Walsham, 2004) (Ebert & De Neve, 2001).
27.	Forming a well-defined organizational structure having clear communication responsibilities (Schmid, 2014).
28.	Establishing peer-to-peer links among distributed sites at the team, project and management level (Schmid, 2014).
29.	Partially synchronizing inter-organizational processes (Schmid, 2014).
30.	Maintaining open communication lines among different well-defined roles of stakeholders (Schmid, 2014).
31.	Regularly checking and notifying the progress about mutually agreed upon artifacts (Schmid, 2014).
32.	By using an awareness support system for requirements management, all the stakeholders should be able to access following information: i) Requirements' descriptions, rationale and priorities. ii) Dependencies among the requirements and with design, coding and testing. iii) Each team member's responsibilities with respect to particular requirement(s) and contact information like email, phone number. iv) Requirements' initiators. v) Issues related to requirements, issues' initiators, status of the resolution of those issues and decisions taken due to issues. vi) Meetings' date, time and location, stakeholders that are involved, discussed issues and decisions taken. vii) Change requests, initiators of change request, status of the decisions about those requests, people involved in taking decisions and decisions taken (D. Damian, et al., 2003).

Table 4.7, Continued

Sr. #	Literature-based Practices to address the issues of RE process issues for SDO
33.	Keeping experienced practitioners in team and those practitioners should bridge the awareness gap (Kwan, et al., 2007).
34.	Implementing centralized communication structure (Kwan, et al., 2007).
35.	Describing summary of proceedings after every meeting. A team member or facilitator should summarize that which issues have been raised during the meeting, what has been decided about each issue, which issues are pending, whose responsibility is to find out further information and whose advice should be sought in case of each issue (Catledge & Potts, 1996).
36.	Using a Requirements Management System (to control and track changes)(Lormans, et al., 2004) that provides following feature: i) Navigating given set of requirements, retrieving specific requirements and grouping requirements based on certain parameters. ii) Management of requirements change process, requirements traceability support and generation of the various types of reports about requirements. iii) Interface to accept external documents. iv) Management of the various versions of requirements. v) Support for performing different types of analysis (like impact analysis, to know a requirement is orphan or not, for tracking of status). vi) Restricting rights to access and edit the given set of requirements (Lormans, et al., 2004).
37.	Informing the relevant stakeholder about the requirements change: i) Through the telephone calls, emails and internet supported communication tools. ii) By generating automatic notifications through the system(M Heindl, et al., 2007).
38.	In case of high number of stakeholders: i) Appointing a person (communication channel) from each unit of organization or group of requirements information sources for gathering the requirements from respective unit or group. Then communication channels transfer requirements to an expert where these requirements can be bundled (Gumm, 2007). ii) Using group elicitation techniques like group Brainstorming, JAD (Joint Application Development), Focus groups and requirements creativity workshops for getting consensus on requirements (Calefato, et al., 2012). iii) Preparing a combined requirements document containing all the requirements (Gumm, 2007).
39.	Taking following measures to overcome cultural issues: **i)** (P6) Appointing cultural liaisons (Carmel & Agarwal, 2001; Christiansen, 2007) (Boden, et al., 2009; Braun, 2007; Deshpande, et al., 2010; Schmid, 2014) or Proxies (individuals who are familiar with the culture of client and vendor)(Brockmann & Thaumüller, 2009). **ii)** Encouraging team members to visit locations of other stakeholders (Deshpande, et al., 2010) (Begel & Nagappan, 2008). **iii)** Arranging the cultural trainings (Deshpande, et al., 2010). **iv)** Conducting orientation courses for cultural differences (Deshpande, et al., 2010). **v)** Keeping in view cultural values of stakeholders while deciding females' roles (Deshpande, et al., 2010). **vi)** Adopting 'Negotiated Culture', a compromised culture that is developed to honor the cultural norms of all the stakeholders (Krishna, et al., 2004). **vii)** Nominating the individuals, who are experienced and acquainted with the culture of the client, to assist for requirements negotiation and specification(Carmel & Agarwal, 2001). **viii)** (P4) Deciding and using a standard language for communication (Illes-Seifert, et al., 2007). **ix)** (P5) Focusing on improving the communication language, for example, offering English language courses (Carmel & Agarwal, 2001; Christiansen, 2007). **x)** Arrangement and monitoring of all the activities that are performed to deal with cultural diversities, by project manager or senior team members (Deshpande, et al., 2010).

Table 4.7, Continued

Sr. #	Literature-based Practices to address the issues of RE process issues for SDO
40.	Introducing Equality Model (EM) for all the stakeholders according to which all stakeholders are equal and can talk about the interests, religion and cultural values of one and another. They can also share knowledge and recommend solutions by considering the perception and position of others (Babar & Zahedi, 2013).
41.	Delineating the processes, tools and policies to be followed (Niazi, et al., 2013).
42.	Sharing knowledge (Niazi, et al., 2013).
43.	Keeping common expectations (Niazi, et al., 2013).
44.	Having technical, managerial and staffing capabilities to meet quality standards and meeting schedule (Babar, et al., 2007).
45.	Starting with the informal conversation to motivate non-fluent or less fluent stakeholders for participating in the conversation (Rafael Prikladnicki, et al., 2014).
46.	Utilizing translation services: i) Use of human translator(Rafael Prikladnicki, et al., 2014)(Calefato, et al., 2011). ii) Using real-time machine translation services (Calefato, et al., 2011).
47.	Using scales to measure the average time for fulfillment of expectations. For example, adding a feature in the email application that calculates the average time taken by an individual/team to respond email. If average response time is 3 days then sender can expect that email should be responded till 3 days (Al-Ani, et al., 2013).
48.	Defining and using requirements specification glossary and notations (Illes-Seifert, et al., 2007).
49.	Taking following measures, by vendor mangers, for creating coordination: i) Defining roles and responsibilities of team members and creating Organizational Charts that display positions and responsibilities (Deshpande, Beecham, & Richardson, 2011). ii) Attaining the required human resources and managing them through Resource Calendar (Deshpande, et al., 2011). iii) Allocating tasks appropriately (Deshpande, et al., 2011). iv) (P30) Establishing peer-to-peer links among distributed sites at the team, project and management level (Schmid, 2014). v) (P31) Partially synchronizing inter-organizational processes(Schmid, 2014). vi) (P32)Maintaining open communication lines among different well-defined roles of stakeholders(Schmid, 2014). vii) (P33)Regularly checking and notifying the progress about mutually agreed upon artifacts (Schmid, 2014).
50.	Developing stakeholders' consensus on operating terms and conditions for attending meetings and, honoring deadlines and commitments (Paré & Dubé, 1999).
51.	Defining the role of every team member and indicating who should communicate with whom (D. Damian, 2007) (Šmite, 2006).
52.	Regarding decisions maintaining continuous communication with customer by arranging: i) Face-to-face meetings. ii) Videoconferences (Šmite, 2006).
53.	Appointing one team member that works after the normal working timings and responses to inquiries (Hashmi, et al., 2013).
54.	Providing training about how to: i) Use the tools. ii) Collaborate effectively in the environment where stakeholders are at distant locations (Edwards & Sridhar, 2005).
55.	Providing training potential team members for using appropriate processes, and supporting tools and technologies (Bhat, et al., 2006).
56.	Following Six common activities for RE, as there is no standard RE process (R Prikladnicki, et al., 2005) (Sommerville & Kotonya, 1998), that are: i) Requirements Elicitation, ii) Requirements Analysis and negotiations, iii) Describing requirements, iv) System Modeling, v) Requirements Validation, and vi) Requirements Management (Sommerville & Sawyer, 1997) (Iqbal, et al., 2013) (Lopes, et al., 2004).
57.	Following shared and agreed processes (Noll, et al., 2010).
58.	Using tools that can interact with other tools (M Heindl, et al., 2007).

Table 4.7, Continued

Sr. #	Literature-based Practices to address the issues of RE process issues for SDO
59.	Assessing capabilities of RE tools by using ISO/IEC TR 24766:2009 framework and relevant information (Juan M Carrillo De Gea et al., 2012) (Portillo-Rodríguez, Vizcaíno, Piattini, & Beecham, 2012).
60.	Appointing a professional as requirements engineer or analyst that has: i) Knowledge or should be able to learn about domain and advanced elicitation techniques. ii) Abilities for operating in international context that is with virtual teams and diverse cultures. iii) Abilities for resolving conflicts and working in uncertain and ambiguous situations (Romero, Vizcaíno, & Piattini, 2008). iv) Knowledge about case tools, system modeling and programming languages, requirements management tools and human-computer interaction (Macaulay, 2012). v) Skills for communication, social interaction, problem solving, working as team member as well as independently, innovation and being adaptable to changes (Ahmed, 2012).
61.	Using a proper procedure to select an adequate requirements elicitation technique (Carrizo, Dieste, & Juristo, 2014).
62.	Defining and following standard document structure (Sommerville & Sawyer, 1997).
63.	Using IEEE Standard 830-1998 For Requirements Specification to structure the requirements specification document (Illes-Seifert, et al., 2007).
64.	Defining minimum standards for requirements documentation (Illes-Seifert, et al., 2007).
65.	Aligning the objectives of client and vendor through negotiation (Bhat, et al., 2006).
66.	Making plan for RE and out of the total project efforts, dedicating 15 to 30 % effort for Requirements Engineering (Hofmann & Lehner, 2001) (Sadraei, et al., 2007).
67.	Designing metrics to measure performance(Paré & Dubé, 1999).
68.	Developing mechanisms for reporting about the progress (Paré & Dubé, 1999).
69.	Enhancing the progress tracking/visibility by increasing the number of RE deliverables (Paré & Dubé, 1999).
70.	Identifying and accessing the key users (Bhat, et al., 2006) (Hanisch & Corbitt, 2007).
71.	Asking the known or identified stakeholders about other stakeholders, based on their suggestions building stakeholders' social network and then prioritizing stakeholders based on measures of social network (Lim, et al., 2011).
72.	Establishing the Change Control Board (CCB) (Berenbach, 2006) and including new requirements by following a proper requirements change management process (change evaluation and propagation mechanism) (Amjad Alam, Binti Ahmad, & Akhtar, 2014; Li, Sun, Leung, & Zhang, 2013; Minhas & Zulfiqar, 2014; Zhang et al., 2014).
73.	Involving real system users in RE process (Goguen, 1993; Lohmann, et al., 2008).
74.	For requirements specification templates following IEEE Standard 830-1998 For Requirements specification (Illes-Seifert, et al., 2007).
75.	Fulfilling the qualities of requirements description given in IEEE Standard 830-1998 For Requirements Specification (Illes-Seifert, et al., 2007).
76.	Using Wikis geographically distributed stakeholders are engaged to explore their needs or requirements, discuss related issues, ask about new features and create requirements (Laurent & Cleland-Huang, 2009).
77.	Adopting asynchronous communication like email so that less competent stakeholder could have time to understand and answer the communicated messages(Holmstrom, et al., 2006) (D. E. Damian & Zowghi, 2002). Features like checking spellings and grammar, and language translation should be integrated with email facility (Dubé & Paré, 2001).
78.	Enabling online collaboration using requirements visualization tools (like use case models, business process diagrams) and social visualization techniques to stimulate the involvement of stakeholders and provide better understanding of requirements (Duarte, Farinha, Silva, & Silva, 2012).
79.	Selecting suitable groupware tools and techniques for requirements elicitation keeping in view cognitive characteristics of stakeholders by using Felder-Silverman's Learning Style Model (LSM) (Aranda, Vizcaíno, Cechich, & Piattini, 2006).

Table 4.7, Continued

Sr. #	Literature-based Practices to address the issues of RE process issues for SDO
80.	Having a common set of tools (Noll, et al., 2010).
81.	Employing requirements workshop (Calefato & Lanubile, 2005).
82.	Using a peer-to-peer workshop tool to substitute traditional face to face workshops(Lanubile, 2003). P2P applications can provide facilities like: i) Instant messaging. ii) Sharing, reviewing and editing documents. iii) Discussions through audio link. iv) Autonomy (A peer can pass on information to others but also can apply restrictions, for not passing information to particular peer(s), by using access rights. v) Intermittency (disappearing of any peer due to network disconnection that can be intentional or accidental) (Lanubile, 2003).
83.	Considering Hofstede's culture dimension that can help managers in identification of individual's behavior as well as group's behavior (Deshpande, et al., 2010). The dimensions are: i) Power distance. ii) Collectivism versus individualism. iii) Masculinity versus Femininity. iv) Uncertainty Avoidance. v) Short-term versus Long-term Orientation(Brockmann & Thaumüller, 2009) (Hofstede, & Minkov, 1991). The team member's' concerns and frustration level can be reduced if these five dimensions are articulated and applied properly (Deshpande, et al., 2010).
84.	Promoting informal communication among the distributed stakeholders (Cusick & Prasad, 2006).
85.	Facilitating frequent communication among stakeholders (Šmite, Moe, & Torkar, 2008).
86.	Introducing appropriate requirements traceability mechanism across requirement, design and implementation phases (Bohner, 1996).
87.	Finding co-change patterns to predict future requirement changes, and devising corresponding strategy (Shi, Wang, & Li, 2013; Zimmermann, Zeller, Weissgerber, & Diehl, 2005) .
88.	Using modified 100 $ technique to prioritize the requirements (Ahmad, Shahzad, et al., 2011).
89.	Keeping in view that customer communication and requirements phase take 10-25 percent of the total project effort (Pressman, 2005).
90.	Organizing the teams in such a way that there is overlapping of the work so that team members can understand each other's responsibilities (Sommerville, 2007).

4.5 Sommerville and Sawyer's significant RE practices to address issues of SDO RE process

Sommerville and Sawyer have recommended RE practices for resolving the issues of traditional RE process (Sommerville & Sawyer, 1997). There is a need to empirically investigate which of those practices are significant to address the issues of RE process in case of SDO.

4.5.1 Identifying the Significant RE Practices for SDO

Taking into consideration the research purpose, the survey research method has been utilized in order to attain data regarding significant RE practices for SDO. This survey (2^{nd} questionnaire survey of this research work) is based upon Sommerville and Sawyer's 49 RE practices (Sommerville & Sawyer, 1997) for six key areas of the RE process which are elicitation of requirements, analyzing and negotiating requirements, requirements description, modeling requirements, validating requirements and managing requirements. The 50% rule has been for data analysis. The survey research method is considered as an appropriate way for the collection of qualitative or quantitative data (Niazi, Babar, & Verner, 2010). Usually, a combination of various techniques for data collection such as interview and questionnaire or any of these techniques is used in a survey research method (Lethbridge, et al., 2005). To gather the data for finding Sommerville and Sawyer's significant RE practices in case of SDO, a questionnaire survey has been conducted. Guidelines provided in study (B. A. Kitchenham & Pfleeger, 2008) have been used to design and conduct the survey.

(a) Data Collection: This survey is a cross sectional study. The questionnaire, provided in Appendix A as questionnaire 2, has been used for the study. A total of 130 questionnaires have been distributed to SDO practitioners. Sixty (60) questionnaires have been sent out through emails, and seventy (70) questionnaires have been distributed and filled out during face-to-face meetings. The survey has been conducted by using semi-supervised approach (Pfleeger & Kitchenham, 2001) in which respondents are guided during face-to-face meetings or by employing Computer-Assisted Telephone Interviewing technique (Anie, et al., 1996).

(b) Questionnaire Format: The questionnaire includes the closed format questions as well as the open format questions. The closed format questions are to select the ranks

(out of the four given ranks) of the benefits of RE practices for SDO. The open format questions are intended to inquire from the respondents if they are using the RE practices other than the given RE practices. The questionnaire contains two parts. The purpose of the first part is to collect data about the respondents' experience, job nature and respective companies. The second part is for data collection about the significant RE practices. To improve the questionnaire layout, assess the language comprehension and estimate the time required to complete the questionnaire, two rounds of pilot study have been conducted. Recommendations have been incorporated after the first round. The second round has been carried out to ensure that the changes made are according to the given suggestions.

The respondents have been requested to rank the Sommerville and Sawyer's RE practices for six key areas according to the perceived benefits of the RE practices for SDO. The different ranks or categories of perceived benefits are (Cox, et al., 2009; Niazi, et al., 2012):

i) High Perceived Benefits (H): An RE practice has 'high perceived benefits' if it is mandatory and always used.
ii) Medium Perceived Benefits (M): An RE practice has 'medium perceived benefits' if it is not mandatory but used widely or often.
iii) Low Perceived Benefits (L): An RE practice has 'low perceived benefits' if it is used only for some particular projects.
iv) Zero Perceived Benefits (Z): An RE practice has 'zero perceived benefits' if it is never or rarely used.

(c) Sampling and population: The Convenience Sampling method has been employed for obtaining a valid sample of respondents. The respondents are project managers, software engineers, team leaders, quality assurance managers, programmers, designers,

requirements engineers, analysts and manager operations having at least 5 years SDO experience. These practitioners can be divided into three categories of 'developers', 'managers' and 'senior managers' (Niazi, et al., 2005).

(d) Response rate: The total responses which have been received back through the emails are 45 out of 60 as concerned practitioners have been in continuous contact. Out of a total of 115 (70+45) responses, the 108(T) responses have been selected for data analysis based on the respondent's company profile, job title and relevant experience. Details about the second questionnaire survey of this research work have been shown in Table 4.8.

Table 4. 8 : Details about the second questionnaire survey of research work

	Survey medium	No. of Questionnaires			Percentages
		Distributed	Received back	Selected for data analysis	
	Email	60	45	----	75%
	Face-to-Face meeting	70	70	----	100%
Total	----	130	115	----	88.46%
	----	130	----	108	83.08%

e) Criteria for the Selection of Significant RE Practices

If, according to the opinion of at least 50% of respondents, the perceived benefits of a RE practice fall in the 'high perceived benefits' and the 'medium perceived benefits' categories then that RE practice is considered to be 'significant' for addressing the issues of RE process for outsourced software development projects.

A similar method, using the criterion of considering the opinion of 50% or more respondents for decision making, has been employed effectively in preceding studies (Cox, et al., 2009; Niazi, et al., 2005; Rainer & Hall, 2002). The study (Rainer & Hall, 2002), have identified key or important factors for software process improvement by using the principle that if 50% or more respondents believe that a factor has a major impact then that factor is treated as important.

4.5.2 Survey results and slection of the signifiacant RE practices

The ‘significant’ means ‘important to be worthy of attention’ or ‘important enough to have an effect’ ("Oxford Dictionary," 2012; "Oxford Learners' Dictionary ", 2012). To identify the significant RE practices for SDO, the ‘high perceived benefits’ and the ‘medium perceived benefits’ categories have been taken into account (Niazi, et al., 2012). The rationale for this decision is that a RE practice having ‘high perceived benefits’ is always followed i.e., it is mandatory. Hence such RE practice must have significance for SDO. Likewise, a RE practice with ‘medium perceived benefits’ is widely followed although it is not mandatory. Thus the RE practices providing medium benefits are frequently followed, therefore, such practices cannot be ignored and must also be considered significant for SDO. For each RE practice, the Prominence Level (PL) represents the percentage of responses in ‘high perceived benefits’ and ‘medium perceived benefits’ categories and has been calculated as given in (1):

$$PL = [(H_i + M_i) / T] \times 100. \quad \ldots\ldots\ldots\ldots (1)$$

Results and discussions have been presented based on six activities of the RE process i.e., i): Practices for Elicitation of Requirements, ii): Practices for Analyzing and Negotiating Requirements, iii): Requirements Description Practices, iv): System Modeling Practices, v): Requirements Validation Practices, and vi): Requirements Management Practices. Requirements Engineering Practices (REPs) have been represented by using unique Identification Numbers (IDs) from REP_1, REP_2, $_{3\ldots}$to REP_{49}.

(a) Significant Requirements Elicitation practices

Table 4.9 shows 13 (n_1=13) requirements elicitation practices represented by REP_n (n = 1, 2… 13); the frequencies of different ranks denoted by H_i, M_i, L_i and Z_i (i = 1, 2… 13) for high, medium, low and zero perceived benefits respectively.

Whereas $\forall REP_n$

$$\sum_{i=1}^{(i+n_1-1)}(H_i + M_i + L_i + Z_i) = T \text{ And also } 0 \leq \sum_{i=1}^{(i+n_1-1)}(H_i \vee M_i \vee L_i \vee Z_i) \leq (n_1 \times T)$$

There are 13 (26.53% of total 49 RE practices) requirements elicitation practices. Practices with at least 50 PL or practices about which at least 50% of respondents think that the perceived benefits of these practices for SDO are high and medium, have been considered as significant REPs. As Table 4.9 shows, with the exception of REP_2 and REP_9, remaining 11 (22.45%) elicitation practices meet the prominence criterion. So REP_1, REP_3, REP_4, REP_5, REP_6, REP_7, REP_8, REP_{10}, REP_{11}, REP_{12} and REP_{13} are significant requirements elicitation practices for SDO.

Table 4. 9 : Significant requirements elicitation practices

IDs	Practices	Assessed Ranks				PL
		H_i	M_i	L_i	Z_i	
REP_1	Assess system feasibility.	29	37	20	22	61.11
REP_2	Sensitivity to organizational and political considerations.	21	28	29	30	45.37
REP_3	Identifying stakeholders of system and consulting them.	27	40	24	17	62.04
REP_4	Recording requirements originating sources.	32	36	21	19	62.96
REP_5	Defining operating environment of system.	31	38	21	18	63.89
REP_6	Using concerns of business for derivation of the elicitation of requirements.	36	34	20	18	64.81
REP_7	Look for domain constraints.	42	29	25	12	65.74
REP_8	Record requirements rationale.	43	29	27	09	66.67
REP_9	Collect requirements from multiple viewpoints.	34	16	35	23	46.30
REP_{10}	Prototype the poorly understood requirements.	40	35	19	14	69.44

Table 4.9, Continued

REP_{11}	Use scenarios to elicit requirements.	50	23	24	11	67.59
REP_{12}	Define operational processes.	42	29	25	12	65.74
REP_{13}	Reuse requirements from already developed similar systems.	46	23	24	15	63.89

This is surprising that only 49(45.37%) respondents out of the total 108 respondents, has stated 'being sensitive to the organizational and political considerations (REP_2)' as significant for SDO. The reason behind this approach may be that practitioners want to avoid organizational politics considering such politics above their levels and duties.

This has also been explored that the RE practice of 'collecting requirements from multiple viewpoints (REP_9)' has high and medium benefits for SDO according to the thinking and experience of only 46.30% practitioners. It seems that gathering requirements from the point of view of multiple sources such as managers, end-users and customers is considered an extra time taking activity by the practitioners as the completion of projects in short time is always preferred (Rong, Mu, & Liu, 2009). Therefore, in order to meet deadlines and save time practitioners do not consider this REP as important for SDO.

(b) Significant Requirements Analysis and Negotiation practices

Table 4.10 shows 8 (n_2=8) requirements analysis and negotiation practices represented by REP_n (n = 14, 15,…, 21); the frequencies of different ranks denoted by H_i, M_i, L_i and Z_i (i = 14, 15,…, 21) for high, medium, low and zero perceived benefits respectively.

Whereas $\forall REP_n$

$$\sum_{i=14}^{(i+n_2-1)}(H_i + M_i + L_i + Z_i) = T \text{ And also } 0 \leq \sum_{i=14}^{(i+n_2-1)}(H_i \vee M_i \vee L_i \vee Z_i) \leq (n_2 \times T)$$

As shown in Table 4.10, out of 8 (16.33% of total 49 RE practices) requirements analysis and negotiation practices, 7 (14.29%) practices are significant as they have PLs

50 or above which means that according to the opinion of 50% or more respondents these practices have high and medium benefits for SDO. So REP_{14}, REP_{15}, REP_{16}, REP_{17}, REP_{18}, REP_{19} and REP_{21} are significant requirements analysis and negotiation practices for SDO.

Table 4. 10 : Significant requirements analysis and negotiation practices

IDs	Practices	Assessed Ranks				PL
		H_i	M_i	L_i	Z_i	
REP_{14}	Define system boundaries.	31	35	19	23	61.11
REP_{15}	Use checklists for requirements analysis.	29	36	20	23	60.19
REP_{16}	Use communication mechanism to support negotiations.	34	37	20	17	65.74
REP_{17}	Plan for conflicts identification & resolution.	33	36	18	21	63.89
REP_{18}	Prioritize requirements.	50	51	07	0	93.52
REP_{19}	Classification of the requirements through multi-dimensional approach.	32	36	18	22	62.96
REP_{20}	Using interaction matrices for finding requirements conflicts and overlaps.	25	19	40	24	40.74
REP_{21}	Assess requirements risks.	34	25	27	22	54.63

Only one REP which is the 'usage of interaction matrices to discover conflicting and overlapping issues among requirements (REP_{20})' has PL 40.74 and is considered as insignificant for SDO. This also confirms the previous study regarding perceived values of REPs (Cox, et al., 2009). In the interaction matrix, rows and columns are labeled with requirements identifiers and cells of the matrix contain specific and predefined values in order to indicate that whether requirements conflict or not, overlap or not etc. As practitioners are normally not familiar with this tool, they may consider it difficult to use or needless to perform their routine activities in spite of the fact that the use of matrices is really useful for requirements identification (Arao, Goto, & Nagata, 2005).

(c) Significant Requirements' Description practices

Table 4.11 shows 5 (n_3=5) requirements description practices represented by REP_n (n = 22, 23,..., 26); the frequencies of different ranks denoted by H_i, M_i, L_i and Z_i (i = 22, 23,…, 26) for high, medium, low and zero perceived benefits respectively.

Whereas $\forall REP_n$

$$\sum_{i=22}^{(i+n_3-1)}(H_i + M_i + L_i + Z_i) = T \text{ And also } 0 \leq \sum_{i=22}^{(i+n_3-1)}(H_i \vee M_i \vee L_i \vee Z_i) \leq (n_3 \times T)$$

Table 4.11 provides data about the requirements description practices. All the 5 (10.20%) requirements description practices i.e., REP_{22}, REP_{23}, REP_{24}, REP_{25} and REP_{26} are significant or important for SDO as for all these practices PLs are 50 or above indicating that 50% or more respondents perceive them as having high and medium benefits for SDO.

Table 4. 11 : Significant requirements description practices

IDs	Practices	Assessed Ranks				PL
		H_i	M_i	L_i	Z_i	
REP_{22}	Define and use standard templates for requirements description.	34	35	19	20	63.89
REP_{23}	Use simple, consistent and concise language to describe requirements.	32	36	17	23	62.96
REP_{24}	Use diagrams appropriately.	36	35	19	18	65.74
REP_{25}	Supplement natural language with other descriptions of the requirements.	39	33	19	17	66.67
REP_{26}	Specify requirements quantitatively where appropriate.	31	38	20	19	63.89

(d) Significant System Modeling practices

Table 4.12 shows 6 (n_4=6) system modeling practices represented by REP_n (n = 27, 28,…, 32); the frequencies of different ranks denoted by H_i, M_i, L_i and Z_i (i = 27, 28,…, 32) for high, medium, low and zero perceived benefits respectively.

Whereas $\forall REP_n$

$$\sum_{i=27}^{(i+n_4-1)}(H_i + M_i + L_i + Z_i) = T \quad \text{And also } 0 \leq \sum_{i=27}^{(i+n_4-1)}(H_i \vee M_i \vee L_i \vee Z_i) \leq (n_4 \times T)$$

As shown in Table 4.12, there are 6 (12.24%) system modeling practices i.e., REP_{27}, REP_{28}, REP_{29}, REP_{30}, REP_{31} and REP_{32}. Out of these 6 modeling practices, only one practice which is REP_{27} (developing complementary system models) is regarded as unimportant for SDO as the PL for the REP_{27} is 48.15 showing that 50% or more respondents do not consider this practice as having high and medium benefits for SDO. The remaining 5 (10.20%) practices i.e., REP_{28}, REP_{29}, REP_{30}, REP_{31} and REP_{32} possess PLs above 50. Therefore, they are significant or substantial system modeling practices for SDO. This is another strange finding that 'developing complementary system models (REP_{27})' has not been considered as a significant REP for SDO. Creating different models such as entity-relationship diagrams, data-flow-diagrams and class diagrams is always beneficial to make system specifications clear. The likely cause behind this perception of practitioners is that they use just a few models and are not interested in the remaining models.

Table 4. 12 : Significant requirements modeling practices

IDs	Practices	Assessed Ranks				PL
		H_i	M_i	L_i	Z_i	
REP_{27}	Develop complementary system models.	22	30	36	20	48.15
REP_{28}	Model the system's environment.	38	35	19	16	67.59
REP_{29}	Model the system's architecture.	37	39	20	12	70.37
REP_{30}	Use structured methods for system modeling.	40	44	13	11	77.78
REP_{31}	Use a data dictionary.	36	38	19	15	68.52
REP_{32}	Documentation of the association between stakeholder requirements and models of system.	40	40	20	08	74.07

(e) Significant Requirements Validation practices

Table 4.13 shows 8 (n_5=8) requirements validation practices represented by REP_n (n = 33, 34… 40); the frequencies of different ranks denoted by H_i, M_i, L_i and Z_i (i = 33, 34… 40) for high, medium, low and zero perceived benefits respectively.

Whereas $\forall REP_n$

$$\sum_{i=33}^{(i+n_5-1)}(H_i + M_i + L_i + Z_i) = T \text{ And also } 0 \leq \sum_{i=33}^{(i+n_5-1)}(H_i \vee M_i \vee L_i \vee Z_i) \leq (n_5 \times T)$$

This can be observed from Table 4.13 that out of 8 (16.33%) requirements validation practices, 7 (14.29%) practices i.e., REP_{33}, REP_{34}, REP_{35}, REP_{36}, REP_{37}, REP_{38} and REP_{40} have the least required PLs. Only one validation practice that is REP_{39} (propose requirements test cases) is regarded as trivial for SDO because the PL for this practice is 47.22, which is insufficient to meet the required criterion. So REP_{33}, REP_{34}, REP_{35}, REP_{36}, REP_{37}, REP_{38} and REP_{40} are significant or important requirements validation practices for SDO.

'Proposing test cases (REP_{39})' is essential for finding out requirements problems which have a negative impact on the expected outcomes of the projects (T. Hall, 2002). According to the findings of this survey, this is not a substantial RE practice which contradicts an earlier study regarding REPs (Cox, et al., 2009). This requires further investigation to know whether this is due to SDO issues like distance, infrequent communication, poor knowledge management, improper coordination, and cultural differences or not.

Table 4. 13 : Significant requirements validation practices

IDs	Practices	Assessed Ranks				PL
		H_i	M_i	L_i	Z_i	
REP_{33}	Checking to verify that the requirements document is according to your standards.	40	36	20	12	70.37
REP_{34}	Organizing the inspections of requirements.	39	36	19	14	69.44
REP_{35}	Using multi-disciplinary teams for reviewing requirements.	42	35	19	12	71.30
REP_{36}	Defining the checklists for validation of requirements.	30	40	28	10	64.81
REP_{37}	Using prototype in order to animate the requirements.	38	36	21	13	68.52
REP_{38}	Writing a user manual draft.	41	37	21	09	72.22
REP_{39}	Proposing requirements test cases.	26	25	38	19	47.22
REP_{40}	Paraphrasing system models into natural language.	41	35	17	15	70.37

(f) Significant Requirements Management practices

Table 4.14 shows 9 (n_6=9) requirements management practices represented by REP_n (n = 41, 42… 49); the frequencies of different ranks denoted by H_i, M_i, L_i and Z_i (i = 41, 42… 49) for high, medium, low and zero perceived benefits respectively.

Whereas $\forall REP_n$

$$\sum_{i=41}^{(i+n_6-1)}(H_i + M_i + L_i + Z_i) = T \text{ And also } 0 \leq \sum_{i=41}^{(i+n_6-1)}(H_i \vee M_i \vee L_i \vee Z_i) \leq (n_6 \times T)$$

This can be observed from Table 4.14 that for requirements management there are 9 (18.37%) practices. Only one management practice that is about recording rejected requirements (REP_{49}) has PL less than 50 (46.30) which is not enough to become a significant RE practice for SDO. This also confirms to the results of previous study on REPs (Cox, et al., 2009). One possible reason for not recording the rejected requirements may be the fact that in several companies the recording of rejected requirements is the decision of project managers.

All the other 8 (16.33%) practices to manage requirements have PLs above 50 indicating that more than 50% of respondents consider these practices as having high

and medium benefits for SDO. Therefore, REP_{41}, REP_{42}, REP_{43}, REP_{44}, REP_{45}, REP_{46}, REP_{47} and REP_{48} are significant requirements management practices for SDO.

Table 4. 14 : Significant requirements management practices

IDs	Practices	Assessed Ranks				PL
		H_i	M_i	L_i	Z_i	
REP_{41}	Identification of each requirement uniquely.	30	36	19	23	61.11
REP_{42}	Defining policies in order to manage requirements.	34	35	24	15	63.89
REP_{43}	Defining requirements traceability policies.	40	37	21	10	71.30
REP_{44}	Maintaining the manual of traceability.	44	32	20	12	70.37
REP_{45}	Usage of database for the management of requirements.	33	36	30	09	63.89
REP_{46}	Defining policies to manage requirements change.	42	36	20	10	72.22
REP_{47}	Identification of the global system requirements.	40	30	25	13	64.81
REP_{48}	Identifying the volatile requirements.	36	32	23	17	62.96
REP_{49}	Recording of the rejected requirements.	14	36	28	30	46.30

Data analysis has uncovered the fact that most of the REPs advocated by Sommerville and Sawyer's study are significant for SDO as 43(11+07+05+05+07+08) REPs out of the 49 or 87.76% REPs meet the required criterion to become significant RE for SDO. The percentages of the REPs and significant REPs have been shown in Figure 4.4 with respect to various activities of RE process.

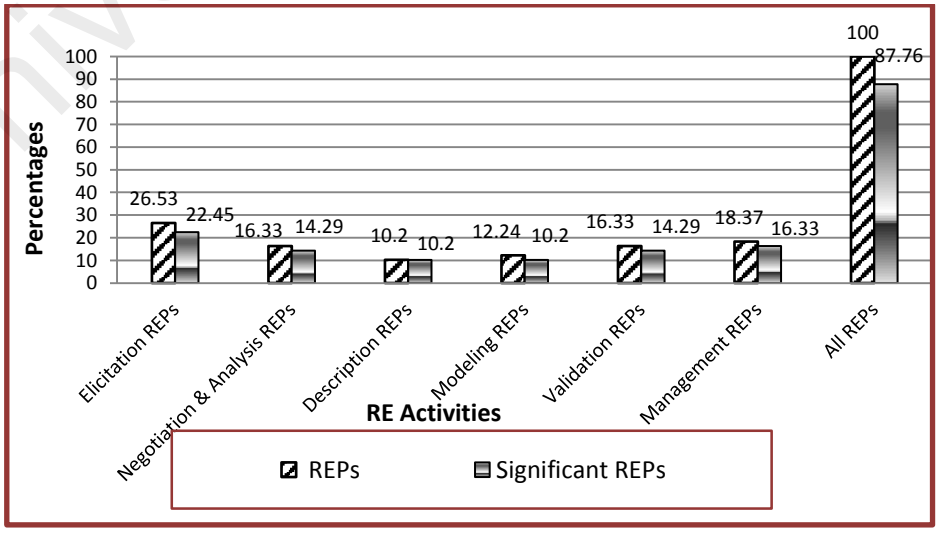

Figure 4. 4 : Percentages of the RE Practices and Significant RE Practices w.r.t activities of RE process

4.5.3 Analysis of the attained prominence levels

For six key areas of the RE process, the 43 REPs have been identified which are significant for SDO because of having PLs equal to 50 or more. On observing the data about PLs this has been found that for one REP that is prioritizing requirements (REP_{18}), the PL is 93.52 which is distant from rest of the data. Therefore, it has been treated as an Outlier and has been omitted from the data. After excluding PL having value 93.52, the remaining PLs' values have been checked for normality.

Table 4.15 contains the results of the two tests of normality which are the Kolmogorov-Smirnov Test and Shapiro-Wilk Test. Keeping in view data set size (42), the Shapiro-Wilk Test is more suitable (D'agostino, Belanger, & D'Agostino Jr, 1990). Therefore, the Shapiro-Wilk Test has been used to assess the normality of the data.

From Table 4.15 it is clear that in the case of the Shapiro-Wilk Test, the p-value is .389 which is greater than 0.05. This shows that the PLs' data is normal.

Table 4. 15 : Results of normality tests

	Kolmogorov-Smirnov			**Shapiro-Wilk**		
	Statistic	df	Sig.	Statistic	df	Sig.
PL	.116	42	.178	.972	42	.389

If μ is the mean of the PLs (x_i) of significant REPs, σ is the standard deviation and N is no. of values in data set.

Then

N=42

$$\sum x_i = 2781.46$$

So $\mu = 66.23$

And $\sum (x_i - \mu)^2 = 794.745$

So $\sigma = 4.35$

Now

$\mu \pm 1\sigma = (66.23 - 4.35, 66.23 + 4.35)$

$= (61.88, 70.58)$

$\mu \pm 2\sigma = (66.23 - 8.7, 66.23 + 8.7)$

$= (57.53, 74.93)$

$\mu \pm 3\sigma = (66.23 - 13.05, 66.23 + 13.05)$

$= (53.18, 79.28)$

The values of $\mu \pm 3\sigma$ reveal that in case of approximately 99% of the significant REPs, the PLs or percentages of the practitioners (who consider these REPs as significant for SDO) lie between 53.18(or 53) and 79.28(or 79).

As for almost 99% of the significant REPs, their corresponding PLs lie between 53 and 79, therefore, this can be concluded that the identified REPs are significant for SDO according to the perception of 53% to 79% of practitioners or around half to $4/5^{th}$ of the SDO industry practitioners.

4.5.4 Selection of 'low perceived benefits' and 'zero perceived benefits' categories

A somewhat odd observation about the responses from various categories of practitioners is that in case of almost all of the REPs, a sufficient number of practitioners have selected 'low perceived benefits' and 'zero perceived benefits' categories. The underlying reason behind this phenomenon might be the fact that for different categories of practitioners, different key areas' REPs are important keeping in view their job nature. According to the perception of one class of practitioners say 'managers', REPs belonging to one key area are important, however, the same REPs can be treated as unimportant by another class of practitioners thereby resulting in the selection of 'low perceived benefits' and 'zero perceived benefits' categories.

4.5.5 Significant RE practices to address issues of RE process for SDO

The 43 RE practices, recommended by Sommerville and Sawyer, which are significant to address the issues of RE process for SDO have been shown in Table 4.16. This provides answer to RQ3.

Table 4.16: Sommerville and Sawyer' Significant RE practices for SDO(Iqbal, et al., 2013)

Sr. #	Significant RE Practices for SDO
1.	Assess system feasibility.
2.	Identifying stakeholders of system and consulting them.
3.	Recording requirements originating sources.
4.	Defining operating environment of system.
5.	Using concerns of business for derivation of the elicitation of requirements.
6.	Look for domain constraints.
7.	Record requirements rationale.
8.	Prototype the poorly understood requirements.
9.	Use scenarios to elicit requirements.
10.	Define operational processes.
11.	Reuse requirements from already developed similar systems.
12.	Define system boundaries.
13.	Use checklists for requirements analysis.
14.	Use communication mechanism to support negotiations.
15.	Plan for conflicts identification & resolution.
16.	Prioritize requirements.
17.	Classification of the requirements through multi-dimensional approach.
18.	Assess requirements risks.
19.	Define and use standard templates for requirements description.
20.	Use simple, consistent and concise language to describe requirements.
21.	Use diagrams appropriately.
22.	Supplement natural language with other descriptions of the requirements.
23.	Specify requirements quantitatively where appropriate.
24.	Model the system's environment.
25.	Model the system's architecture.
26.	Use structured methods for system modeling.
27.	Use a data dictionary.
28.	Documentation of the association between stakeholder requirements and models of system.
29.	Checking to verify that the requirements document is according to your standards.
30.	Organizing the inspections of requirements.
31.	Using multi-disciplinary teams for reviewing requirements.
32.	Defining the checklists for validation of requirements.
33.	Using prototype in order to animate the requirements.
34.	Writing a user manual draft.
35.	Paraphrasing system models into natural language.
36.	Identification of each requirement uniquely.
37.	Defining policies in order to manage requirements.
38.	Defining requirements traceability policies.
39.	Maintaining the manual of traceability.
40.	Usage of database for the management of requirements.
41.	Defining policies to manage requirements change.
42.	Identification of the global system requirements.
43.	Identifying the volatile requirements.

4.6 Identifying the additional issues of RE process for SDO and exploring RE practices to address those issues

A questionnaire survey (3rd questionnaire survey of the research work) has been performed with SDO practitioners to identify the additional issues of RE process for SDO and to find the relevant RE practices that are used by SDO practitioners to address those issues. Guidelines provided in study (B. A. Kitchenham & Pfleeger, 2008) have been used to design and conduct the survey.

(a) Data Collection: This survey is a cross sectional study. The questionnaire, provided in Appendix A as questionnaire 3, has been used for the study. A total of 200 questionnaires have been distributed through drop-off/ pick up method. The survey has been conducted by using semi-supervised approach (Pfleeger & Kitchenham, 2001). Survey's objectives, expectations from the practitioners, questionnaire format and respondents' queries have been made clear through Computer-Assisted Telephone Interviewing technique (Anie, et al., 1996).

(b) Questionnaire Format: The questionnaire contains two parts. The purpose of the first part is to collect data about the respondents' experience, job nature and respective companies. The second part is meant for collecting the issues of SDO RE process faced by SDO practitioners and the practices they use to address those issues. To improve the questionnaire layout, assess the language comprehension and estimate the time required to complete the questionnaire, two rounds of pilot study have been conducted. Recommendations have been incorporated after the first round. The second round has been carried out to ensure that the changes made are according to the given suggestions.

In the questionnaire, 129 literature-based issues of RE process for SDO (identified through SLR) have been provided in the form of seven categories that are: i) Communication, ii) Knowledge management and awareness, iii) Cultural diversities, iv)

Management and coordination, v) Processes and tools, vi) Relationship among stakeholders, and vii) Requirements centric. By providing this category-wise literature-based list of SDO RE process issues, SDO practitioners have been solicited to:

i) Change the category of issue(s) along with the reason(s) of change, if they feel that any issue should be placed in a category other than present one.

ii) Mention those issues of RE process for SDO that they have been facing during their SDO careers OR mention the issues about which they perceive that such issues may arise during the RE process for SDO but have not been provided in the category-wise literature-based list of issues. The SDO practitioners have also been requested to recommend suitable RE practices for addressing such issues.

(c) Sampling and population: The Convenience Sampling method has been employed for obtaining a valid sample of respondents. The respondents are project managers, software engineers, team leaders, quality assurance managers, programmers, designers, requirements engineers, analysts and manager operations having at least 5 years SDO experience.

(d) Response rate: Totally 110 responses have been received back. Out of a total of 110 responses, the 106 responses have been selected for data analysis based on the respondent's company profile, job title, relevant experience and credibility of the data. Details about the third questionnaire survey of this research have been shown in Table 4.17.

Table 4. 17 : Details about the third questionnaire survey of research work

		No. of Questionnaires			
	Survey Medium	**Distributed**	**Received Back**	**Selected for Data analysis**	**Percentages**
	Questionnaire Drop-Off/Pick-Up	200	110	----	57.89%
Total	----	200	----	106	55.79%

Seven respondents have suggested for changing the categories of seven issues but the reasons are not logical to support the category change. This has also been discussed later while performing Root Cause Analysis.

4.6.1 Consolidation of SDO RE process issues and RE Practices

Two fellow researchers have been involved to prepare the final: i) List of SDO RE process issues, ii) List of RE practices to address those issues. Ambiguities in the terms have been removed and identical issues from literature and SDO industry have been combined. Similarly, identical RE practices from the literature and the industry have been combined.

4.6.1.1 Additional issues of RE process for SDO

Through the 3rd questionnaire survey of this research work, 21 additional issues have been reported by SDO practitioners. Out of these 21 issues, 1 issue belongs to 'Communication' category that has been represented as Issue22. Similarly, 3 issues belong to 'Knowledge management and awareness' that have been represented by Issue44, Issue45 and Issue46. 'Cultural diversities' category causes 3 additional issues that have been denoted by Issue66, Issue67 and Issue68. Furthermore, 3 issues belong to 'Management and coordination' that have been represented by Issues88, Issue89 and Issue90. According to the opinion of SDO practitioners, 'Processes and tools' create 3 additional issues that have been represented by Issue107, Issue108 and Issue109. No additional issue related to 'Relationship among stakeholders' has been reported by SDO practitioners whereas 8 additional issues related to 'Requirements centric' category have been reported by SDO practitioners that have been symbolized by Issue143, Issue144,…,Issue150.

All the 21 additional issues have been given in Table 4.6. This provides the answer to RQ4. Thus Table 4.6 presents consolidated list of 150 issues of RE process for SDO.

4.6.1.2 Additional RE practices to address the issues

Through the 3rd questionnaire survey of this research work, 14 additional RE practices have also been identified that can be used to address the issues of RE process for SDO. These practices have been shown in Table 4.18. This provides answer to RQ5.

Table 4. 18 : Additional RE practices to address the issues of RE process for SDO

Sr. #	Additional practices, reported by SDO Practitioners, to address the issues of RE process for SDO.
1.	Encouraging use of Facebook or Twitter as communication mechanism [Proposed].
2.	Recording the synchronous communication through telephone calls, Skype and videoconferencing [Proposed].
3.	Identifying and accessing all requirements sources. The possible requirements sources are: i) End-users of the system, managers, directors, administrators, clients, developers and maintenance personnel. ii) Individuals who are involved in the activities of business processes. iii) Individuals who are concerned or affected as stated by client management. iv) Requirements specification provided by client or needs of various stakeholders. v) Problems or issues faced by stakeholders. vi) Domain experts. vii) Domain constraints, regulations and standards to be followed. viii) Similar existing systems. ix) Users of similar existing systems. x) Documents about the target system like record-keeping books, bills, receipts and reports. xi) Other software(s) or system(s) that interact with the system to be developed [Proposed].
4.	Having training and knowing about different features of RE tool(s) before selecting tools [Proposed].
5.	Consulting domain experts if possible [Proposed].
6.	Assessing the time required for different activities by considering the fact that delays are most likely to occur as stakeholders are spread [Proposed].
7.	Calculating and accommodating the Float or Slack Time in schedule if possible [Proposed].
8.	In case of slow progress: Spending more time and resources. OR Decreasing RE work after consulting stakeholders. OR Transferring some load to some other contractor [Proposed].
9.	Identifying a set of minimum requirements to satisfy the needs of client [Proposed].
10.	Writing an agreed upon Software Requirements Specification document [Proposed].
11.	Sharing requirements related information only with concerned people [Proposed].
12.	Relating extra requirements to additional budget and time [Proposed].
13.	Following common working standard or processes, if it is not possible then minimum possible number of common working standards or processes should be recommended [Proposed].
14.	Informing client side, as earlier as possible, about the requirement(s) that cannot be fulfilled [Proposed].

Now Table 4.7, Table 4.16 and Table 4.18 present 147 RE practices (90 from Table 4.7, 43 from Table 4.16 and 14 from Table 4.18).

Thus 150 issues of RE process for SDO have been identified and 147 relevant RE practices have also been explored that can be employed to address those issues. The details about identification of the 150 issues and 147 RE practices have been provided in the Table 4.19.

Table 4. 19 : No. of identified SDO RE process issues and relevant RE practices

	Methods Employed	**No. of Issues**	**No. of RE Practices**
	Systematic literature review to find literature-based issues of SDO RE process and literature-based RE practices to address those issues.	**129** (Table[4.6])	**90** (Table[4.7])
	3rd Questionnaire survey with SDO practitioners to find additional issues and additional RE practices from SDO industry.	**21** (Table[4.6])	**14** (Table[4.18])
	2nd Questionnaire survey with SDO practitioners to explore Sommerville and Sawyer's significant RE practices for SDO	**----**	**43** (Table[4.16])
Total	**----**	**150**	**147**

In order to propose a workable model, reduction in the number of issues is essential. This has been achieved by performing filtration of the issues based on the 'frequency of occurrence' of the issues. Also next step is to apply the Root Cause Analysis (RCA) method to discover the root causes for occurrence of issues and to recommend relevant RE practices to address the issues. In many studies, number of issues or problems is reduced before performing RCA like (Wallin, Larsson, Fröberg, & Axelsson, 2012) where 21 problems about the development of the architecture of software intensive systems have been identified. Out of the 21 identified problems, for the RCA only four have been selected by conducting a questionnaire survey that is based on the occurrence of these problems in various companies. Therefore the next step of research work is to filter out those issues of RE process for SDO that occur frequently.

4.7 Summary

This chapter is completed in the two phases. During the first phase, through the Systematic Literature Review, 129 issues of the Requirements Engineering (RE) process for Software Development Outsourcing (SDO) are identified along with the 90 RE practices that can be used to address those issues. Through the 1st questionnaire survey, with SDO industry practitioners, seven categories of the issues of RE process for SDO are originated that are : i) Communication, ii) Knowledge management and awareness, iii) Cultural diversities, iv) Management and coordination, v) Processes and tools, vi) Relationship among stakeholders, and vii) Requirements centric. Subsequently, Sommerville and Sawyer's 43 significant RE practices for SDO are identified through the 2nd questionnaire survey. This completes the exploration of the literature to achieve the research objectives. In the second phase, the 3rd questionnaire survey with the SDO industry practitioners, identifies 21 SDO RE process issues faced by SDO practitioners along with the 14 RE practices to address such issues. The chapter is concluded by identifying 150 issues (129 + 21) of the RE process for SDO and by exploring the 147 RE practices (90 +43+14) that are employed to address the issues.

CHAPTER 5: FORMATION OF THE REP MODEL

This chapter describes the process for the extraction of 43 frequently occurring issues, of the Requirements Engineering (RE) process for Software Development Outsourcing (SDO), out of 150 issues gathered from literature and SDO industry. Afterwards, 43 frequently occurring issues are ranked with respect to frequently occurring issues within the respective categories (Category-wise ranking) and with respect to frequently occurring issues of all the seven categories (Overall- ranking). Next, seven categories of the issues are ranked. After that, the root causes for the frequently occurring issues are discovered. This is followed by the mapping of the RE practices to the corresponding frequently occurring SDO RE process issues to address those issues in case of respective root causes. Thus, the development of the REP Model is accomplished at the end of Chapter 5. Table 5.1 shows the association of the research objectives and research questions with the contents of Chapter 5.

Table 5. 1 : Relationship between research objectives and contents of chapter 5

Research Objectives(ROs)	Research Questions (RQ)	Research Methods	Output
RO3	RQ6	Delphi method, Cut-off value method (4^{th} questionnaire survey of research work)	Table [5.6]
	RQ7	Delphi method, Ranking based on means of response values (4^{th} questionnaire survey of research work)	Table [5.18]
	RQ8	Root Cause Analysis, 5 Whys and Brainstorming techniques	Table [5.20]

5.1 Steps for formation of the REP Model

The basic aim of the REP Model is to present the sets of best RE practices for addressing the frequently occurring issues of RE process for SDO. For this purpose, the REP Model formation involves three steps:

i) **Step 1:** Extraction of the frequently occurring issues of RE process for SDO, out of 150 issues identified from the literature and the industry.

ii) **Step 2:** Ranking of the frequently occurring issues of RE process for SDO and ranking of those issues' categories.

iii) **Step 3:** Identification of the root causes for the frequently occurring issues and recommendation of the relevant RE practices to address those issues in case of respective root causes.

REP Model formation is described step by step.

5.2 Extracting and ranking the frequently occurring issues of RE process for SDO

This research work employs Delphi method to:

i) Identity the frequently occurring issues of RE process for SDO

ii) Rank the frequently occurring issues of RE process for SDO and categories of those issues

5.2.1 Delphi Method

The research has employed Delphi method as recommended by (Nakatsu & Iacovou, 2009; R. Schmidt, Lyytinen, & Mark Keil, 2001; R. C. Schmidt, 1997) in which a three phase approach has been adopted. With respect to number of rounds, many variations of Delphi method are followed. According to (Fan & Cheng, 2006) three rounds are adequate. Delphi method can be shortened to two or three rounds for achieving research objectives according to (Habibi, Sarafrazi, & Izadyar, 2014; Nevo & Chan, 2007; Okoli & Pawlowski, 2004; Skulmoski, et al., 2007). For this research work, three rounds have been performed. Like first round of (R. Schmidt, et al., 2001; R. C. Schmidt, 1997), issues of RE process for SDO have been identified in previous steps of this research (Section 4.3, Section 4.6.1.1 and Table 4.6). This has been taken as the first round of

Delphi method. During this round, 150 issues have been identified through systematic literature review and by involving SDO industry practitioners. The list of issues has been consolidated as advised in (Nakatsu & Iacovou, 2009; R. Schmidt, et al., 2001; R. C. Schmidt, 1997) by involving two other researchers. During the consolidation process, identical issues from the literature and the industry have been combined, ambiguities about terms have been removed (different terms or texts are used to described same meanings and same texts or terms are meant to convey different meanings) and final list of 150 issues has been prepared. The consolidated list of 150 issues (Table 4.6) has been used during 2nd and 3rd rounds. Frequently occurring issues could be extracted after 2nd round but all the 150 issues have been carried forward and presented in round 3 for developing further consensus among practitioners regarding 'frequencies of occurrence' of the issues. After round 3, the frequently occurring issues have been identified and ranked. Thus 2nd and 3rd rounds serve two purposes: i) Extracting the frequently occurring issues, and ii) Ranking those issues and categories of issues.

5.2.1.1 Performing 2nd and 3rd rounds of Delphi Method

As described earlier three rounds of Delphi method have been performed for this research work. During the already completed first round, the list of 150 issues of RE process for SDO has been consolidated (Table 4.6). To complete 2nd and 3rd rounds of the Delphi method, two rounds of questionnaire survey (4th questionnaire survey of research work) have been conducted. Guidelines provided in study (B. A. Kitchenham & Pfleeger, 2008) have been used to design and conduct the survey.

(a) Data collection: This survey is cross sectional study. The questionnaire, provided in Appendix A as questionnaire 4, has been used for the study. Like previous surveys, this survey has also been facilitated through semi-supervised approach (Pfleeger & Kitchenham, 2001). Participants have been briefed about Delphi method and their

queries have been replied by using Computer-Assisted Telephone Interviewing technique (Anie, et al., 1996).

(b) Sampling and population: The Convenience Sampling method has been employed for obtaining a valid sample of respondents. The respondents are project managers, system analysts, requirements engineers, technical managers and senior managers having at least 5 years' of SDO experience as basic criterion. Prior to conducting the study, 200 practitioners have been identified who satisfied the basic criterion. Out of 200, 118 have shown willingness directly or indirectly for participating in the 2nd and 3rd rounds of study. However, only 106 respondents have completed both the rounds. Many Delphi studies involve more than 100 participants (Kelly & Porock, 2005; Meadows, Maine, Keyes, Pearson, & Finstuen, 2005).

5.2.1.2 Second round

Details of second round are:

(a) Questionnaire Format: The questionnaire used during second round has been divided into two parts. The first part is intends to obtain information about the respondent's job nature, experience and respective company. The succeeding part is to collect data about the 'frequencies of occurrence' of RE process issues in case of SDO. Before starting surveys, to enhance the layout of the questionnaires, to assess the comprehension of the language and to estimate time required to fill the questionnaire, two rounds of pilot study have been carried out. Suggestions given during first round have been accommodated. The second round has been conducted to make sure that alterations are in accordance with the recommendations given during first round.

A category-wise list of 150 issues, extracted from the literature and the SDO industry, has been provided to practitioners. The practitioners have been solicited to mention the 'frequency of occurrence' in case of each issue by selecting a category out of the five

given categories. Based on 5-point Likert Scale different categories for 'frequency of occurrence' have been devised as suggested by (Ramasubbu, Krishnan, & Kompalli, 2005; Vagias, 2006) and are as follows:

i) **Almost always (5):** An issue is referred as occurring 'Almost always' if it occurs almost **every time(90-100%)** during the RE process for Software Development Outsourcing**.**

ii) **Frequently (4):** An issue is referred as occurring 'Frequently' if it occurs **often (60-89%)** during the RE process for Software Development Outsourcing.

iii) **About half of the time (3):** An issue is referred as occurring **'**About half of the time' if it occurs almost **half of the time (40-59% time)** during the RE process for Software Development Outsourcing.

iv) **Occasionally (2):** An issue is referred as occurring 'Occasionally' if it occurs **less often (10-39% time)** during the RE process for Software Development Outsourcing**.**

v) **Rarely (1):** An issue is referred as occurring 'Rarely' if it occurs **rarely or never** during the RE process for Software Development Outsourcing.

(b) Response Rate: The questionnaire has been distributed to 118 practitioners by using drop-off/pick-up method. Out of 118 questionnaires, 110 questionnaires have been received back. Average frequency and standard deviation have been calculated in case of each issue at the end of second round.

5.2.1.3 Third round

Details of third round are:

(a) Questionnaire Format: During the third round questionnaires have been sent to those 110 SDO practitioners, by using drop-off/pick-up method, who responded during the second round. For each issue, practitioners have been provided with their respective

individual round 2 frequencies and average frequency. The practitioners have been offered to reassess their respective individual frequencies, for each issue, keeping in view the average frequency if necessary.

(b) Response Rate: During third round, 106 responses have been received back. Out of those 106 responses, 103 have been considered for the data analysis based on the respondent's company profile, job title, relevant experience and accuracy of data.

Details of the Delphi questionnaire survey have been shown in Table 5.2.

Table 5. 2 : Details about the Delphi questionnaire survey

	Survey Stage	Survey Medium	Invitations / Questionnaires sent	No. of Questionnaires		Percentages
				Received Back	Selected for Data analysis	
	Getting consent	Email	200	118	----	59%
	Delphi method 2nd Round	Questionnaire Drop-Off/Pick-Up	118	110	----	93.22%
	Delphi method 3rd Round	Questionnaire Drop-Off/Pick-Up	110	106	----	96.36%
Total	200				103	51.50%

5.2.1.4 Results of Delphi Method survey

As described earlier, before starting the third round of Delphi method, average frequencies and standard deviations have been calculated in case of each issue. At the start of third round, for each issue, SDO practitioners have been provided with their respective individual round 2 frequency and average frequency. The practitioners have been requested to reconsider their respective frequencies in case of each issue, keeping in view the average frequencies if they feel it appropriate. The average frequency and standard deviation, for each issue, have been calculated again after third round.

The average frequencies and standard deviations calculated, for each issue, after second and third rounds have been shown in Table 5.3. The averages of the standard deviations

after second and third round have also been calculated. This can be observed that average standard deviation has reduced from .729 in round 2 to .688 in round 3.

As described earlier (Section 5.2.1) the criterion to stop Delphi study is completion of three rounds. Also practitioners were not available to participate in the fourth round (Nakatsu & Iacovou, 2009), therefore, it was decided to conclude the study after 3rd round.

Table 5. 3 : Average frequency & Standard Deviation, in case of each issue, calculated after 2nd round & 3rd round of Delphi method

Sr. #	Issues' IDs	Round 2		Round 3	
		Average	St. Dev.	Average	St. Dev.
1.	Issue1	4.077670	.7629833	4.116505	.7316510
2.	Issue2	4.194175	.7417289	4.203883	.7324311
3.	Issue3	1.592233	.6632790	1.563107	.5886159
4.	Issue4	1.689320	.6864105	1.669903	.6004630
5.	Issue5	4.106796	.7658472	4.126214	.7628586
6.	Issue6	1.485437	.6695635	1.485437	.6240927
7.	Issue7	4.203883	.7456965	4.213592	.7363195
8.	Issue8	1.941748	.8612035	1.912621	.8057002
9.	Issue9	1.679612	.7031246	1.660194	.6191930
10.	Issue10	1.504854	.6697056	1.495146	.6242452
11.	Issue11	1.543689	.6970062	1.533981	.6540303
12.	Issue12	4.058252	.7647278	4.097087	.6790213
13.	Issue13	1.679612	.6295593	1.660194	.5866722
14.	Issue14	1.553398	.6527191	1.543689	.6067706
15.	Issue15	1.650485	.6960496	1.640777	.6080243
16.	Issue16	1.737864	.8039262	1.728155	.7435233
17.	Issue17	1.679612	.6449440	1.660194	.6031518
18.	Issue18	1.504854	.6083373	1.504854	.5920020
19.	Issue19	1.543689	.6827956	1.543689	.6382682
20.	Issue20	1.825243	2.0264292	1.796117	2.0017601
21.	Issue21	1.495146	.6397577	1.495146	.6242452
22.	Issue22	4.174757	.6920725	4.194175	.6868264
23.	Issue23	3.844660	.7765848	3.854369	.7721598

Table 5.3, Continued

Sr. #	Issues' IDs	Round 2		Round 3	
		Average	St. Dev.	Average	St. Dev.
24.	Issue24	1.563107	.6366256	1.553398	.5895854
25.	Issue25	1.543689	.7109328	1.504854	.6242452
26.	Issue26	4.165049	.7933188	4.165049	.7933188
27.	Issue27	1.631068	.6102120	1.631068	.5939283
28.	Issue28	1.786408	.7363195	1.766990	.7029892
29.	Issue29	4.077670	.7368364	4.087379	.7290444
30.	Issue30	1.553398	.6820982	1.504854	.6242452
31.	Issue31	1.766990	.7695668	1.766990	.7567200
32.	Issue32	1.679612	.6746617	1.640777	.5916804
33.	Issue33	1.514563	.6396089	1.504854	.6242452
34.	Issue34	4.135922	.7547048	4.165049	.7553351
35.	Issue35	1.543689	.6534479	1.533981	.5910365
36.	Issue36	1.660194	.6649989	1.631068	.6102120
37.	Issue37	4.048544	.8674805	4.077670	.8247319
38.	Issue38	1.504854	.6397577	1.504854	.6083373
39.	Issue39	1.660194	.7078467	1.631068	.6415406
40.	Issue40	1.524272	.6393112	1.514563	.6240927
41.	Issue41	1.961165	.7786657	1.961165	.7530634
42.	Issue42	2.009709	.8459262	2.000000	.8284169
43.	Issue43	4.067961	.7829323	4.077670	.7757264
44.	Issue44	1.475728	.5915195	1.485437	.6240927
45.	Issue45	4.097087	.7860869	4.106796	.7785434
46.	Issue46	1.631068	.6714090	1.601942	.6158018
47.	Issue47	1.553398	.6059858	1.543689	.5903920
48.	Issue48	1.504854	.6549029	1.485437	.6240927
49.	Issue49	1.524272	.6393112	1.514563	.5918412
50.	Issue50	3.970874	.8795756	4.009709	.8342561
51.	Issue51	3.970874	.8219574	4.000000	.7669650
52.	Issue52	1.631068	.5939283	1.640777	.6080243
53.	Issue53	3.990291	.9234966	4.009709	.9020146
54.	Issue54	1.524272	.6237876	1.514563	.5918412
55.	Issue55	1.640777	.6546121	1.621359	.6122364
56.	Issue56	1.495146	.5920020	1.504854	.5920020
57.	Issue57	1.514563	.6081808	1.514563	.6240927
58.	Issue58	1.592233	.6778989	1.543689	.6067706
59.	Issue59	1.495146	.6242452	1.495146	.6242452
60.	Issue60	1.533981	.6388644	1.514563	.5918412
61.	Issue61	1.834951	.7289139	1.815534	.6965964
62.	Issue62	1.514563	.6695635	1.495146	.6242452
63.	Issue63	1.543689	.6382682	1.524272	.5915195
64.	Issue64	1.689320	.6421338	1.669903	.6004630
65.	Issue65	1.533981	.7251171	1.504854	.6397577
66.	Issue66	3.961165	.8623080	3.970874	.8569933
67.	Issue67	1.669903	.6165742	1.660194	.6031518

Table 5.3, Continued

Sr. #	Issues' IDs	Round 2		Round 3	
		Average	St. Dev.	Average	St. Dev.
68.	Issue68	3.980583	.8964044	4.019417	.8964044
69.	Issue69	4.058252	.7899521	4.077670	.7882634
70.	Issue70	1.543689	.6227186	1.524272	.5915195
71.	Issue71	1.504854	.6242452	1.495146	.6242452
72.	Issue72	4.145631	.7721598	4.165049	.7682050
73.	Issue73	1.572816	.6355782	1.553398	.5895854
74.	Issue74	1.553398	.7239347	1.543689	.6970062
75.	Issue75	4.077670	.8247319	4.106796	.8033340
76.	Issue76	1.543689	.5903920	1.533981	.5742093
77.	Issue77	1.543689	.6827956	1.524272	.6393112
78.	Issue78	1.504854	.6697056	1.485437	.6240927
79.	Issue79	1.533981	.6073978	1.533981	.5910365
80.	Issue80	1.514563	.6840490	1.495146	.6397577
81.	Issue81	1.669903	.6475951	1.660194	.6031518
82.	Issue82	1.504854	.6549029	1.485437	.6240927
83.	Issue83	1.563107	.6366256	1.553398	.5895854
84.	Issue84	4.058252	.8022669	4.058252	.8022669
85.	Issue85	1.689320	.7005478	1.650485	.6056715
86.	Issue86	1.524272	.7118694	1.495146	.6242452
87.	Issue87	1.553398	.6675703	1.533981	.5742093
88.	Issue88	1.495146	.6397577	1.485437	.6240927
89.	Issue89	4.135922	.7675853	4.145631	.7593569
90.	Issue90	1.514563	.6081808	1.514563	.5918412
91.	Issue91	1.660194	.6500890	1.650485	.6056715
92.	Issue92	1.572816	.7222234	1.524272	.5915195
93.	Issue93	1.553398	.7505313	1.504854	.6397577
94.	Issue94	1.563107	.6518436	1.533981	.5910365
95.	Issue95	3.961165	.8736034	4.000000	.8284169
96.	Issue96	3.902913	.8461512	3.922330	.8247319
97.	Issue97	1.650485	.6524274	1.640777	.6080243
98.	Issue98	1.504854	.6697056	1.485437	.6240927
99.	Issue99	3.970874	.8683578	4.009709	.8224205
100.	Issue100	1.495146	.6242452	1.504854	.6242452
101.	Issue101	1.601942	.7321712	1.553398	.6059858
102.	Issue102	1.582524	.7346371	1.533981	.6540303
103.	Issue103	1.582524	.6934465	1.563107	.6050426
104.	Issue104	1.679612	.6890401	1.650485	.6056715
105.	Issue105	4.000000	.8966167	4.029126	.8795756
106.	Issue106	1.582524	.7074432	1.543689	.6067706
107.	Issue107	3.852941	.8832552	3.854369	.8790343
108.	Issue108	1.873786	.8004853	1.873786	.7498969
109.	Issue109	1.582524	.6934465	1.563107	.6050426
110.	Issue110	3.941748	.8725132	3.970874	.8569933
111.	Issue111	1.504854	.6697056	1.504854	.6397577

Table 5.3, Continued

Sr. #	Issues' IDs	Round 2		Round 3	
		Average	St. Dev.	Average	St. Dev.
112.	Issue112	1.533981	.6388644	1.533981	.6233297
113.	Issue113	3.970874	.8683578	3.990291	.8687962
114.	Issue114	1.495146	.6549029	1.504854	.6549029
115.	Issue115	3.912621	.8977837	3.922330	.8821689
116.	Issue116	1.592233	.6778989	1.582524	.6343790
117.	Issue117	3.932039	.8315133	3.961165	.7786657
118.	Issue118	1.524272	.7255108	1.504854	.6397577
119.	Issue119	3.796117	.8895827	3.825243	.8451382
120.	Issue120	4.000000	.8966167	4.009709	.8910794
121.	Issue121	1.533981	.6073978	1.543689	.6067706
122.	Issue122	1.475728	.6393112	1.475728	.6237876
123.	Issue123	1.689320	.7279992	1.640777	.6080243
124.	Issue124	4.019417	.8399414	4.038835	.7911561
125.	Issue125	1.504854	.6697056	1.495146	.6242452
126.	Issue126	3.951456	.8674805	3.970874	.8219574
127.	Issue127	1.563107	.6812604	1.524272	.5915195
128.	Issue128	4.009709	.8224205	4.019417	.8162634
129.	Issue129	4.019417	.8742569	4.029126	.8683578
130.	Issue130	1.553398	.6375221	1.543689	.5903920
131.	Issue131	1.553398	.7373529	1.533981	.6540303
132.	Issue132	3.961165	.8736034	3.990291	.8224205
133.	Issue133	4.067961	.7953558	4.077670	.7882634
134.	Issue134	1.582524	.7736376	1.533981	.6540303
135.	Issue135	1.563107	.6812604	1.524272	.5915195
136.	Issue136	1.519608	.7275402	1.495146	.6397577
137.	Issue137	1.514563	.6840490	1.504854	.6397577
138.	Issue138	1.572816	.6802817	1.563107	.6050426
139.	Issue139	1.699029	.7253796	1.640777	.6080243
140.	Issue140	1.592233	.7062313	1.553398	.5895854
141.	Issue141	1.524272	.6837707	1.485437	.6240927
142.	Issue142	4.009709	.7982228	4.029126	.7977457
143.	Issue143	1.708738	.7089217	1.679612	.6137891
144.	Issue144	1.572816	.6355782	1.563107	.6050426
145.	Issue145	1.524272	.7255108	1.504854	.6397577
146.	Issue146	4.067961	.7829323	4.077670	.7757264
147.	Issue147	1.582524	.6934465	1.572816	.6802817
148.	Issue148	2.029126	.8569933	2.019417	.8281870
149.	Issue149	1.737864	.7404446	1.728155	.6743795
150.	Issue150	3.980583	.8629700	3.990291	.8574374
Average			**.72896708**		**.68786044**

5.2.1.5 Measurement of Internal Consistency

After the 3rd round of Delphi method, to measure the internal consistency of scale, Reliability Analysis has been performed. The value of Cronbach Alpha, as shown in

Table 5.4, is .964. Value of Cronbach Alpha equal to .7 or higher is acceptable, greater than .8 is considered 'good' whereas greater than .9 indicates 'excellent' internal consistency(Gliem & Gliem, 2003; Santos, 1999).

Table 5. 4 : Reliability statistics

Cronbach's Alpha	N of Items
.964	150

5.2.2 Selecting frequently occurring issues

The means of response values, obtained after 3rd round of Delphi method, for the 150 issues have been shown in the Table 5.5 in descending order.

Table 5. 5 : Means, in descending order, of responses values for 150 issues after 3rd round of Delphi method

Sr. #	Issue IDs	Means		Sr. No	Issue IDs	Means
1.	Issue7	4.213592		32.	Issue150	3.990291
2.	Issue2	4.203883		33.	Issue132	3.990291
3.	Issue22	4.194175		34.	Issue113	3.990291
4.	Issue34	4.165049		35.	Issue110	3.970874
5.	Issue72	4.165049		36.	Issue66	3.970874
6.	Issue26	4.165049		37.	Issue126	3.970874
7.	Issue89	4.145631		38.	Issue117	3.961165
8.	Issue5	4.126214		39.	Issue96	3.922330
9.	Issue1	4.116505		40.	Issue115	3.922330
10.	Issue75	4.106796		41.	Issue107	3.854369
11.	Issue45	4.106796		42.	Issue23	3.854369
12.	Issue12	4.097087		**43.**	**Issue119**	**3.825243**
13.	Issue29	4.087379		44.	Issue148	2.019417
14.	Issue37	4.077670		45.	Issue42	2.000000
15.	Issue133	4.077670		46.	Issue41	1.961165
16.	Issue69	4.077670		47.	Issue8	1.912621
17.	Issue146	4.077670		48.	Issue108	1.873786
18.	Issue43	4.077670		49.	Issue61	1.815534
19.	Issue84	4.058252		50.	Issue20	1.796117
20.	Issue124	4.038835		51.	Issue31	1.766990
21.	Issue142	4.029126		52.	Issue28	1.766990
22.	Issue129	4.029126		53.	Issue149	1.728155
23.	Issue105	4.029126		54.	Issue16	1.728155
24.	Issue128	4.019417		55.	Issue143	1.679612
25.	Issue68	4.019417		56.	Issue64	1.669903
26.	Issue99	4.009709		57.	Issue4	1.669903
27.	Issue53	4.009709		58.	Issue67	1.660194
28.	Issue50	4.009709		59.	Issue9	1.660194
29.	Issue120	4.009709		60.	Issue81	1.660194
30.	Issue95	4.000000		61.	Issue17	1.660194
31.	Issue51	4.000000		62.	Issue13	1.660194

Table 5.5, Continued

Sr. #	Issue IDs	Means		Sr. No	Issue IDs	Means
63.	Issue104	1.650485		107.	Issue77	1.524272
64.	Issue91	1.650485		108.	Issue135	1.524272
65.	Issue85	1.650485		109.	Issue127	1.524272
66.	Issue123	1.640777		110.	Issue92	1.524272
67.	Issue97	1.640777		111.	Issue63	1.524272
68.	Issue15	1.640777		112.	Issue70	1.524272
69.	Issue139	1.640777		113.	Issue90	1.514563
70.	Issue52	1.640777		114.	Issue60	1.514563
71.	Issue32	1.640777		115.	Issue57	1.514563
72.	Issue39	1.631068		116.	Issue54	1.514563
73.	Issue36	1.631068		117.	Issue40	1.514563
74.	Issue27	1.631068		118.	Issue49	1.514563
75.	Issue55	1.621359		119.	Issue93	1.504854
76.	Issue46	1.601942		120.	Issue65	1.504854
77.	Issue116	1.582524		121.	Issue56	1.504854
78.	Issue147	1.572816		122.	Issue38	1.504854
79.	Issue138	1.563107		123.	Issue18	1.504854
80.	Issue144	1.563107		124.	Issue145	1.504854
81.	Issue109	1.563107		125.	Issue33	1.504854
82.	Issue103	1.563107		126.	Issue30	1.504854
83.	Issue3	1.563107		127.	Issue25	1.504854
84.	Issue83	1.553398		128.	Issue137	1.504854
85.	Issue24	1.553398		129.	Issue118	1.504854
86.	Issue101	1.553398		130.	Issue114	1.504854
87.	Issue73	1.553398		131.	Issue111	1.504854
88.	Issue140	1.553398		132.	Issue100	1.504854
89.	Issue121	1.543689		133.	Issue136	1.495146
90.	Issue130	1.543689		134.	Issue125	1.495146
91.	Issue106	1.543689		135.	Issue21	1.495146
92.	Issue58	1.543689		136.	Issue10	1.495146
93.	Issue47	1.543689		137.	Issue71	1.495146
94.	Issue19	1.543689		138.	Issue86	1.495146
95.	Issue14	1.543689		139.	Issue80	1.495146
96.	Issue74	1.543689		140.	Issue62	1.495146
97.	Issue35	1.533981		141.	Issue59	1.495146
98.	Issue11	1.533981		142.	Issue141	1.485437
99.	Issue112	1.533981		143.	Issue6	1.485437
100.	Issue94	1.533981		144.	Issue98	1.485437
101.	Issue87	1.533981		145.	Issue88	1.485437
102.	Issue79	1.533981		146.	Issue82	1.485437
103.	Issue76	1.533981		147.	Issue78	1.485437
104.	Issue134	1.533981		148.	Issue48	1.485437
105.	Issue131	1.533981		149.	Issue44	1.485437
106.	Issue102	1.533981		150.	Issue122	1.475728

5.2.2.1 Cut-off value method for extracting frequently occurring issues

The method of reducing data items or filtering factors is quite common in research in several disciplines including psychology, telecommunication and education, and is

frequently used for interpretation of self-reported studies (Tam & Tummala, 2001; Williams, Onsman, & Brown, 2010). This research work has employed a method similar to that of (Tam & Tummala, 2001).

Using mean values given in Table 5.5.

The highest mean value= 4.213592

The lowest mean value= 1.475728

Average of highest and lowest means= 2.84466

This average determines cut-off value. The issues in case of which mean is equal to or higher than 2.84466, have been selected as frequently occurring issues and hence have been included in the REP Model.

By applying the 'average of highest and lowest means' criterion and observing values in the Table 5.5, the first 43 issues have been selected for the model as all these issues have means greater than 2.84466. In case of the rest of 107 issues, means are less than 2.84466.

The 43 selected issues are:

Issue1, Issue2, Issue5, Issue7, Issue12, Issue22 , Issue23 , Issue26, Issue29, Issue34, Issue37, Issue43, Issue45, Issue50, Issue51, Issue53, Issue66, Issue68, Issue69, Issue72, Issue75, Issue84, Issue89, Issue95, Issue96, Issue99, Issue105, Issue107, Issue110, Issue113, Issue115, Issue117, Issue119, Issue120, Issue124, Issue126, Issue128, Issue129, Issue132, Issue133, Issue142, Issue146 and Issue150. These issues belong to 7 categories that are communication, Knowledge management and awareness, Cultural diversities, Management and coordination, Processes and tools, Relationship among stakeholders and Requirements centric.

A similar method to find cut-off value is using average of all the 150 means as cut-off value.

5.2.2.2 Cut-off value based on average of all means

Table 5.5 shows 'means of response values' in case of all the 150 issues.

Average of the means in case of 150 issues= 2.286084

The average of all means is 2.286084. It is considered as cut-off value. The issues in case of which mean is equal to or higher than 2.286084, have been selected as frequently occurring issues and hence have been included in the REP Model.

By applying 'average of means' criterion and observing values in the Table 5.5, again the first 43 issues have been selected as in case of all these issues means are greater than 2.286084 . In case of the rest of 107 issues, means are less than 2.286084. Thus the 43 selected issues are similar to those of extracted by using the cut-off value based on the average of the highest and the lowest mean values. The 43 issues along with the IDs, respective means and categories have been shown in Table 5.6.

Table 5. 6 : Frequently occurring issues of RE process for SDO along with means and categories

Sr.#	Frequently Occurring Issues and IDs	Means	Category
1.	Issue1: Infrequent and constrained communication among the stakeholders during RE process.	4.116505	Communication
2.	Issue2: Lack of informal communication among the stakeholders during RE process.	4.203883	Communication
3.	Issue5: Lack of synchronous communication.	4.126214	Communication
4.	Issue7: Delayed responses.	4.213592	Communication
5.	Issue12: Unproductive meetings that are held to take decisions about the requirements.	4.097087	Communication
6.	Issue22: Usually non recording of commitments made during videoconferencing or telephonic conversation, therefore, it cannot be referred if required.	4.194175	Communication
7.	Issue23: Hindrance in circulation of requirements knowledge from/to organizations.	3.854369	Knowledge management and awareness
8.	Issue26: Unawareness of the stakeholders from current/latest information about requirements.	4.165049	Knowledge management and awareness
9.	Issue29: Reopening of the already discussed and seemingly settled issues.	4.087379	Knowledge management and awareness
10.	Issue34: Poor requirements change management.	4.165049	Knowledge management and awareness
11.	Issue37: Working on obsolete requirements.	4.077670	Knowledge management and awareness
12.	Issue43: Unawareness of requirements engineers from the effects of new system implementation on the client organization.	4.077670	Knowledge management and awareness
13.	Issue45: Unawareness from or not accessing all requirements sources .	4.106796	Knowledge management and awareness
14.	Issue50: Lack of trust.	4.009709	Cultural diversities
15.	Issue51: Avoidance of the commitments from the stakeholders.	4.000000	Cultural diversities

Table 5.6, Continued

Sr.#	Frequently Occurring Issues and IDs	Means	Category
16.	Issue53: Difficulties in achieving consensus on requirements.	4.009709	Cultural diversities
17.	Issue66: Nonparticipation or exclusion of stakeholders from RE activities.	3.970874	Cultural diversities
18.	Issue68: Difficulties in setting realistic expectations about response time.	4.019417	Cultural diversities
19.	Issue69: Difficulties in comprehending information, reasons and activities that are required for common Requirements Understanding (RU) among the dispersed stakeholders.	4.077670	Management and coordination
20.	Issue72: Delay in clarifications about requirements and decision making.	4.165049	Management and coordination
21.	Issue75: Poorly defined or undefined responsibilities.	4.106796	Management and coordination
22.	Issue84: Need for adjustment of actual requirements to interact with other software(s).	4.058252	Management and coordination
23.	Issue89: Nonperformance of a Requirements Engineering related task as everybody presumes that this is the responsibility of somebody else.	4.145631	Management and coordination
24.	Issue95: Use of different RE processes, resulting in different templates and methodologies, at the different locations of client.	4.000000	Processes and tools
25.	Issue96: Use of unsuitable RE processes.	3.922330	Processes and tools
26.	Issue99: RE rework or data loss during transfer from one tool to other.	4.009709	Processes and tools
27.	Issue105: Selection of inappropriate RE tool(s).	4.029126	Processes and tools
28.	Issue107: Use of unsuitable requirements elicitation technique.	3.854369	Processes and tools
29.	Issue110: Lack of firm relationship among stakeholders.	3.970874	Relationship among stakeholders
30.	Issue113: Use of different requirements documentation standards by customer and vendor.	3.990291	Relationship among stakeholders
31.	Issue115: Different priorities of client and vendor for collecting and finalizing requirements.	3.922330	Relationship among stakeholders
32.	Issue117: Misconceptions of the vendor teams about client's working practices.	3.961165	Relationship among stakeholders
33.	Issue119: Failure in meeting deadlines and fulfilling commitments about requirements by vendor.	3.825243	Relationship among stakeholders
34.	Issue120: Issues in signing-off requirements engineering deliverables.	4.009709	Relationship among stakeholders
35.	Issue124: Finalizing requirements for all stakeholders based on the requirements gathered or information obtained from the available stakeholders.	4.038835	Requirements centric
36.	Issue126: Incorrect or false requirements.	3.970874	Requirements centric
37.	Issue128: Gold plating or extra requirements.	4.019417	Requirements centric
38.	Issue129: Incomplete requirements.	4.029126	Requirements centric
39.	Issue132: Poor or ambiguous requirements specification.	3.990291	Requirements centric
40.	Issue133: Not providing information or providing intentionally ambiguous information about requirements.	4.077670	Requirements centric
41.	Issue142: Pressure on Requirements Engineers to hide certain information about requirements, resulting in compromised requirements elicitation and specification.	4.029126	Requirements centric
42.	Issue146: Client's insistence on adding new requirements after settlement of cost and time.	4.077670	Requirements centric
43.	Issue150: Applying suppositions for finalizing requirements.	3.990291	Requirements centric

This provides answer to RQ6. Table 5.7 shows no. of frequently occurring issues in each category.

Table 5. 7 : Category-wise no. of frequently occurring SDO RE process issues

Sr. No.	Categories of Issues	No. of Issues
1.	Communication	6
2.	Knowledge management and awareness	7
3.	Cultural diversities	5
4.	Management and coordination	5
5.	Processes and tools	5
6.	Relationship among stakeholders	6
7.	Requirements centric	9

Figure 5.1 shows no. of frequently occurring issues in each category graphically.

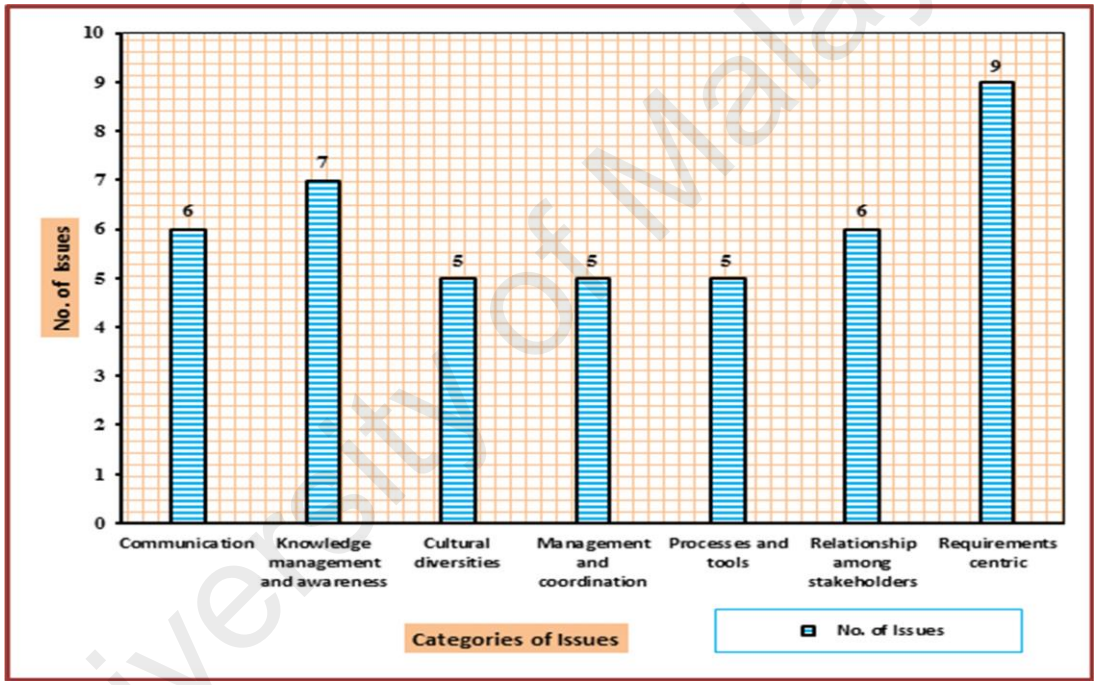

Figure 5. 1: No. of frequently occurring issues in each category

5.2.3 Ranking frequently occurring issues category-wise

The frequently occurring issues of SDO RE process can be ranked based on means like (Barak & Rafaeli, 2004; Gerrish & Clayton, 2004; Vizcaíno, García, Villar, Piattini, & Portillo, 2013). The ranking criterion is frequency of occurrence. This section deals with ranking of the frequently occurring issues within the respective categories.

(a) Ranks of communication issues: Using Table 5.6, Ids and means in case of the communication issues have been given in Table 5.8 in descending order. Based on the

means, ranks of the communication issues and average of the means of communication issues have also been mentioned.

Table 5. 8 : Ranks of communication issues

Sr. #	Issue IDs	Means in Descending order	Category wise Ranks
1.	Issue7	4.213592	1
2.	Issue2	4.203883	2
3.	Issue22	4.194175	3
4.	Issue5	4.126214	4
5.	Issue1	4.116505	5
6.	Issue12	4.097087	6
Average of the means of communication issues		4.158576	

(b) Ranks of knowledge management and awareness issues: Using Table 5.6, IDs and means in case of knowledge management and awareness issues have been given in Table 5.9 in descending order. Based on the means, ranks of the knowledge management and awareness issues, and average of the means of knowledge management and awareness issues have also been mentioned.

Table 5. 9 : Ranks of knowledge management and awareness issues

Sr. #	Issue IDs	Means in Descending	Category wise Ranks
7.	Issue34	4.165049	1
8.	Issue26	4.165049	2
9.	Issue45	4.106796	3
10.	Issue29	4.087379	4
11.	Issue43	4.077670	5
12.	Issue37	4.077670	6
13.	Issue23	3.854369	7
Average of the means of knowledge management and awareness issues		4.076283	

(c) Ranks of cultural diversities' issues: Using Table 5.6, IDs and means in case of cultural diversities' issues have been given in Table 5.10 in descending order. Based on the means, ranks of the cultural diversities' issues and average of the means of cultural diversities' issues have also been mentioned.

Table 5. 10 : Ranks of cultural diversities' issues

Sr. #	Issue IDs	Means in Descending	Category wise Ranks
14.	Issue68	4.019417	1
15.	Issue53	4.009709	2
16.	Issue50	4.009709	3
17.	Issue51	4.000000	4
18.	Issue66	3.970874	5
Average of the means of cultural diversities' issues		4.001942	

(d) Ranks of management and coordination issues: Using Table 5.6, IDs and means in case of management and coordination issues have been given in Table 5.11 in descending order. Based on the means, ranks of management and coordination issues, and average of the means of management and coordination issues have also been mentioned.

Table 5. 11 : Ranks of management and coordination issues

Sr. #	Issue IDs	Means in Descending	Category wise Ranks
19.	Issue72	4.165049	1
20.	Issue89	4.145631	2
21.	Issue75	4.106796	3
22.	Issue69	4.077670	4
23.	Issue84	4.058252	5
Average of the means of management and coordination issues		4.110680	

(e) Ranks of processes and tools' issues: Using Table 5.6, IDs and means in case of processes and tools' issues have been given in Table 5.12 in descending order. Based on the means, ranks of processes and tools' issues, and average of the means of processes and tools' issues have also been mentioned.

Table 5. 12 : Ranks of processes and tools' issues

Sr. #	Issue IDs	Means in Descending order	Category wise Ranks
24.	Issue105	4.029126	1
25.	Issue99	4.009709	2
26.	Issue95	4.000000	3
27.	Issue96	3.922330	4
28.	Issue107	3.854369	5
Average of the means of processes and tools'		3.963107	

(f) Ranks of relationship among stakeholders' issues: Using Table 5.6, IDs and means in case of relationship among stakeholders' issues have been given in Table 5.13 in descending order. Based on the means, ranks of relationship among stakeholders' issues, and average of the means of relationship among stakeholders' issues have also been mentioned.

Table 5. 13 : Ranks of relationship among stakeholders' issues

Sr. #	Issue IDs	Means in Descending order	Category wise Ranks
29.	Issue120	4.009709	1
30.	Issue113	3.990291	2
31.	Issue110	3.970874	3
32.	Issue117	3.961165	4
33.	Issue115	3.922330	5
34.	Issue119	3.825243	6
Average of the means of relationship among stakeholders' issues		3.946602	

(g) Ranks of requirements centric issues: Using Table 5.6, IDs and means in case of requirements centric issues have been given in Table 5.14 in descending order. Based on the means, ranks of requirements centric issues and average of the means of requirements centric issues have also been mentioned.

Table 5. 14 : Ranks of requirements centric issues

Sr. #	Issue IDs	Means in Descending order	Category wise Ranks
35.	Issue146	4.077670	1
36.	Issue133	4.077670	2
37.	Issue124	4.038835	3
38.	Issue142	4.029126	4
39.	Issue129	4.029126	5
40.	Issue128	4.019417	6
41.	Issue150	3.990291	7
42.	Issue132	3.990291	8
43.	Issue126	3.970874	9
Average of the means of Requirements centric issues		4.024811	

5.2.4 Ranking categories of issues

Using values provided in last rows of Tables 5.8, 5.9, 5.10, 5.11, 5.12, 5.13 and 5.14, means of different categories have been shown in Table 5.15.

Table 5. 15 : Means of the 7 categories of SDO RE process issues

Sr. #	Categories	Means
1.	Communication	4.158576
2.	Knowledge management and awareness	4.076283
3.	Cultural diversities	4.001942
4.	Management and coordination	4.110680
5.	Processes and tools	3.963107
6.	Relationship among stakeholders	3.946602
7.	Requirements centric	4.024811

IDs and means in case of 7 categories of issues have been given in Table 5.16 in descending order. Based on the means, ranks of these categories have also been mentioned.

Table 5. 16 : Ranks of the categories of frequently occurring SDO RE process issues

Sr. #	Categories	Means in Descending order	Categories' Ranks
1.	Communication	4.158576	1
2.	Management and coordination	4.110680	2
3.	Knowledge management and awareness	4.076283	3
4.	Requirements centric	4.024811	4
5.	Cultural diversities	4.001942	5
6.	Processes and tools	3.963107	6
7.	Relationship among stakeholders	3.946602	7

5.2.5 Overall ranks of the frequently occurring issues

By using Table 5.6, means of the response values in case of the 43 selected issues have been shown in the Table 5.17 in descending order. Using those means, the overall ranks of 43 frequently occurring issues have also been mentioned.

Table 5. 17 : Overall ranks of the 43 frequently issues of RE process for SDO

Sr. #	Issue IDs	Means	Overall Ranks
1.	Issue7	4.213592	1
2.	Issue2	4.203883	2
3.	Issue22	4.194175	3
4.	Issue34	4.165049	4
5.	Issue72	4.165049	4
6.	Issue26	4.165049	4
7.	Issue89	4.145631	7
8.	Issue5	4.126214	8
9.	Issue1	4.116505	9
10.	Issue75	4.106796	10
11.	Issue45	4.106796	10
12.	Issue12	4.097087	12
13.	Issue29	4.087379	13
14.	Issue37	4.077670	14
15.	Issue133	4.077670	14
16.	Issue69	4.077670	14
17.	Issue146	4.077670	14
18.	Issue43	4.077670	14
19.	Issue84	4.058252	19
20.	Issue124	4.038835	20
21.	Issue142	4.029126	21
22.	Issue129	4.029126	21
23.	Issue105	4.029126	21
24.	Issue128	4.019417	24
25.	Issue68	4.019417	24
26.	Issue99	4.009709	26
27.	Issue53	4.009709	26
28.	Issue50	4.009709	26
29.	Issue120	4.009709	26
30.	Issue95	4.000000	30
31.	Issue51	4.000000	30
32.	Issue150	3.990291	32
33.	Issue132	3.990291	32
34.	Issue113	3.990291	32
35.	Issue110	3.970874	35
36.	Issue66	3.970874	35
37.	Issue126	3.970874	35
38.	Issue117	3.961165	38
39.	Issue96	3.922330	39
40.	Issue115	3.922330	39
41.	Issue107	3.854369	41
42.	Issue23	3.854369	41
43.	Issue119	3.825243	43

5.2.6 Putting Category-wise ranks, Overall ranks and Categories' ranks together

The 43 frequently occurring issues of SDO RE process along with their ranks in respective categories, overall ranks and categories' ranks have been shown in Table 5.18. The 43 frequently occurring issues have been represented by serial numbers I_1, I_2, I_3, ..., I_{43} respectively.

Table 5. 18 : Ranks of the frequently occurring issues of SDO RE process and ranks of issues' categories

Sr. #	Issues and IDs	Issues' Ranks		Categories' Ranks and Names
		Category-wise	**Overall**	**1**
I_1	Issue7: Delayed responses.	**1**	**1**	Communication
I_2	Issue2: Lack of informal communication among the stakeholders during RE process.	**2**	**2**	Communication
I_3	Issue22: Usually non recording of commitments made during videoconferencing or telephonic conversation, therefore, it cannot be referred if required.	**3**	**3**	Communication
I_4	Issue5: Lack of synchronous communication.	**4**	**8**	Communication
I_5	Issue1: Infrequent and constrained communication among the stakeholders during RE process.	**5**	**9**	Communication
I_6	Issue12: Unproductive meetings that are held to take decisions about the requirements.	**6**	**12**	Communication
				2
I_7	Issue72: Delay in clarifications about requirements and decision making.	**1**	**4**	Management and coordination
I_8	Issue89: Nonperformance of a Requirements Engineering related task as everybody presumes that this is the responsibility of somebody else.	**2**	**7**	Management and coordination
I_9	Issue75: Poorly defined or undefined responsibilities.	**3**	**10**	Management and coordination
I_{10}	Issue69: Difficulties in comprehending information, reasons and activities that are required for common Requirements Understanding (RU) among the dispersed stakeholders.	**4**	**14**	Management and coordination
I_{11}	Issue84: Need for adjustment of actual requirements to interact with other software(s).	**5**	**19**	Management and coordination
				3
I_{12}	Issue34: Poor requirements change management.	**1**	**4**	Knowledge management and awareness
I_{13}	Issue26: Unawareness of the stakeholders from current/latest information about requirements.	**2**	**4**	Knowledge management and awareness
I_{14}	Issue45: Unawareness from or not accessing all requirements sources.	**3**	**10**	Knowledge management and awareness
I_{15}	Issue29: Reopening of the already discussed and seemingly settled issues.	**4**	**13**	Knowledge management and awareness
I_{16}	Issue43: Unawareness of requirements engineers from the effects of new system implementation on the client organization.	**5**	**14**	Knowledge management and awareness
I_{17}	Issue37: Working on obsolete requirements.	**6**	**14**	Knowledge management and awareness
I_{18}	Issue23: Hindrance in circulation of requirements knowledge from/to organizations.	**7**	**41**	Knowledge management and awareness
				4
I_{19}	Issue146: Client's insistence on adding new requirements after settlement of cost and time.	**1**	**14**	Requirements centric
I_{20}	Issue133: Not providing information or providing intentionally ambiguous information about requirements.	**2**	**14**	Requirements centric

Table 5.18, Continued

Sr. #	Issues and IDs	Issues' Ranks		Categories' Ranks and Names
		Category wise	Overall	4
I_{21}	Issue124: Finalizing requirements for all stakeholders based on the requirements gathered or information obtained from the available stakeholders.	3	20	Requirements centric
I_{22}	Issue142: Pressure on Requirements Engineers to hide certain information about requirements, resulting in compromised requirements elicitation and specification.	4	21	Requirements centric
I_{23}	Issue129: Incomplete requirements.	5	21	Requirements centric
I_{24}	Issue128: Gold plating or extra requirements.	6	24	Requirements centric
I_{25}	Issue150: Applying suppositions for finalizing requirements.	7	32	Requirements centric
I_{26}	Issue132: Poor or ambiguous requirements specification.	8	32	Requirements centric
I_{27}	Issue126: Incorrect or false requirements.	9	35	Requirements centric
				5
I_{28}	Issue68: Difficulties in setting realistic expectations about response time.	1	24	Cultural diversities
I_{29}	Issue53: Difficulties in achieving consensus on requirements.	2	26	Cultural diversities
I_{30}	Issue50: Lack of trust.	3	26	Cultural diversities
I_{31}	Issue51: Avoidance of the commitments from the stakeholders.	4	30	Cultural diversities
I_{32}	Issue66: Nonparticipation or exclusion of stakeholders from RE activities.	5	35	Cultural diversities
				6
I_{33}	Issue105: Selection of inappropriate RE tool(s).	1	21	Processes and tools
I_{34}	Issue99: RE rework or data loss during transfer from one tool to other.	2	26	Processes and tools
I_{35}	Issue95: Use of different RE processes, resulting in different templates and methodologies, at the different locations of client.	3	30	Processes and tools
I_{36}	Issue96: Use of unsuitable RE processes.	4	39	Processes and tools
I_{37}	Issue107: Use of unsuitable requirements elicitation technique.	5	41	Processes and tools
				7
I_{38}	Issue120: Issues in signing-off requirements engineering deliverables.	1	26	Relationship among stakeholders
I_{39}	Issue113: Use of different requirements documentation standards by customer and vendor.	2	32	Relationship among stakeholders
I_{40}	Issue110: Lack of firm relationship among stakeholders.	3	35	Relationship among stakeholders
I_{41}	Issue117: Misconceptions of the vendor teams about client's working practices.	4	38	Relationship among stakeholders
I_{42}	Issue115: Different priorities of client and vendor for collecting and finalizing requirements.	5	39	Relationship among stakeholders
I_{43}	Issue119: Failure in meeting deadlines and fulfilling commitments about requirements by vendor.	6	43	Relationship among stakeholders

This provides answer to RQ7.

5.2.7 Top 10 frequently occurring issues of the RE process for SDO

Idea of presenting the top-ten items is fairly common. Sommerville and Sawyer mention top-ten RE practices (Sommerville & Sawyer, 1997), Xindong and Kumar discuss top-ten algorithms for data mining (Wu & Kumar, 2009) and J. M. Schopf raises

top-ten questions about Grids (Schopf & Nitzberg, 2002). T. Arnuphaptrairong specifies top-ten lists of software project risks (Arnuphaptrairong, 2011). Many studies present top-ten software project risks (Boehm, 1988, 1991; Han & Huang, 2007; R. Schmidt, et al., 2001). Therefore, the top 10 frequently issues of RE process for SDO have been mentioned in Table 5.19.

Table 5. 19 : Top 10 frequently occurring issues of RE process for SDO

Sr.#	Issues and IDs	Means	Overall Ranks	Categories
I_1	Issue7: Delayed responses.	4.213592	**1**	Communication
I_2	Issue2: Lack of informal communication among the stakeholders during RE process.	4.203883	**2**	Communication
I_3	Issue22: Usually non recording of commitments made during videoconferencing or telephonic conversation, therefore, it cannot be referred if required.	4.194175	**3**	Communication
I_{12}	Issue34: Poor requirements change management.	4.165049	**4**	Knowledge management and awareness
I_7	Issue72: Delay in clarifications about requirements and decision making.	4.165049	**4**	Management and coordination
I_{13}	Issue26: Unawareness of the stakeholders from current/latest information about requirements.	4.165049	**4**	Knowledge management and awareness
I_8	Issue89: Nonperformance of a Requirements Engineering related task as everybody presumes that this is the responsibility of somebody else.	4.145631	**7**	Management and coordination
I_4	Issue5: Lack of synchronous communication.	4.126214	**8**	Communication
I_5	Issue1: Infrequent and constrained communication among the stakeholders during RE process.	4.116505	**9**	Communication
I_9	Issue75: Poorly defined or undefined responsibilities.	4.106796	**10**	Management and coordination
I_{14}	Issue45: Unawareness from or not accessing all the requirements sources.	4.106796	**10**	Knowledge management and awareness

This can be observed that out of 11 issues having top 10 ranks, 5 issues belong to communication, 3 issues are related to knowledge management and awareness, and 3 issues are associated to management and coordination.

After identifying frequently occurring issues of the RE process for SDO, the next step is to find the causes for the occurrence of issues and recommending the RE practices to address those issues.

5.3 Exploring root causes for the frequently occurring issues of SDO RE process and recommending RE practices to address those issues

The Root Cause Analysis method has been employed to find the root causes for the frequently occurring issues of RE process for SDO and to recommend the relevant RE practices to address those issues.

5.3.1 Root Cause Analysis

Root Cause Analysis (RCA) method is used in numerous fields to handle the problems by focusing on knowing root causes for occurrence of those problems and by recommending preventive or corrective actions to deal with corresponding problems (Rooney & Heuvel, 2004; Sandeep Dalal, 2013).

A Cause or Casual Factor is a condition or an event that creates an effect (Guideline, 1992). Sequence of Events is a cause and effect sequence in which a condition or event results in an event or condition that in turn creates a new condition or event and so on (Guideline, 1992). A cause is called Root Cause if its correction prevents its recurrence and that of other unwanted results (Guideline, 1992). According to (Lehtinen, et al., 2011) Root Cause is the deepest cause at the end of casual structure and as per definition of (Rooney & Heuvel, 2004), Root Causes are underlying causes. RCA method comprises of three steps:

i) Detecting Problems: To define the problems or issues.

ii) Detecting Root Causes: To discover the root causes of problems or issues.

iii) Recommending Corrective Actions: To recommend the actions to be taken or practices to be followed in order to correct or address the issues (Lehtinen, et al., 2011).

5.3.1.1 Detecting the problem(s)

The frequently occurring issues of RE process for SDO have been extracted, out of 150 issues collected from the literature and the industry, through questionnaire surveys with SDO practitioners (4th questionnaire survey of research work) like (Wallin, et al., 2012). Table 5.18 presents the frequently occurring issues of RE process for SDO.

To find the root causes for the frequent occurring issues of RE process in case of SDO and recommending RE practices to address those issues, root cause analysis workshops have been conducted like (Lehtinen, et al., 2014; Wallin, et al., 2012).

5.3.1.2 Root Cause Analysis workshops

Five workshops were held, one in a week, and three participants contributed in each workshop. Among the three participants, one was researcher and two were SDO practitioners having 10 and 12 years' experience. The researcher also acted as moderator or facilitator during workshops. The agenda of each workshop was available to participants in advance. Each workshop was continued approximately for 4 hours (2 sessions, each session of 2 hours). Thus, total duration of workshops was 20 (5x4) hours. As, there were three participants; so, actual effort to apply RCA method was 60 (20x3) man-hours.

5.3.1.3 Detecting root causes

Many techniques are available that can be used to discover the root causes for frequently occurring issues of RE process for SDO like Cause-Effect Analysis, Fault-Tree Analysis,

Causal Factor Charting, Brainstorming and 5 Whys (Sandeep Dalal, 2013). In this research work, 5 Whys technique has been employed.

(a) 5 Whys Technique

The 5 Whys technique is based on asking the questions to find the root cause(s) (Sandeep Dalal, 2013). While applying this technique up to 5 questions, all starting with why, are raised and answered (Vorley, 2008). The answer of first why-question leads to second why-question, answer of the second why-question guides to third why-question and so on. This process is continued till the discovery of root cause(s). Generally, first why-question is to know why an issue is occurring. For example, an issue may be that some of the team members are not using recommended software. To apply the 5 Whys technique, first why-question is:

Why-question-1: Why team members are not using recommended software?

The likely answer is because they do not like it.

From this answer, second why-question can be formulated as:

Why-question-2: Why team members do not like software?

The answer may be that for some team members this software is not easy to use and also it requires information that all team members do not have. From this answer, two why-questions are generated. The first one is:

Why-question-3.1: Why software is difficult to use for some team members?

The probable answer is that they have not been trained for using this software.

So one root cause has been discovered by using just three Why-questions and the root cause is not providing training to team members.

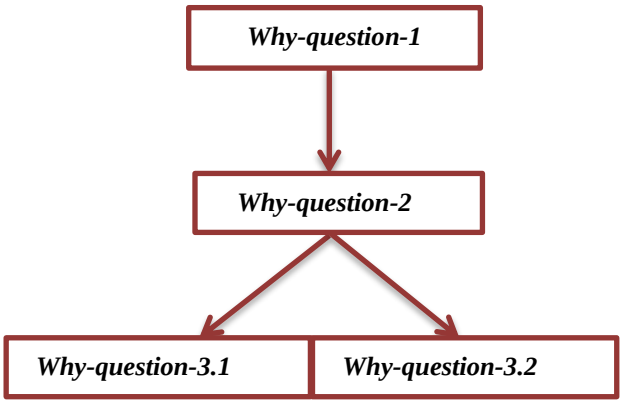

Figure 5. 2: Sequence of Why-questions

The second question generated from the answer of second why-question is:

Why-question-3.2: Why some team members do not have required information to use software?

The possible answer is that they do not have access to that information. Thus another root cause has been identified again just by asking three why-questions. The root cause is that team members do not have access to the relevant information. The sequence of Why-questions has been shown in Figure 5.2.

The 5 Whys technique has been used in similar way to discover the root cause(s) for each of the frequently occurring issues of RE process for SDO.

5.3.1.4 Recommending the corrective action or RE practices to address issues

The relevant RE practices, which can be used to address the frequently occurring issues, have been recommended and mapped to corresponding issues by applying Brainstorming technique like (Lehtinen, et al., 2011).

(a) Brainstorming

During the Brainstorming as many ideas are gathered about the subject as possible and all participants are encouraged to present ideas without any criticism (Sandeep Dalal, 2013; Vorley, 2008). For this research work 147 RE practices have been collected, from

relevant literature and SDO industry (Table 4.19), to address the SDO RE process issues. Those RE practices have been presented during the brainstorming sessions, some technical reports and research papers have also been consulted, and then the best available RE practices have been selected and mapped to corresponding issues by using Multi-voting like method.

By performing RCA, 89 root causes have been discovered for the 43 frequently occurring issues of RE process for SDO. For 89 root causes, 124 relevant RE practices have been recommended and mapped to corresponding issues to address the issues. The frequently occurring issues, the root causes for the issues and relevant RE practices to address the issues in case of respective root causes are presented in Table 5.20.

This provides answer to RQ8.

5.4 The REP Model to address the frequently issues of RE process for Software Development Outsourcing

The 43 frequently occurring ranked issues of RE process for SDO, root causes for occurrence of those issues and the relevant RE practices to address the issues have been shown in the Table 5.20, according to descending ranks (1 is the highest and 7 is the lowest) of issues' categories. The ranks of issues' categories (R_w) are: Communication=1, Management and coordination=2, Knowledge management and awareness=3, Requirements centric=4, Cultural diversities=5, Processes and tools=6, and Relationship among stakeholders=7. The seven categories have been represented by $C_1, C_2 \ldots C_7$ respectively with respect to ranks. $I_1, I_2, I_3 \ldots I_{43}$ represent the 43 frequently occurring issues of RE process for SDO, CR_v stands for Category-wise Ranks of the issues and OR_u stands for the Overall Ranks of issues. $RC_1, RC_2, RC_3 \ldots RC_{89}$ represent 89 root causes. $P_1, P_2, P_3 \ldots P_{124}$ represent *124 RE* practices to address the issues. This accomplishes formation of the REP Model.

Table 5. 20 : The REP Model to address the issues of RE process for SDO

Communication Issues (C_1)	CR_v	OR_u	Root Causes	RE Practices
I_1: Delayed responses.	**1**	**1**	**RC_1**: Lack of informal communication.	**P_1:** Establishing proper infrastructure to facilitate communication and ensuring that it works properly. **P_2:** Encouraging Synchronous communication in form of chatting, telephone calls, and videoconferencing. **P_3:** Adapting and understanding the culture of other stakeholders means knowing about the traditions, beliefs, ethos and native language. **P_4:** Deciding and using a standard language for communication. **P_5:** Focusing on improving the communication language, for example, offering English language courses. **P_6:** Appointing cultural liaisons or Proxies (individuals who are familiar with the culture of client and vendor). **P_7:** Establishing 'proximity development center' in the region having no or a little time zone difference from the region of client. **P_8:** Trying to find natural overlapping of working hours. **P_9:** Assessing 'around-the-clock' capability of working. **P_{10}:** Achieving time zone proximity through time-shifting (changing one's working hours in order to overlap with other's working hours) for which different approaches are: i) Flextime (working at flexible timings to overlap). ii) Overtime (working for extra time to overlap). iii) Telework (working with flexible schedules from residence to overlap). iv) Long working days (availing working time overlap either at start of day or at end of the day). v) Unrestricted working hours (there are no restricted working hours and employees set their own working hours to overlap). **P_{11}:** Equipping remote practitioners' rooms with electronic message "drop in", remote calling and artifacts sharing facilities. **P_{12}:** Facilitating socialization among the practitioners from the beginning of the project, like arranging face-to-face start-off meetings to establish personal relationships. **P_{13}:** Arranging traveling to remote sites frequently in order to build trust. **P_{14}:** Facilitating direct communication among the stakeholders. **P_{15}:** Ensuring that stakeholders introduce themselves to one another right from beginning of the project. **P_{16}:** Encouraging communication in the native language of client. **P_{17}:** Encouraging use of Facebook or Twitter as communication mechanism.
			RC_2: Time Zone differences	**P_7, P_8, P_9, P_{10}.**
			RC_3: Use of asynchronous tools.	**P_2,** **P_{18}:** Promoting the use of groupware tools. **P_{73}:** Appointing one team member that works after the normal working timings and responses to inquiries.
I_2: Lack of informal communication.	**2**	**2**	**RC_4:** Communication is infrequent and constrained.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}.**
			RC_5: Lack of socialization.	**P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}** **P_{17}**
I_3: Usually commitments made during videoconferencing or telephonic conversation cannot be referred if required.	**3**	**3**	**RC_6:** No recording of the conversation.	**P_{26}:** Recording the synchronous communication through telephone calls, Skype and videoconferencing. **P_{27}:** Using email as communication medium for verification as it keeps written record of communication.
			RC_7: Client and vendor rely on oral agreement.	**P_{28}:** Reaching written and properly documented agreements.

Table 5.20,Continued

Communication Issues (C_1)	CR_v	OR_u	Root Causes	RE Practices
I_4: Lack of synchronous communication.	4	8	**RC_8:** Lack of communication infrastructure.	**P_1, P_2.**
			RC_2: Time zone differences.	**P_7, P_8, P_9, P_{10}.**
			RC_9: Reluctance to share information or propensity for non-reporting of the problems because of the fear of negative consequences.	**P_{18}** **P_{19}:** Persuading the stakeholders that revealing the issues or providing information will not have negative fallouts instead will have positive consequences.
			RC_{10}: Shyness of the stakeholders.	**P_{12}, P_{14}, P_{15}, P_{17}.**
I_5: Infrequent and constrained communication among the stakeholders.	5	9	**RC_8:** Lack of communication infrastructure.	**P_1, P_2**
			RC_{11}: Unfamiliarity from cultural values.	**P_3, P_6**
			RC_{12}: Language diversities among stakeholders.	**P_4, P_5, P_6**
			RC_2: Time zone differences.	**P_7, P_8, P_9, P_{10}**
I_6: Meetings that are held to take decisions about the requirements are unproductive.	6	12	**RC_{13}:** Use of inappropriate communication medium. **RC_{14}:** Un-readiness or concealing of agenda. **RC_{15}:** Relevant stakeholders are not selected for meeting. **RC_{16}:** Key participants and decision makers are not consulted and/or informed about meeting schedule. **RC_{17}:** No access to the supporting documents that have information about the requirements.	**P_{21}:** Arranging requirements engineering meetings by: i) Engaging a human facilitator and using a rich communication media that supports integration of data, videos and audios. ii) Preparing agenda and following it. iii) Selecting relevant participant and informing them timely to take part in requirements meetings. iv) Timely exchanging supporting documents to give participants enough time to read the relevant material. v) Enabling participants of requirements meetings to access the resources (like emails, relevant documents, work artifacts etc.) that contain information about the requirements.
			RC_{18}: Expected participants do not honor commitments made for participation.	**P_{70}:** Developing stakeholders' consensus on operating terms and conditions for attending meetings and, honoring deadlines and commitments. **P_{20}:** Scheduling video conferences or teleconferences daily, weekly, bimonthly, monthly so that there are no or minimal inconvenient hours for all the stakeholders.
			RC_2: Time zone differences.	**P_7, P_8, P_9, P_{10}.**
Management and coordination Issues(C_2)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_7: Delay in clarifications about requirements and decision making.	1	4	**RC_1:** Lack of informal communication.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}.**
			RC_2: Time Zone differences.	**P_7, P_8, P_9, P_{10}.**
			RC_3: Use of asynchronous tools.	**P_2, P_{18}, P_{73}**
I_8: Nonperformance of a Requirements Engineering related task as everybody presumes that this is the responsibility of somebody else.	2	7	**RC_{19}:** Responsibilities are assigned without consent and/ or to inappropriate persons.	**P_{24}:** Having clearly defined and agreed responsibilities for each individual and group.
			RC_{20}: The responsibilities are poorly defined or undefined.	**P_{22}:** Establishing authoritative leadership at the level of project managers and team heads. **P_{23}:** Marinating explicit sequence of commands. **P_{24},** **P_{25}:** Having clearly delineated and comprehended requirements engineering processes. **P_{34}:** By using an awareness support system for requirements management, all the stakeholders should be able to access following information: i) Requirements' descriptions, rationale and priorities. ii) Dependencies among the requirements and with design, coding and testing. iii) Each team member's responsibilities with respect to particular requirement(s) and contact information like email, phone number.

				iv) Requirements' initiators. v) Issues related to requirements, issues' initiators, status of the resolution of those issues and decisions taken due to issues. vi) Meetings' date, time and location, stakeholders that are involved, discussed issues and decisions taken. vii) Change requests, initiators of change request, status of the decisions about those requests, people involved in taking decisions and decisions taken. **P_{77}:** Providing training potential team members for using appropriate processes, and supporting tools and technologies. **P_{78}:** There is no standard RE process but six common activities for RE process are : i) Requirements Elicitation, ii) Requirements Analysis and negotiations, iii) Describing requirements, iv) System Modeling, v) Requirements Validation, and vi) Requirements Management.
			RC_{21}: Leaders do not use authority.	**P_{22}, P_{23}**

Table 5.20,Continued

Management and coordination Issues(C_2)	CR_v	OR_u	Root Causes	RE Practices
I_9: Poorly defined or undefined.	**3**	**10**	**RC_{22}:** Absence of central and trusted management.	**P_{22}, P_{23}, P_{24}, P_{34}.**
			RC_{23}: Unclear or undefined RE processes.	**P_{25}, P_{78}, P_{77}**
I_{10}: Difficulties in comprehending information, reasons and activities that are required for common Requirements Understanding (RU) among the dispersed stakeholders.	**4**	**14**	**RC_1:** Lack of informal communication.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}.**
			RC_{24}: Stakeholders belonging to diverse cultural backgrounds: i) Have different values regarding hierarchies, handling risks, following schedules and precision of work. ii) Speak different languages, use different communication styles and are at different proficiency level of communication language. iii) Deduce inexplicit meanings and explanations from the information about requirements.	**P_{59}:** Taking following measures to overcome cultural issues: i) (P_6) Appointing cultural liaisons or Proxies (individuals who are familiar with the culture of client and vendor). ii) Encouraging team members to visit locations of other stakeholders. iii) Arranging the cultural trainings. iv) Conducting orientation courses for cultural differences. v) Keeping in view cultural values of stakeholders while deciding females' roles. vi) Adopting 'Negotiated Culture', a compromised culture that is developed to honor the cultural norms of all the stakeholders. vii) Nominating the individuals, who are experienced and acquainted with the culture of the client, to assist for requirements negotiation and specification. viii) (P_4) Deciding and using a standard language for communication. ix) (P_5) Focusing on improving the communication language, for example, offering English language courses. x) Arrangement and monitoring of all the activities, which are performed to deal with cultural diversities, by project manager or senior team members.
			RC_{25}: Different terminologies and notations are used to express same meanings or same terminologies are used to convey different meanings.	**P_{68}:** Defining and using requirements specification glossary and notations.
			RC_{26}: Lack of coordination.	**P_{69}:** Taking following measures, by vendor mangers, for creating coordination: i) Defining roles and responsibilities of team members and creating Organizational Charts that display positions and responsibilities. ii) Attaining the required human resources and managing them through Resource Calendar.

				iii) Allocating tasks appropriately. iv) (P_{30}) Establishing peer-to-peer links among distributed sites at the team, project and management level. v) (P_{31}) Partially synchronizing inter-organizational processes. vi) (P_{32}) Maintaining open communication lines among different well-defined roles of stakeholders. vii) (P_{33}) Regularly checking and notifying the progress about mutually agreed upon artifacts.
			RC_{27}: Interaction among stakeholders is difficult.	**P_{118}:** Using Wikis geographically distributed stakeholders are engaged to explore their needs or requirements, discuss related issues, ask about new features and create requirements.
			RC_{28}: Stakeholders' lack of motivation to participate in RE activities.	**P_{120}:** Enabling online collaboration using requirements visualization tools (like use case models, business process diagrams) and social visualization techniques to stimulate the involvement of stakeholders and provide better understanding of requirements**.**
			RC_2: Time zone differences	**P_7, P_8, P_9, P_{10}.**

Table 5.20,Continued

Management and coordination Issues(C_2)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{11}: Need for adjustment of actual requirements to interact with other software(s).	**5**	**19**	**RC_{29}:** Requirements belong to a software system that, being part of a large system, interacts with other software.	**P_{45}:** Identifying all the stakeholders and considering their needs. **P_{47}:** Defining operational processes. **P_{48}:** Defining system boundaries. **P_{49}:** Defining operating environment of system. **P_{50}:** Using business concerns of client to derive requirements elicitation. **P_{56}:** Developing the model of system's environment. **P_{74}:** Organizing the requirements inspections and involve multi-disciplinary teams for reviewing requirements. **P_{75}:** Defining the checklists for validation of requirements. **P_{41}:** Defining policies to manage changes in requirements.
Knowledge management and awareness Issues(C_3)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{12}: Poor requirements change management.	**1**	**4**	**RC_{30}:** Inability to identify and refer requirements.	**P_{46}:** Recording requirements originating sources. **P_{38}:** Identifying each requirement through a unique identifier.
			RC_{31}: Inability to trace requirements sources, rationale, dependencies among requirements, and dependencies between requirements and design, sub-systems and interface.	**P_{39}:** Defining requirements traceability policies. **P_{40}:** Maintaining the manual for traceability.
			RC_{32}: Not defining requirements change request process, and process for analysis of impacts and costs of changes.	**P_{41}** **P_{101}:** Establishing the Change Control Board (CCB) and including new requirements by following a proper requirements change management process (change evaluation and propagation mechanism). **P_{42}:**Using a Requirements Management System (to control and track changes) that provides following feature: i) Navigating given set of requirements, retrieving specific requirements and grouping requirements based on certain parameters. ii) Management of requirements change process, requirements traceability support and generation of various types of reports about requirements. iii) Interface to accept external documents. iv) Management of the various versions of requirements. v) Support for performing different types of analysis (like impact analysis, to know a requirement is orphan or not, for tracking of status).

				vi) Restricting rights to access and edit the given set of requirements.
			RC_{33}: Ineffective dissemination of the information about requirements changes.	**P_{34}.**
			RC_{34}: Analysts change requirements by ignoring the change management process.	**P_{41}, P_{101} , P_{42}, P_{22}**

Table 5.20, Continued

Knowledge management and awareness Issues(*C_3*)	CR_v	OR_u	Root Causes	RE Practices
I_{13}: Unawareness of the stakeholders from current or latest information about requirements.	**2**	**4**	**RC_1:** Lack of informal communication.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}.**
			RC_{35}: Distance among the stakeholders. **RC_{36}:** Inexperienced team members. **RC_{37}:** Decentralized communication structure.	**P_{34}** **P_{35}:** Keeping experienced practitioners in team and those practitioners should bridge the awareness gap. **P_{36}:** Implementing centralized communication structure.
I_{14}: Unawareness from or not accessing all requirements sources.	**3**	**10**	**RC_{38}:** Not identifying all potential requirements sources.	**P_{45}** **P_{57}:** Identifying and accessing all requirements sources. The possible requirements sources are: i) End-users of the system, managers, directors, administrators, clients, developers and maintenance personnel. ii) Individuals who are involved in the activities of business processes. iii) Individuals who are concerned or affected as stated by client management. iv) Requirements specification provided by client or needs of various stakeholders. v) Problems or issues faced by stakeholders. vi) Domain experts. vii) Domain constraints, regulations and standards to be followed. viii) Similar existing systems. ix) Users of similar existing systems. x) Documents about the target system like record-keeping books, bills, receipts and reports. xi) Other software(s) or system(s) that interact with the system to be developed. **P_{100}:** Asking the known or identified stakeholders about other stakeholders, based on their suggestions building stakeholders' social network and then prioritizing stakeholders based on measures of social network.
			RC_{39}: High number of stakeholders as sources of requirements.	**P_{58}:** In case of high number of stakeholders: i) Appointing a person (communication channel) from each unit of organization or group of requirements information sources for gathering the requirements from respective unit or group. Then communication channels transfer requirements to an expert where these requirements can be bundled. ii) Using group elicitation techniques like group Brainstorming, JAD (Joint Application Development), Focus groups and requirements creativity workshops for getting consensus on requirements. iii) Preparing a combined requirements document containing all the requirements. **P_{118}**
I_{15}: Reopening of the already discussed and seemingly settled issues.	**4**	**13**	**RC_{40}:** Stakeholders are not aware of the current information about requirements.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}. P_{34}, P_{35}, P_{36}.**
			RC_{41}: Repetitive discussions among the stakeholders as: i) They forget about already taken decisions. ii) Any team member is allowed to communicate with any other stake holder.	**P_{37}:** Describing summary of proceedings after every meeting. A team member or facilitator should summarize that which issues have been raised during the meeting, what has been decided about each issue, which issues are pending, whose responsibility is to find out further information and

				whose advice should be sought in case of each issue. **P_{72}:** Regarding decisions maintaining continuous communication with customer by arranging : i) Face-to-face meetings ii) Videoconferences. **P_{71}:** Defining the role of every team member and indicating who should communicate with whom. **P_{36}**

Table 5.20, Continued

Knowledge management and awareness Issues(C_3)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{16}: Unawareness of requirements engineers from the effects of new system implementation on the client organization.	**5**	**14**	**RC_{42}:** No assessment of system feasibility.	**P_{44}:** Assessing system feasibility.
			RC_{43}: Lack of the awareness, about the environment in which system is to be deployed.	**P_{45}, P_{46}, P_{47}, P_{48}, P_{49}**
			RC_{44}: Unawareness from the context and importance of requirements.	**P_{50}** **P_{51}:** Looking for domain constraints. **P_{52}:** Recording requirements rationale. **P_{53}:** Planning for conflict identification and resolution. **P_{54}:** Prioritizing requirements by consulting stakeholders. **P_{55}:** Assessing requirements risks. **P_{56}**
I_{17}: Working on obsolete requirements.	**6**	**14**	**RC_{45}:** Delayed responses.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}** **P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{73}.**
			RC_1: Lack of informal communication.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}** **P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}**
			RC_{46}: Poor requirements change management.	**P_{46}, P_{38}, P_{39}, P_{40}, P_{41}, P_{101}, P_{42},** **P_{34}, P_{22}.** **P_{43}:** Informing the relevant stakeholder about the requirements change: i) Through the telephone calls, emails and internet supported communication tools. ii) By generating automatic notifications through the system.
I_{18}: Hindrance in circulation of requirements knowledge from or to organizations.	**7**	**41**	**RC_{47}:** Diverse and undefined organizational structure.	**P_{29}:** Forming a well-defined organizational structure having clear communication responsibilities. **P_{30}:** Establishing peer-to-peer links among distributed sites at the team, project and management level. **P_{31}:** Partially synchronizing inter- organizational processes. **P_{32}:** Maintaining open communication lines among different well-defined roles of stakeholders. **P_{33}:** Regularly checking and notifying the progress about mutually agreed upon artifacts. **P_6.**
Requirements centric Issues (C_4)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{19}: Client's insistence on adding new requirements after settlement of cost and time.	**1**	**14**	**RC_{48}:** Change in operational processes. **RC_{49}:** Change in business concerns. **RC_{50}:** Change in laws. **RC_{51}:** Change in operating environment.	**P_{117}:** Relating extra requirements to additional budget and time. **P_{101}.**
			RC_7: Client and vendor rely on oral agreement.	**P_{28}**
I_{20}: Not providing information or providing intentionally ambiguous information about requirements.	**2**	**14**	**RC_9:** Reluctance to share information or propensity for non-reporting of the problems because of the fear of negative consequences.	**P_{18}, P_{19}.**

Table 5.20, Continued

Requirements centric Issues (*C4*)	CR_v	OR_u	Root Causes	RE Practices
I_{21}: Finalizing requirements for all stakeholders based on the requirements gathered or information obtained from the available stakeholders.	**3**	**20**	**RC_{52}:** Unawareness from or not accessing all requirements sources.	**P_{45},P_{57}, P_{100}, P_{58} , P_{118}**
			RC_{53}: Only selected stakeholders are consulted during the requirements elicitation that results in biased elicitation.	**P_{45},P_{46}, P_{57}, P_{100}, P_{58}**
			RC_{54}: Key users are not identified or accessed.	**P_{99}:** Identifying and accessing the key users.
I_{22}: Pressure on Requirements Engineers to hide certain information about requirements, resulting in compromised requirements elicitation and specification.	**4**	**21**	**RC_{55}:** Sensitivity of data.	**P_{19} ,** **P_{116}:** Sharing requirements related information only with concerned people.
I_{23}: Incomplete requirements.	**5**	**21**	**RC_{52}:** Unawareness from or not accessing all requirements sources.	**P_{45}, P_{57}, P_{100}, P_{58},P_{118}**
			C_{53}: Only selected stakeholders are consulted during the requirements elicitation that results in biased elicitation.	**P_{45},P_{46}, P_{57}, P_{100}, P_{58}**
			RC_{54}: Key users are not identified or accessed.	**P_{99}**
			RC_{56}: Requirements are not based upon appropriate or sound business case.	**P_{50},P_{47}**
			RC_{57}: Requirements related information is not provided or intentionally ambiguous information is provided.	**P_{18}, P_{19}**
			RC_{58}: System users and people who interact with the requirements engineering team are different.	**P_{102}:** Involving real system users in RE process.
			RC_{59}: Stakeholders are not clear about their requirements.	**P_{103}:** Prototyping the poorly understood requirements. **P_{104}:** Using elicitation techniques like Brainstorming. **P_{52}** **P_{105}:** Reusing requirements from already developed similar systems.
			RC_{60}: Analysts do not have domain knowledge.	**P_{83}:** Appointing a professional as requirements engineer or analyst that has: i) Knowledge or should be able to learn about domain and advanced elicitation techniques. ii) Abilities for operating in international context that is with virtual teams and diverse cultures. iii) Abilities for resolving conflicts and working in uncertain and ambiguous situations. iv) Knowledge about case tools, system modeling and programming languages, requirements management tools and human-computer interaction. v) Skills for communication, social interaction, problem solving, working as team member as well as independently, innovation and being adaptable to changes. **P_{85}:** Consulting domain experts if possible.
			RC_{61}: RE teams work with tight schedules to meet deadlines.	**P_{91}:** Making plan for requirements engineering and out of the total project efforts, dedicating 15 to 30 % effort for Requirements Engineering. **P_{92}:** Assessing the time required for different activities by considering the fact that delays are most likely to occur as stakeholders are spread. **P_{93}:** Calculating and accommodating the Float or Slack Time in schedule if possible.

				P_{94}: Reusing requirements from already developed similar systems if possible. **P_{98}:** In case of slow progress: Spending more time and resources OR Decreasing RE work after consulting stakeholders OR Transferring some load to some other contractor.

Table 5.20, continued

Requirements centric Issues (*C4*)	CR_v	OR_u	Root Causes	RE Practices
I_{24}: Gold plating or extra requirements.	**6**	**24**	**RC_{62}:** Requirements are added for sake of goodwill or to make client happy.	**P_{45}, P_{50}, P_{47}** **P_{109}:** Defining boundaries of the system and eliminating out of scope requirements.
			RC_{63}: Users are fascinated by the features of other systems and want to have in their system but actually those features not required.	**P_{45}, P_{47}, P_{109}**
			RC_{64}: Requirements Engineers assume, based on their experience, that they know requirements of users.	**P_{45},** **P_{106}:** Identifying a set of minimum requirements to satisfy the needs of client. **P_{107}:** Using checklists (a list of question to asses each requirement) for requirements analysis. **P_{108}:** Writing an agreed upon Software Requirements Specification document. **P_{74}, P_{75}.**
			RC_{60}: Analysts do not have domain knowledge.	**P_{83}, P_{85}**
I_{25}: Applying suppositions for finalizing requirements.	**7**	**32**	**RC_{57}:** Requirements related information is not provided or intentionally ambiguous information is provided.	**P_{18}, P_{19}**
			RC_{12}: Language diversities among stakeholders	**P_4, P_5, P_6.**
			RC_{59}: Stakeholders are not clear about their requirements.	**P_{103}, P_{104}, P_{52}, P_{105}**
			RC_{64}: Requirements Engineers assume, based on their experience, that they know requirements of users.	**P_{45}, P_{106}, P_{107}, P_{108}, P_{74}, P_{75}**
I_{26}: Poor or ambiguous requirements specification.	**8**	**32**	**RC_{65}:** Specifying requirements without following any standard templates.	**P_{110}:** Defining and using standard templates for requirements specification. IEEE Standard 830-1998 For Requirements specification can be followed.
			RC_{66}: Complex terminology or inconsistent terminology is used to specify requirements.	**P_{68},** **P_{111}:** Using simple, consistent and concise language to describe requirements. IEEE Standard 830-1998 For Requirements Specification can be followed.
			RC_{25}: Different terminologies and notations are used to express same meanings or same terminologies are used to convey different meanings.	**P_{68}**
			RC_{67}: Essential details are not provided in requirements specification assuming that readers have domain knowledge.	**P_{112}:** Drawing diagrams wherever they are appropriate. **P_{113}:** Describing requirements, in addition to natural language, using formulas, notations, decision tables etc. wherever appropriate. **P_{114}:** Specifying requirements quantitatively where appropriate. **P_{115}:** Using Prototypes in order to animate requirements.
			RC_{43}: Lack of awareness about the environment in which system is to be deployed.	**P_{45}, P_{46}, P_{47}, P_{48}, P_{49}.**
I_{27}: Incorrect or false requirements.	**9**	**35**	**RC_{56}:** Requirements are not based upon appropriate or sound business case.	**P_{50}, P_{47}**
			RC_{57}: Requirements related information is not provided	**P_{18}, P_{19}.**

			or intentionally ambiguous information is provided.	
			RC_{53}: Only selected stakeholders are consulted during the requirements elicitation that results in biased elicitation.	**P_{45},P_{46}, P_{57}, P_{100}, P_{58}**
			RC_{68}: Non-stakeholders are involved for requirements elicitation.	**P_{45},P_{46}, P_{57}, P_{100}, P_{58}**
			RC_{58}: System users and people who interact with the requirements engineering team are different.	**P_{102}**
			RC_{59}: Stakeholders are not clear about their requirements.	**P_{103} ,P_{104},P_{52}, P_{105}**
			RC_{64}: Requirements Engineers assume, based on their experience, that they know requirements of users.	**P_{45}, P_{106}, P_{107}, P_{108}, P_{74}, P_{75}**
			RC_{60}: Analysts do not have domain knowledge.	**P_{83}, P_{85}**

Table 5.20, Continued

Cultural diversities' Issues (*C_5*)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{28}: Difficulties in setting realistic expectations about response time.	**1**	**24**	**RC_{69}:** No tracking of the time(s) taken for previous response(s) from an individual or team.	**P_{67}:** Using scales to measure the average time for fulfillment of expectations. For example, adding a feature in the email application that calculates the average time taken by an individual/team to respond email. If average response time is 3 days then sender can expect that email should be responded till 3 days.
I_{29}: Difficulties in achieving consensus on requirements.	**2**	**26**	**RC_{11}:** Unfamiliarity from cultural values.	**P_3, P_6.**
			RC_{70}: Stakeholders' interests are contradicting to one another	**P_{50}, P_{47}, P_{52},** **P_{89}:** Aligning the objectives of client and vendor through negotiation. **P_{90}:** Classifying the requirements through multi-dimensional approach. **P_{60}:** Introducing Equality Model (EM) for all the stakeholders according to which all stakeholders are equal and can talk about the interests, religion and cultural values of one and another. They can also share knowledge and recommend solutions by considering the perception and position of others. **P_{54}, P_{53}.**
			RC_{39}: High number of stakeholders as sources of requirements.	**P_{58}, P_{118}.**
I_{30}: Lack of trust.	**3**	**26**	**RC_5:** Lack of socialization.	**P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}.**
			RC_{71}: Lack of face to face meetings.	**P_1,P_2** **P_{123}:** Employing requirements workshop.
			RC_4: Communication is infrequent and constrained.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}**
			RC_{11}: Unfamiliarity from cultural values.	**P_3, P_6.**
			RC_{72}: Poor conflict handling.	**P_{61}:** Delineating the processes, tools and policies to be followed. **P_{62}:** Sharing knowledge. **P_{53}**
			RC_{73}: Lack of capability, reliability and expertise.	**P_{62},** **P_{64}:** Having technical, managerial and staffing capabilities to meet quality standards and meeting schedule.
			RC74: Not knowing and fulfilling expectations of other stakeholders.	**P_{63}:** Keeping common expectations.

I_{31}: Avoidance of the commitments from the stakeholders.	**4**	**30**	**RC_{75}:** Lack of trust.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17} P_{123}, P_{53}, P_{61}, P_{62}, P_{63}, P_{64}**

Table 5.20, Continued

Cultural diversities' Issues(C_5)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{32}: Nonparticipation or exclusion of stakeholders from RE activities.	**5**	**35**	**RC_{76}:** Ignoring limitations (availability, consent from relevant authorities, and participation with some conditions) of stakeholders.	**P_{70}, P_{20}.**
			RC_{28}: Stakeholders' lack of motivation to participate in RE activities.	**P_{120}**
			RC_{77}: Stakeholders are not fluent in one communication language.	**P_4, P_5, P_6.** **P_{65}:** Starting with the informal conversation to motivate non-fluent or less fluent stakeholders for participating in the conversation. **P_{66}:** Utilizing translation services: i) Use of human translator. ii) Using real-time machine translation services. **P_{119}:** Adopting asynchronous communication like email so that less competent stakeholder could have time to understand and answer the communicated messages. Features like checking spellings and grammar, and language translation should be integrated with email facility.
			RC_2: Time zone differences.	**P_7, P_8, P_9, P_{10}.**
			RC_{78}: Stakeholders are unfamiliar from the use of tools and technology being used.	**P_{76}:** Providing training about how to: i) Use the tools. ii) Collaborate effectively in the environment where stakeholders are at distant locations.
Processes and tools' Issues (C_6)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{33}: Selection of inappropriate RE tool(s).	**1**	**21**	**RC_{79}:** Unawareness from the features of tool(s).	**P_{82}:** Having training and knowing about different features of RE tool(s) before selecting tools. **P_{81}:** Assessing capabilities of RE tools by using ISO/IEC TR 24766:2009 framework and relevant information.
			RC_{74}: Not knowing and fulfilling expectations of other stakeholders.	**P_{63}**
			RC_{80}: Unawareness from the cognitive styles of stakeholders.	**P_{121}:** Selecting suitable groupware tools and techniques for requirements elicitation keeping in view cognitive characteristics of stakeholders by using Felder-Silverman's Learning Style Model (LSM).
I_{34}: RE rework or data loss during transfer from one tool to other.	**2**	**26**	**RC_{81}:** Different RE processes are used, resulting in usage of different templates and methodologies, at the different locations of client.	**P_{25}, P_{78}, P_{77}, P_{22}, P_{23},** **P_{79}:** Following shared and agreed processes.
			RC_{82}: Use of tools that do not integrate.	**P_{122}:** Having a common set of tools. **P_{80}:** Using tools that can interact with other tools. **P_{77},P_{81}**
I_{35}: Use of different RE processes, resulting in usage of different templates and methodologies, at the different locations of client.	**3**	**30**	**RC_{23}:** Unclear or undefined RE processes.	**P_{25}, P_{78}, P_{77}**
			RC_{21}: Leaders do not use authority.	**P_{22}, P_{23}.**
			RC_{83}: Stakeholders at different locations are at different maturity levels of RE process.	**P_{79}, P_{77}.**
I_{36}: Use of unsuitable RE processes.	**4**	**39**	**RC_{23}:** Unclear or undefined RE processes.	**P_{25}, P_{78}, P_{77}.**
			RC_{84}: Use of standard processes without adjusting them to distributed context.	**P_{77}**

I_{37}: Use of unsuitable requirements elicitation technique.	**5**	**41**	**RC_{85}:** Absence of a firm, skilled and central analyst role like unfamiliarity with the elicitation techniques and not knowing when to use them.	**P_{83}** **P_{84}:** Using a proper procedure to select an adequate requirements elicitation technique. **P_{85}**
			RC_{80}: Unawareness from the cognitive styles of stakeholders.	**P_{121}**

Table 5.20, Continued

Relationship among stakeholders' Issues(C_7)	CR_v	OR_u	Root Causes	RE Practices
I_{38}: Issues in signing-off requirements engineering deliverables.	**1**	**26**	**RC_7:** Client and vendor rely on oral agreement.	**P_{28}**
I_{39}: Use of different requirements documentation standards by customer and vendor.	**2**	**32**	**RC_{83}:** Stakeholders at different locations are at the different maturity levels of RE processes.	**P_{79}, P_{77}**
			RC_{86}: Lack of documentation standardization.	**P_{86}:** Defining and following standard document structure. **P_{87}:** Using IEEE Standard 830-1998 For Requirements Specification to structure the requirements specification document. **P_{88}:** Defining minimum standards for requirements documentation. **P_{124}:** Checking to verify that the requirements document structure is consistent with defined standards.
I_{40}: Lack of firm relationship among stakeholders.	**3**	**35**	**RC_{75}:** Lack of trust.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}** **P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}** **P_{123}, P_{53}, P_{61}, P_{62}, P_{63}, P_{64}**
			RC_1: Lack of informal communication.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}** **P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}**
			RC_5: Lack of socialization	**P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}**
			RC_{11}: Unfamiliarity from cultural values.	**P_3, P_6.**
			RC_{87}: Lack of onsite visits.	**P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}.**
			RC_{72}: Poor conflict handling.	**P_{61}, P_{62}, P_{53}**
I_{41}: Misconceptions of the vendor teams about client's working practices.	**4**	**38**	**RC_{24}:** Stakeholders belonging to diverse cultural backgrounds: i) Have different values regarding hierarchies, handling risks, following schedules and precision of work. ii) Speak different languages, use different communication styles and are at different proficiency level of communication language. iii) Deduce inexplicit meanings and explanations from the information about requirements.	**P_{59}**
I_{42}: Different priorities of client and vendor for collecting and finalizing requirements.	**5**	**39**	**RC_{88}:** Client and vendor have undisclosed and dissimilar objectives.	**P_{50} ,P_{52}, P_{53}, P_{54}, P_{89}, P_{60}**
I_{43}: Failure in meeting deadlines and fulfilling commitments about requirements by vendor.	**6**	**43**	**RC_{61}:** RE teams work with tight schedules to meet deadlines.	**P_{91},P_{92}, P_{93}, P_{94}, P_{98}**

			RC_{18}: Expected participants do not honor commitments made for participation.	**P_{70}, P_{20}.**
			RC_{89}: Absence of mechanisms for tracking progress.	**P_{95}:** Designing metrics to measure performance. **P_{96}:** Developing mechanisms for reporting about the progress. **P_{97}:** Enhancing the progress tracking/visibility by increasing the number of RE deliverables.

5.4.1 Definitions and properties

Basic definitions and properties used during formation of the REP Model are:

i) *Definition 1:* An Issue is defined as "A matter that is in dispute between two or more parties" ("Merriam Webster ", 2015) or "A problem that people are thinking and talking about ("Cambridge ", 2015)".

*So a **Requirements Engineering process issue** denoted by **"I_i"** can be defined as the problem about which practitioners think or talk about during Requirements Engineering process and which can create dispute among the parties involved.*

Let *I* be set of all the frequently occurring issues of RE process for SDO, then

$$I = \{I_i\} \; where \; i = \{a : a \in N \wedge 1 \leq a \leq 43\} \wedge N = Set \; of \; Natural \; numbers$$

ii) *Definition 2:* A Category is defined as a class or division of things having common characteristics ("oxforddictionary," 2015).

Using Definition 1, *Category of Issues* can be defined as.

*A **Category of Issues** denoted by **"C_z"** is a class or division of issues (issues of Requirements Engineering process for Software Development Outsourcing) having common characteristics.*

iii) From definition 2, following property of the *"REP"* Model can be derived.

***Property 1:** The **"REP"** Model has seven categories of issues i.e.*

$$REP = \{C_z\} \; where \; z = \{b : b \in N \wedge 1 \leq b \leq 7\} \wedge N = Set \; of \; Natural \; numbers \wedge \forall C_z, \{C_z\} \subset I$$

for $z = 1,2,3,\cdots,7$, Seven categories of issues have been defined as following:

C_1 *is Communication,*

C_2 *is Management and coordination,*

C_3 *is Knowledge management and awareness,*

C_4 *is Requirement centric issues,*

C_5 *is Cultural diversitie,*

C_6 *is Processes and tools, and,*

C_7 *is Relationship among stakeholders.*

iv) From Definition 1 and Property 1, following property can be derived for categories of issues.

Property 2: *Each category has many issues but one issue belongs to only one category.*

$$So \quad \exists! C_z ,\ \exists\ I_i : C_z = \{I_i\}$$
$$And \quad \exists! I_i , \quad \exists!\ C_z : I_i \in \{C_z\}\ \forall\ z = (1,2,3,...,7) \wedge i = (1,2,3,...,43)$$

v) ***Definition 3:*** A Cause or Casual Factor is a condition or an event that creates an effect (Guideline, 1992).

A cause is called ***<u>Root Cause</u>*** *denoted by* ***"RCy"*** *if its correction prevents its recurrence and that of other unwanted results (Guideline, 1992).*

Let *RC* be set of all the root causes, then

$$RC = \{RC_y\} \text{ where } y = \{k : k \in N \wedge 1 \le k \le 89\} \wedge N = Set\ of\ Natural\ numbers$$

vi) From Definitions 1 and 3, property 3 is derived as:

Property 3: *For an issue there are one or more root causes and one root cause can be root cause for one or more issues.*

$$So \quad \exists! I_i\ ,\ \exists\ RC_y : \exists! I_i \ \Rightarrow \exists RC_y$$
$$And \quad \exists! RC_y , \quad \exists\ I_i : \exists! RC_y \Rightarrow \exists\ I_i \qquad \forall\ y = (1,2,3,...,89) \wedge i = (1,2,3,...,43)$$

vii) ***Definition 4:*** A Practice is defined as "The action or process of doing something ("Dictionary," 2015)" or "A way of doing something that is usual or expected in a particular situation ("oxforddictionary," 2015)" or "Repeated performance or systematic exercise for the purpose of acquiring skill or proficiency ("Dictionary," 2015)".

According to IEEE definition "A software requirement is a condition or capability which is needed by a user to solve a problem or achieve an objective, and it must be met or possessed by a software system or system component (Radatz, et al., 1990)".

Thus ***Requirements Engineering Practices*** *denoted by* ***"P_s"*** *are the actions which are performed customarily during Requirements Engineering process to successfully:*

i) Collect, write, validate and organize software requirements,

ii) Avoid or eliminate the problems that arise or are expected to arise during software requirements' collection, documentation, validation and organization.

Let *P* be the set of all the Requirements Engineering Practices that can be used to address the frequently occurring issues of SDO RE process, then

$$P = \{P_s\} \text{ where } s = \{d : d \in N \wedge 1 \le d \le 124\} \wedge N = \text{Set of Natural numbers}$$

viii) From Definitions 3 and 4, following property can be derived:

Property 4: *To address one root cause, one or more Requirements Engineering Practices can be recommended, and one Requirements Engineering Practice can be recommended to address one or more root causes.*

$$\text{So} \quad \exists! RC_y \ , \ \exists P_s \ : \exists! RC_y \ \Rightarrow \exists P_s$$

$$\text{And} \ \exists! P_s, \ \exists RC_y : \exists! P_s \Rightarrow \exists RC_y \qquad \forall \ y = (1,2,3,...,89) \wedge s = (1,2,3,...,124)$$

ix) ***Definition 5:*** A rank is a particular position, higher or lower than others ("Cambridge," 2015).

In the REP Model there are three different types of ranks i.e. ***Ranks of categories***, ***Ranks of issues within a category***, *and* ***Overall ranks of issues***. *Each category of issues has a rank (based on the 'frequency of occurrence' of issues in that category) with respect to other categories denoted by R_w. Each frequently occurring issue has two ranks (based on frequency of occurrence) i.e. Rank of the issue with respect to other issues within a*

category called Category-wise Rank denoted by CR_v, and Rank of the issue with respect to all other frequently occurring issues called Overall Rank denoted by OR_u.

x) Definitions 2 and 5 lead to property 5.

Property 5: *Each category of issues has only one rank with respect to all other categories and one rank can be assigned to only one category of issues.*

Let *R* be set of the ranks of issues' categories, then

$$R = \{R_w\} \text{ where } w = \{f : f \in N \wedge 1 \leq f \leq 7\} \wedge N = \text{Set of Natural numbers}$$
$$\text{So} \quad \exists! C_z \ , \ \exists! R_w \ : \exists! C_z \ \Rightarrow \exists! R_w$$
$$\text{And} \quad \exists! R_w, \ \ \exists! \ C_z \ : \ \exists! R_w \Rightarrow \exists! \ C_z \qquad \forall \ z, w = (1, 2, 3, ..., 7)$$

xi) Definitions 1 and 5 lead to property 6.

Property 6: *A frequently occurring issue of RE process for SDO has only one category-wise rank in the respective category and one category-wise rank can be assigned to only one frequently occurring issue in that category.*

Let *CR* be set of all the Category-wise ranks then

$$CR = \{CR_v\} \text{ where } v = \{g : g \in N \wedge 1 \leq g \leq 9\} \wedge N = \text{Set of Natural numbers}$$
$$\text{So} \quad \exists! I_i \quad , \ \exists! CR_v : \exists! I_i \ \Rightarrow \exists! CR_v$$
$$\text{And} \quad \exists! CR_v, \ \ \exists! \ I_i \ : \exists! CR_v \Rightarrow \exists! \ I_i \qquad \forall \ i = (1, 2, 3, ..., 43) \wedge v = (1, 2, 3, ..., 9)$$

xii) Definitions 1 and 5 also lead to property 7.

Property 7: *A frequently occurring issue of RE process for SDO has only one overall rank with respect to all other frequently occurring issues and one overall rank can be assigned to only one frequently occurring issue.*

Let *OR* be set of all Overall Ranks then

$$OR = \{OR_u\} \text{ where } u = \{h : h \in N \wedge 1 \leq h \leq 43\} \wedge N = \text{Set of Natural numbers}$$
$$\text{So} \quad \exists! I_i \quad , \ \exists! OR_u : \exists! I_i \quad \Rightarrow \exists! OR_u$$
$$\text{And} \quad \exists! OR_u, \ \ \exists! \ I_i \ : \exists! OR_u \Rightarrow \exists! \ I_i \qquad \forall \ i, u = (1, 2, 3, ..., 43)$$

5.4.2 Relationship among the units of the REP Model

Figure 5.3 shows relationships among the various units of REP Model.

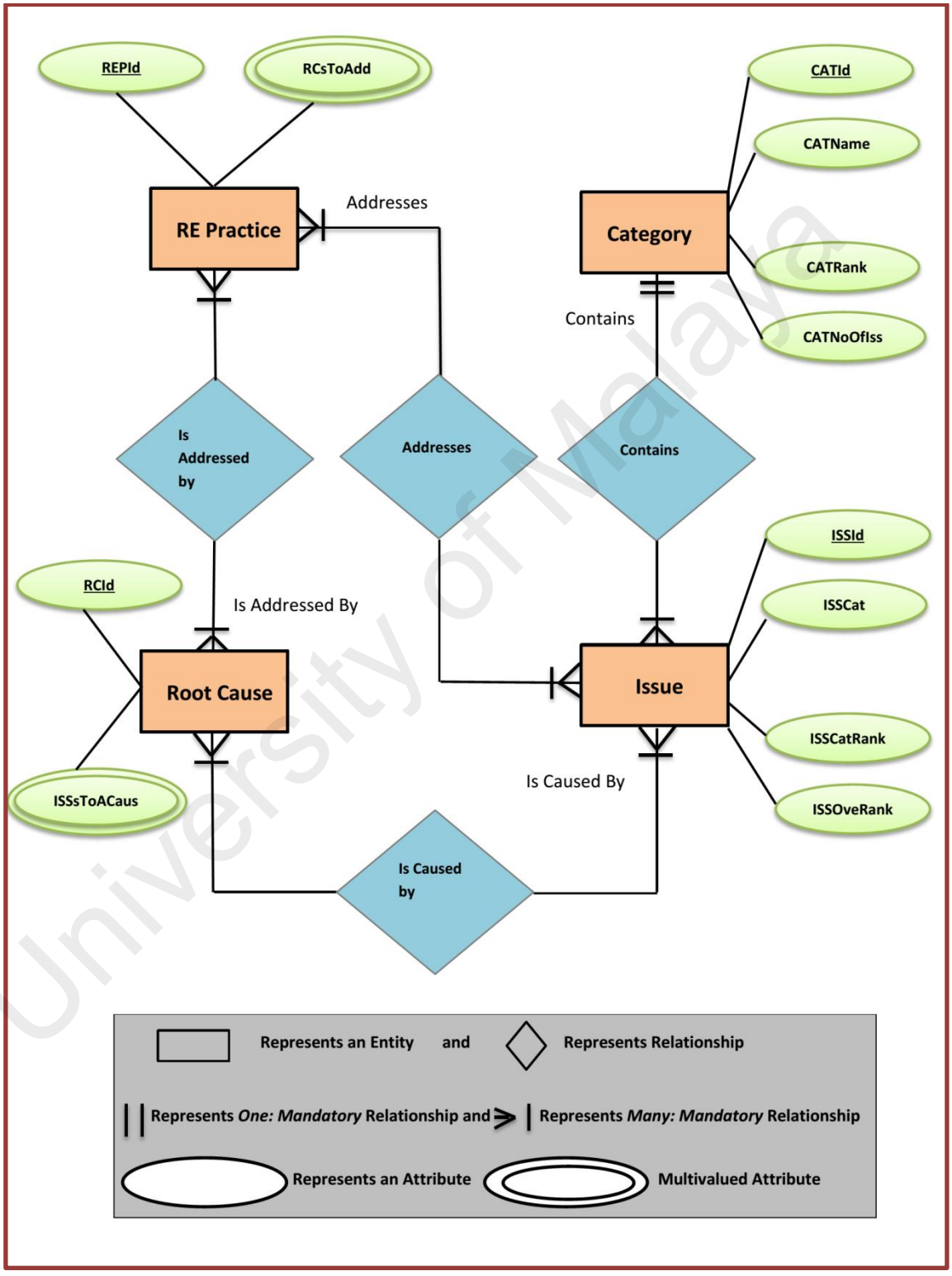

Figure 5. 3 : Relationships among various units of the REP Model

As figure 5.3 shows, there are four basic units of the REP Model: i) Categories of issues, ii) Issues, iii) Root Causes, and iv) Requirements Engineering (RE) Practices.

For a category, CATId represents category identification, CATName denotes name of the category, CATRank shows rank of the category with respect to other categories and CATNoOfIss indicates no. of the frequently occurring issues in the category.

For an issue, IssId represents identification of a frequently occurring issue, IssCat denotes category of the frequently occurring issue, IssCatRank shows rank of the frequently occurring issue in the respective category whereas IssOveRank indicates overall rank of the frequently occurring issue with respect to frequently occurring issues of all the categories.

For a root cause, RCId represents root cause identification and IsssToACaus indicates issues which are caused by the root cause.

For a requirements engineering practice, REPId represents identification of requirements engineering practice and RCsToAdd shows root causes which are addressed by the requirements engineering practice.

5.4.3 The REP Model diagram

Figure 5.4 presents REP Model diagram.

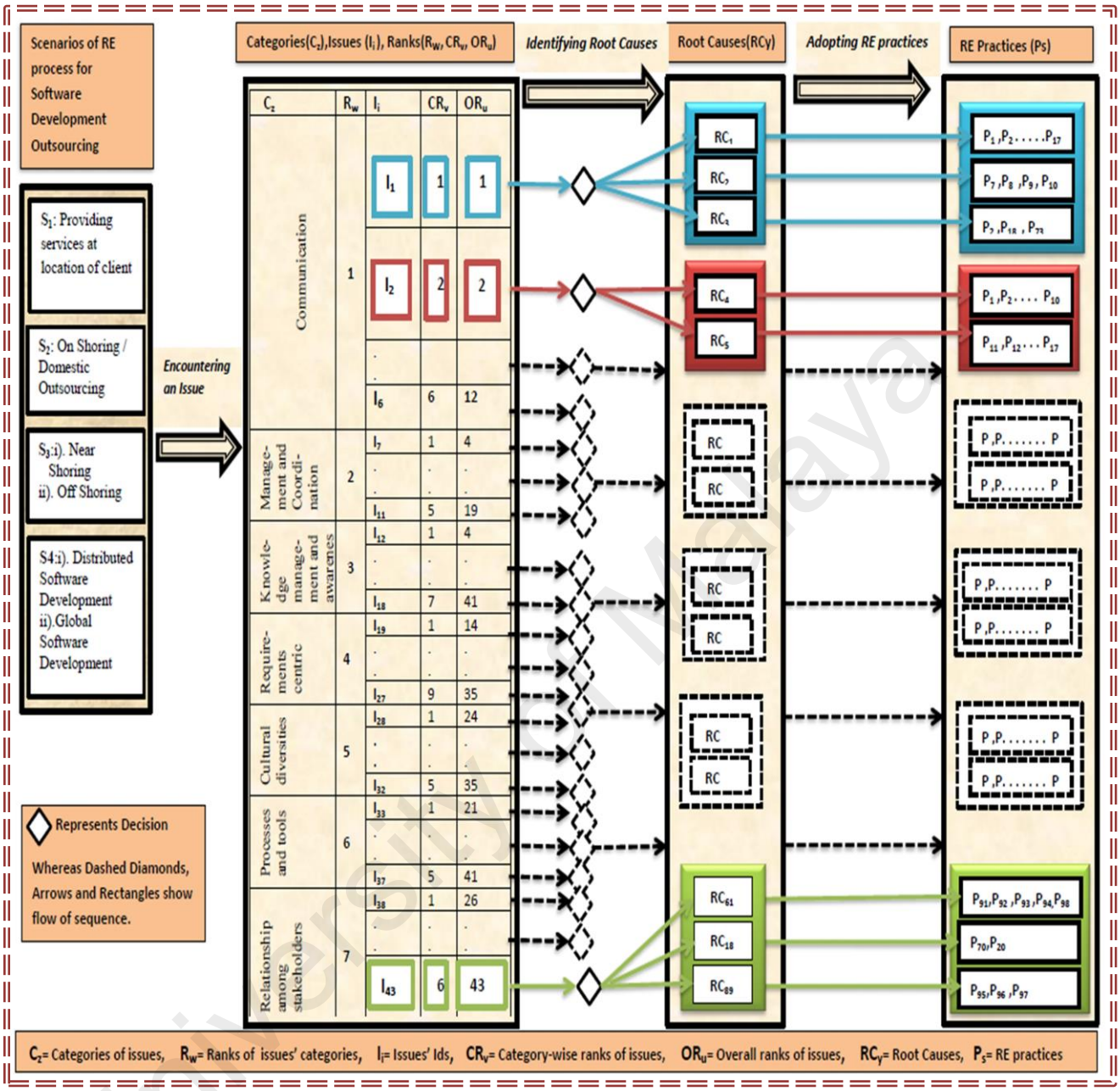

Figure 5. 4 : The REP Model diagram

The REP Model diagram shows that there are the four scenarios of the RE process for SDO (S_1, S_2, S_3 and S_4) that may encounter a RE process issue say **I**. There are 7 categories of the issues of RE process for SDO (Communication, Management and coordination, Knowledge management and awareness, Requirements centric, Cultural diversities, Processes and tools, and Relationship among stakeholders) and 43 frequently occurring issues of RE process for SDO (I_1, I_2, I_3, …, I_{43}) belong to these 7

categories. The issue **I** may be any one of these 43 issues. To address an issue, root cause(s) for the issue must be known. So, next step is to identify root cause(s) for issues. RC_1, RC_2, RC_3,…, RC_{89} are 89 root causes for 43 frequently occurring issues. For example there are 3 root causes for issue I_1 that are RC_1, RC_2 and RC_3. The issue I_1 may occur because of RC_1 or RC_2 or RC_3 or (RC_1 and RC_2) or (RC_1 and RC_3) or (RC_2 and RC_3) or (RC_1 and RC_2 and RC_3). Similarly, the issue **I** may occur because of one or more root causes that can be identified from the root causes given for that particular issue.

For addressing an issue, after identification of the root cause(s) for the issue, next step is to adopt the relevant RE practices. The 124 RE practices have been recommended for this purpose that are P_1, P_2, P_3, ..., P_{124}. In case of the issue I_1, for the root cause RC_1, seventeen RE practices have been recommended that are P_1, P_2, P_3, …, P_{17}, for RC_2 four RE practices have been recommended that are P_7, P_8, P_9, and P_{10}, and for RC_3 three RE practices have been recommended that are P_2, P_{18} and P_{73}. Likewise the issue I can be addressed by adopting one or more relevant RE practices that can be selected from the RE practices recommended for that particular issue, keeping in view the root cause(s) for the issue.

5.5 Summary

This chapter presents the process to extract the 43 frequently occurring issues, of the Requirements Engineering (RE) process for Software Development Outsourcing (SDO), by employing the Delphi method and the Cut-off value method. Out of the 43 frequently occurring issues, 6 issues are related to communication, 7 issues are connected to knowledge management and awareness, 5 issues occur because of cultural diversities, 5 issues are linked with management and coordination, 5 issues are associated to processes and tools, and 6 issues stem from relationship among stakeholders whereas 9 issues are requirements centric. After extraction, the 43 frequently occurring issues are ranked,

based on the means of response values, within the respective categories which is called Category wise-ranking. The frequently occurring issues are also ranked with respect to all the 43 frequently occurring issues named as Overall-ranking. The ranking of the issues' categories is also performed that is: Communication=1, Management and coordination=2, Knowledge management and awareness=3, Requirements centric=4, Cultural diversities=5, Processes and tools= 6, and Relationship among stakeholders=7. Afterwards, by performing the Root Cause Analysis, 89 root causes are discovered for the 43 frequently occurring issues of RE process for SDO. The Root Cause Analysis also identifies and maps the 124 RE practices to the 43 frequently occurring SDO RE process issues to address the issues in the case of respective root causes. This accomplishes the formation of the first version of REP Model.

CHAPTER 6: REP MODEL EVALUATION RESULTS AND DISCUSSIONS

This chapter describes the REP Model evaluation process, evaluation results and discussions. The model is evaluated from: i) The academic perspective through the expert panel of researchers and academicians, ii) The industrial perspective through the practitioners from Software Development Outsourcing (SDO) industry. For evaluation from the academic perspective, 'Completeness', 'Practicality' and 'Usefulness' are the three criteria. The experts evaluate the model against the three criteria by using a 7-point Likert Scale. To evaluate the model from the industrial viewpoint, criterion is 'usefulness of the recommended RE practice(s) for addressing the corresponding issue in the case of respective root cause'. The SDO practitioners evaluate the model against the given criterion by using a 4-point Likert Scale. The chapter presents the analysis of the expert panel evaluation by performing i) Inter-Rater Reliability analysis through the calculation of Cohen's kappa coefficient (k), and ii) Analysis of Means (ANOM). This is followed by the investigations of the industrial evaluation through: i) 50% rule, ii) Content Validity Index analysis, and iii) Confidence Interval analysis.

Chapter 6 fulfills the research objective 3 partially, and answers Research Question (RQ) 9.

Figure 6.1 summarizes the evaluation process for the REP Model.

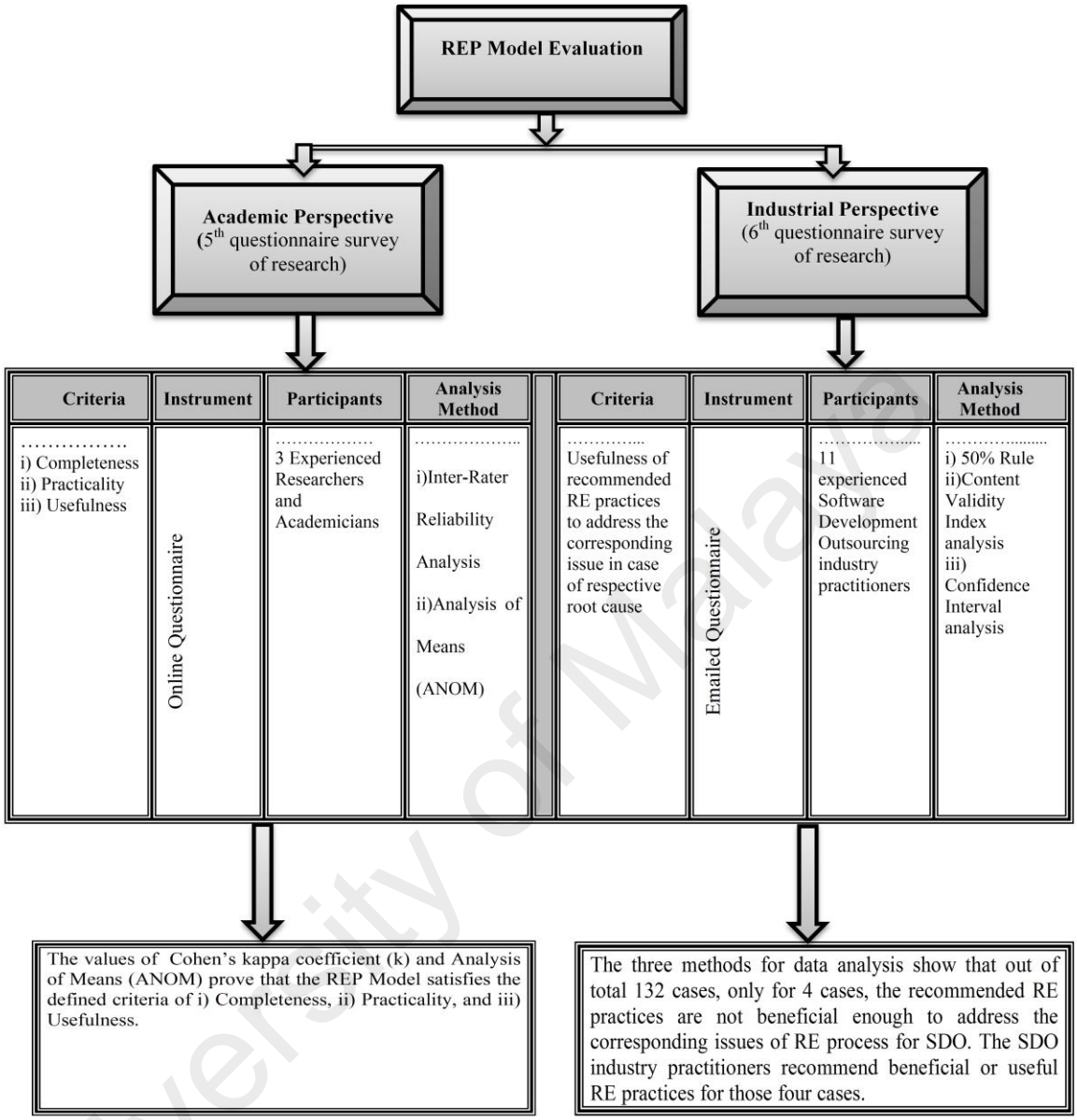

Figure 6. 1: Evaluation process for the REP Model

The REP Model evaluation process is described step by step.

6.1 The REP Model evaluation

Model has been evaluated from:

i) The academic point of view through the expert panel of academicians and researchers.

ii) The industry perspective through SDO industry practitioners.

Experts and practitioners having diverse backgrounds and relevant experience are recommended for an effective evaluation (Beecham, et al., 2005; B. A. Kitchenham et al., 2002; Mathew, et al., 2011). Therefore, experienced SDO practitioners and academicians with varied backgrounds have been engaged for evaluation of the REP Model. The efficacy of evaluation through experts, in a field, is widely recognized (B. Kitchenham, et al., 2002; Lauesen & Vinter, 2001) and numerous fields like medicine, building construction, operational research, sports, computer science, agriculture and sociology etc. are benefited momentously from it (Abramson, et al., 2014; Bertolino, et al., 2011; Carpio, et al., 2015; Mathew, et al., 2011; Ruiz, et al., 2015).

6.1.1 The REP Model evaluation from the academic perspective through the expert panel of academicians and researchers

The small number of experts can be used for development and testing (Hakim, 1988). For example in the studies (Lam, Petri, & Smith, 2000; Lauesen & Vinter, 2001; Rosqvist, et al., 2003) three experts have been employed for review and evaluation. Similarly, in this research work for evaluation of the REP Model from the academic viewpoint, an expert panel of three experienced academicians and researchers has been involved. Out of three experts, two possess industrial experience as well. Two experts have more than 10 years' experience whereas one expert has more than 15 years' experience. Table 6.1 provides details about the experts.

Table 6. 1: Demographic information of the academicians and researchers

Expert ID	Qualification	Designation(s)/ Specialization	Research Areas	Experience (Yeas)	Countries of Working
Academician& Researcher1	PhD	Associate Professor of Software Engineering, Research Scientist, Senior System Analyst, Project Manager	Software Engineering, Social Computing, Global System Development and Management, Project Management, Systems Quality, Software Process Improvement, Quality Assurance, Requirements Engineering, Evidence-Based Software Engineering	More than 10 years	United Kingdom, Australia, Kingdom of Saudi Arabia
Academician& Researcher2	PhD	Senior Lecturer, Program Director	Software Engineering, software evaluation and testing, Usability Engineering, Mobile Computing, Human Computer Interaction	More than 15 years	Malaysia
Academician& Researcher3	PhD	Senior Lecturer, Project Leader	Software Engineering, Agile Software Methods, Secure Software Engineering, Requirements Engineering, Software Architecture & Design, Semantic Web, Ontology, IT Governance	More than 10 years	South Korea , Dubai , Malaysia

6.1.1.1 Conducting the REP Model evaluation from the academic perspective

An online questionnaire survey (5th questionnaire survey of this research work) has been conducted to evaluate the REP Model through expert panel consisting of academicians

and researchers. Guidelines provided in study (B. A. Kitchenham & Pfleeger, 2008) have been used to design and conduct the survey.

(a) Data Collection: The online questionnaire, provided in Appendix A as questionnaire 5, has been used for the REP Model evaluation from academicians and researchers. The model, link to online survey-questionnaire and related information have been emailed to three experts. The survey has been conducted by using semi-supervised approach (Pfleeger & Kitchenham, 2001). Survey's objectives and respondents' queries have been made clear through Computer-Assisted Telephone Interviewing technique (Anie, et al., 1996).

(b) Questionnaire Format: The questionnaire contains two parts. The purpose of the first part is to collect data about the experts' experience, job nature and respective organizations. The second part is meant for evaluation of the REP Model. To improve the questionnaire layout, assess the language comprehension and estimate the time required to complete the questionnaire, two rounds of pilot study have been conducted. Recommendations have been incorporated after the first round. The second round has been carried out to ensure that the changes made are according to the given suggestions. The questionnaire contained 10 questions to evaluate three evaluation criteria that is 'Completeness', 'Practicality' and 'Usefulness'. Out of 10 questions, 4 questions (Q1, Q2, Q3 and Q4) are to assess 'Completeness', 3 questions (Q5, Q6 and Q7) are regarding 'Practicality' of the model whereas last 3 questions (Q8, Q9 and Q10) are to judge 'Usefulness' of the model.

(c) Sampling and population: The Convenience Sampling method has been employed for obtaining a valid sample of respondents. Seven experts having research and academics background with at least 10 years' experience have been invited to participate in the model evaluation. But only three of them have shown their willingness

to participate in the evaluation. Demographic information of those three academicians and researchers has been provided in Table 6.1.

(d) Responses: The experts have been solicited to answer the survey questions by using the seven-point Likert Scale. All the three academicians and researchers have performed evaluation from the academic perspective. Out of the 3 experts, one expert has given suggestions for improvement. The suggestions have been accommodated and relationship diagram has been sketched to show relationship among the instances of the various units of REP Model. The expert has been requested to perform evaluation again.

6.1.1.2. Criteria for the REP Model evolution from the academic perspective

There are three criteria for evaluation of the model from the academic point of view:

i) Completeness, ii) Practicality, and iii) Usefulness.

By 'Completeness' means that the model covers all the relevant categories of the frequently occurring issues of RE process for SDO and deals with almost all such issues. Furthermore, each set of root causes contains sufficient root causes for occurrence of the corresponding issues and each set of RE practices contains enough RE practices for addressing corresponding issues.

By 'Practicality' means that in case of each issue, corresponding root causes and RE practices to address those causes have been clearly defined. Further in case of each issue, recommended set of RE practices is easy to adapt in most of scenarios without any special arrangements.

By 'Usefulness' means that for every issue, given set of root causes is beneficial enough to explore relevant RE practices and each set of RE practices is beneficial enough for addressing the corresponding issue. Additionally, the proposed model is beneficial enough to support RE process for SDO.

6.1.1.3 Scale to evaluate 'Completeness', 'Practicality' and 'Usefulness'

A seven-point Likert Scale has been used to rank the three given criteria:

i) Agree Strongly (1), ii) Agree Moderately (2), iii) Agree Slightly (3), iv) Neither Agree nor Disagree (4), v) Disagree Slightly (5), vi) Disagree Moderately (6), vii) Disagree Strongly (7)

6.1.2 Discussions and results of the REP Model evaluation from the academic perspective

For the REP Model evaluation from the academic perspective, an online questionnaire survey has been conducted. The results have been presented in Table 6.2.

Table 6. 2 : Results of online questionnaire survey for REP Model evaluation from academicians and researchers

Criterion	Evaluation Focus	Academician& Researcher1	Academician& Researcher2	Academician& Researcher3
Completeness	Categories of frequently occurring issues (Q1)	1	1	1
	Frequently occurring issues (Q2)	2	2	2
	Each set of Root Causes (Q3)	1	1	1
	Each set of Requirements Engineering Practices (Q4)	1	1	1
Practicality	Each set of Root Causes to understand (Q5)	1	1	1
	Each set of Requirements Engineering Practices to understand (Q6)	1	1	1
	Each set of Requirements Engineering Practices to adapt (Q7)	3	2	3
Usefulness	Each set of Root Causes to explore the relevant Requirements Engineering Practices (Q8)	1	1	1
	Each set of Requirements Engineering Practices to address corresponding issue (Q9)	1	1	1
	Overall model to support RE process for SDO (Q10)	1	1	1

Figure 6.2 shows evaluation results for 'Completeness' criterion.

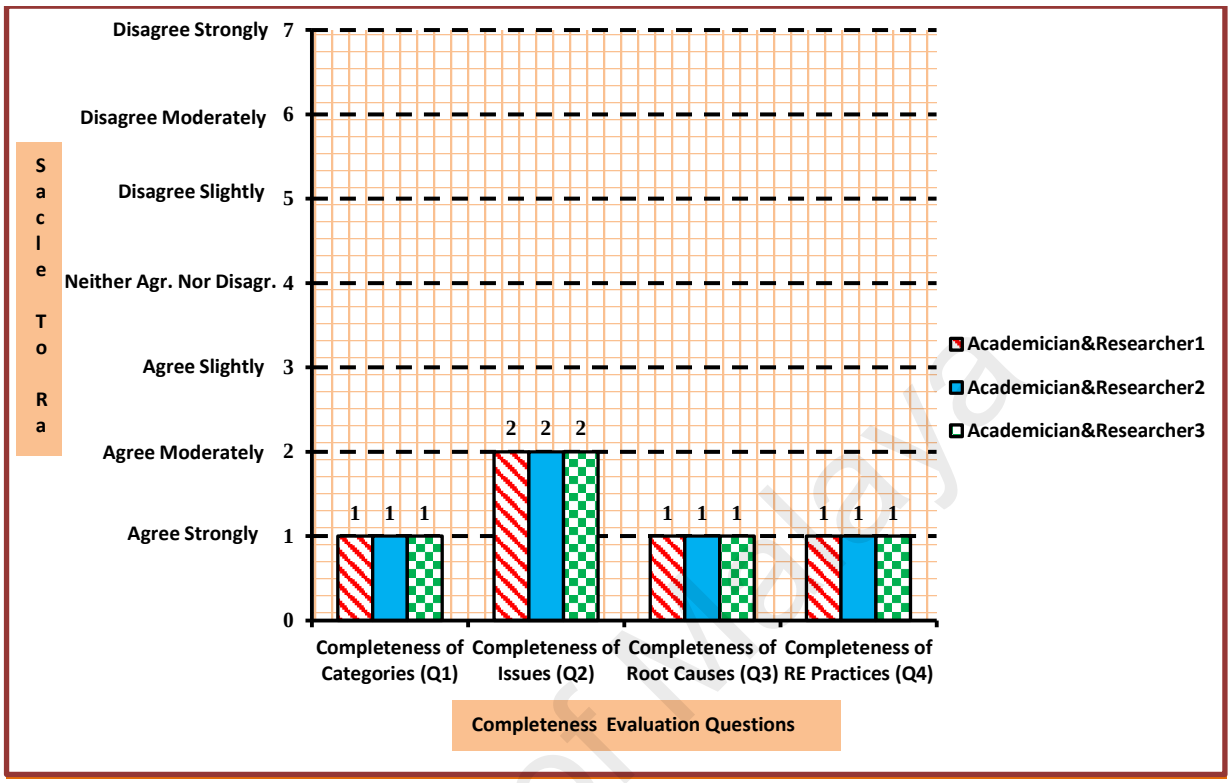

Figure 6. 2: Results of online questionnaire survey for 'Completeness' evaluation from academicians and researchers

There are four questions to evaluate the criterion of 'Completeness'. Q1 is 'The proposed model deals with all the relevant categories for the frequently occurring issues of RE process for Software Development Outsourcing'. Q2 is 'The given set of issues contains almost all the frequently occurring issues of RE process for Software Development Outsourcing'. Q3 is 'Each set of Root Causes contains sufficient Root Causes for the occurrence of the corresponding Issue'. Q4 is 'Each set of Requirements Engineering Practices contains sufficient Practices to address the corresponding Issue'. This can be observed from the Figure 6.2 that in case of Q1, Q3 and Q4, all experts 'Agree Strongly'. For Q2, all experts 'Agree Moderately'. It indicates that the model deals with all the relevant categories of frequently occurring issues, contains almost all the frequently occurring issues, each set of Root Causes contains sufficient root causes and each set of RE practices contains enough practices to address corresponding issue.

Figure 6.3 shows evaluation results for ‘Practicality’ criterion.

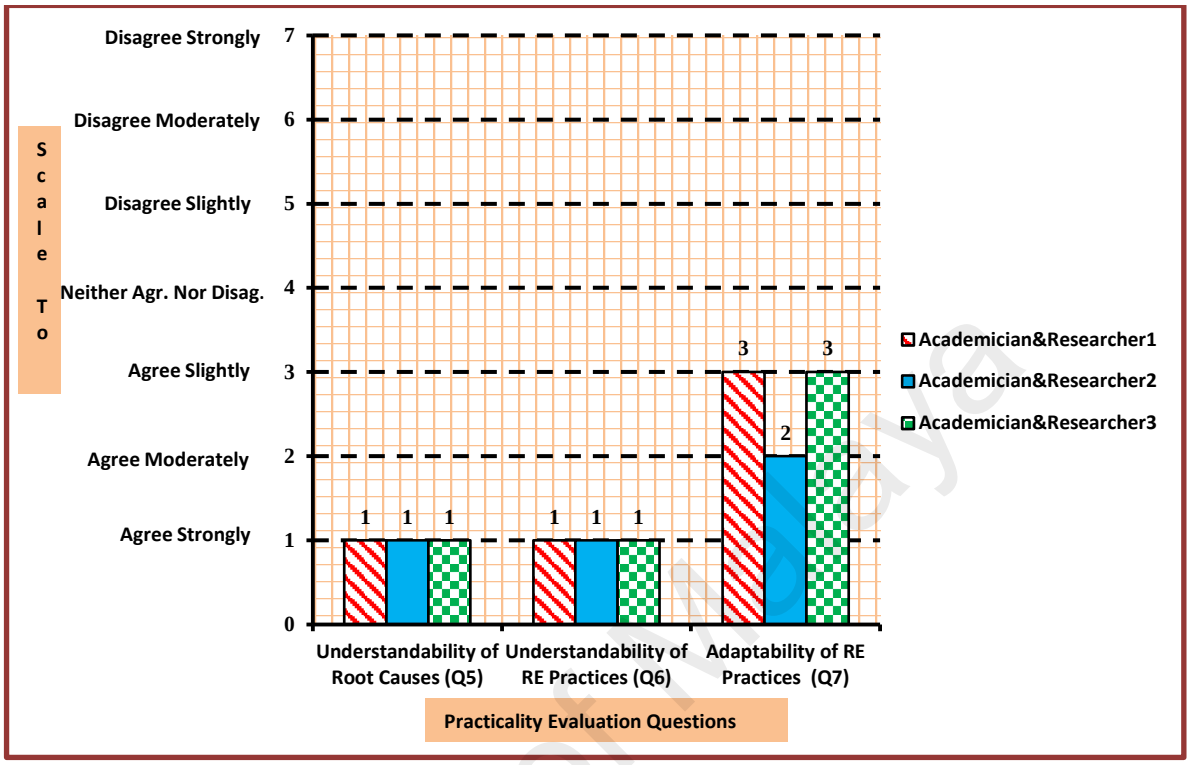

Figure 6. 3: Results of online questionnaire survey for ‘Practicality’ evaluation from academicians and researchers

For evaluation of the ‘Practicality’ criterion, three questions (Q5, Q6 andQ7) have been designed. Q5 is about clarity and unambiguousness of the each set of Root Causes. According to Figure 6.3, all experts ‘Agree Strongly’ that each set of Root Causes has been clearly defined. Q6 is related to clarity and unambiguousness of the each set of recommended RE practices. Like Q5 again experts ‘Agree Strongly’. This proves that given sets of Root Causes and RE practices have been clearly defined and are unambiguous. Q7 deals with the adaptability of the each set of recommended RE practices in different situations. Two experts ‘Agree Slightly’ but one expert ‘Agree Moderately’ that each set of RE practices is easy to adapt in the most of scenarios. This may be because of the fact that various organizations prefer to follow certain practices and do not utilize certain practices because of the organizational rules and structures.

Figure 6.4 shows evaluation results in case of the criterion of ‘Usefulness’.

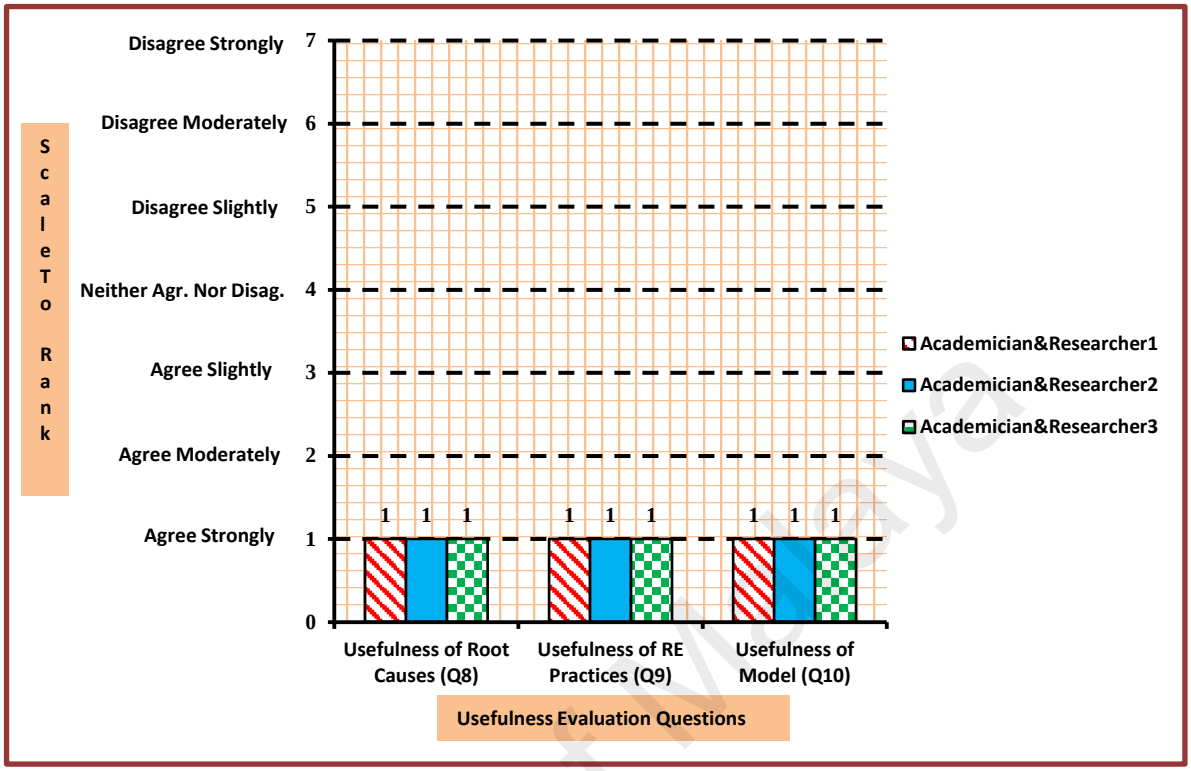

Figure 6. 4: Results of online questionnaire survey for 'Usefulness' evaluation from academicians and researchers

To evaluate the criterion of 'Usefulness', there are three questions (Q8, Q9 and Q10). Q8 is to judge that in case of the each frequently occurring issue, the given set of Root Causes is how much beneficial to explore the RE Practices for addressing corresponding issue. According to Figure 6.4 all the experts 'Agree Strongly' that in case of the each issues, the given set of Root Causes is beneficial enough to explore the RE Practices for addressing corresponding issue. This proves the usefulness of given set of Root Causes in case of each issue. Through Q9 it has been inquired that in case of the each issue, the recommend set of RE practices is how much beneficial to address the corresponding issue in case of each corresponding root cause. Again experts 'Agree Strongly' that endorsed sets of RE practices can address the corresponding issues. It helps to determine the usefulness of the recommended set of RE practices in case of each issue and each respective root cause. The last question (Q10) is regarding usefulness of the overall REP

Model for RE process during SDO. This is evident from the Figure 6.4 that while agreeing strongly, experts are of the point of view that the model supports RE process for SDO. To analyze the level of consensus among the three experts, Inter-Rater Reliability analysis has been performed.

6.1.2.1 Inter-Rater Reliability Analysis

To measure the degree of consensus among the three experts from academic and research background, Cohen's kappa coefficient (k) has been calculated for each pair of experts. Kappa coefficient helps to measure the degree of agreement between evaluators (Fleiss, 1971; Viera & Garrett, 2005). Usually Kappa coefficient's value greater than .60 is considered an acceptable degree of agreement between experts (Landis & Koch, 1977). Tables 6.3, 6.4, 6.5, 6.6, 6.7 and 6.8 show results of Inter-Rater Reliability Analysis.

Table 6. 3: AcademicianandResearcher1 * AcademicianandResearcher2 Cross Tabulation

		AcademicianandResearcher2		Total
		1.00	2.00	
AcademicianandResearcher1	1.00	8	0	8
	2.00	0	1	1
	3.00	0	1	1
Total		8	2	10

Table 6. 4 : Symmetric Measures Corresponding to Table 6.3

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	.706	.198	2.963	.003
N of Valid Cases		10			

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

Table 6. 5 : AcademicianandResearcher1 * AcademicianandResearcher3 Cross Tabulation

		AcademicianandResearcher3			Total
		1.00	2.00	3.00	
AcademicianandResearcher1	1.00	8	0	0	8
	2.00	0	1	0	1
	3.00	0	0	1	1
Total		8	1	1	10

Table 6. 6 : Symmetric Measures Corresponding to Table 6.5

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	**Kappa**	1.000	.000	4.135	.000
N of Valid Cases		10			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Table 6. 7 : AcademicianandResearcher2 * AcademicianandResearcher3 Cross Tabulation

		AcademicianandResearcher3			Total
		1.00	2.00	3.00	
AcademicianandResearcher2	1.00	8	0	0	8
	2.00	0	1	1	2
Total		8	1	1	10

Table 6. 8 : Symmetric Measures Corresponding to Table 6.7

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	**Kappa**	.706	.198	2.963	.003
N of Valid Cases		10			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Using Tables 6.4, 6.6 and 6.8, Table 6.9 shows required Kappa values.

Table 6. 9 : Values of Cohen's Kappa Coefficient

Expert Pair	Kappa Value
AcademicianandResearcher1 Vs. AcademicianandResearcher2	**.71**
AcademicianandResearcher1 Vs. AcademicianandResearcher3	**1.00**
AcademicianandResearcher2 Vs. AcademicianandResearcher3	**.71**

This is clear from Table 6.9 that:

Kappa coefficient for AcademicianandResearcher1 & AcademicianandResearcher2= .71

Kappa coefficient for AcademicianandResearcher1 & AcademicianandResearcher3= 1.00

Kappa coefficient for AcademicianandResearcher2 & AcademicianandResearcher3= .71

It is already known that usually Kappa coefficient's value greater than .60 indicates an acceptable degree of agreement between experts (Landis & Koch, 1977). This confirms

the ‘Completeness’, ‘Practicality’, and ‘Usefulness’ of the REP Model according to perception of academicians and researchers.

6.1.2.2 Analysis of Means (ANOM)

To analyze whether the means of responses from an expert are statistically different from the overall mean or not, Analysis of Means (ANOM) has been performed. The tool ‘Q1 Macros for Excel’ has been used for performing ANOM.

(a) ANOM for criterion of Completeness

Figure 6.5 shows ANOM plot for ‘Completeness’ criterion covering questions Q1, Q2, Q3 and Q4.

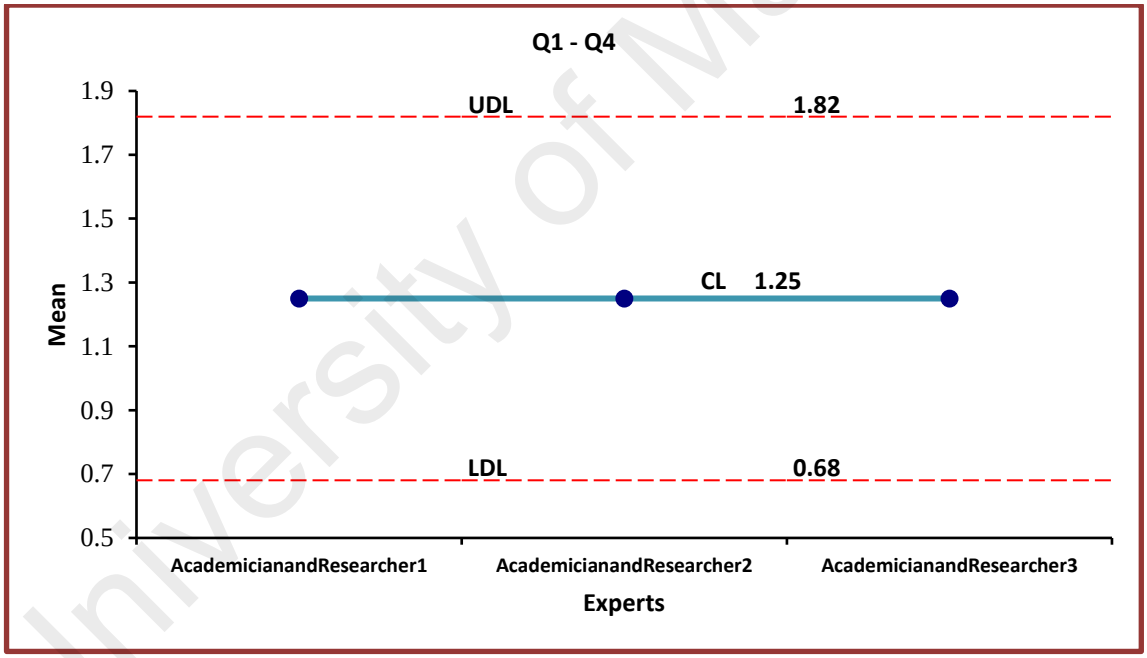

Figure 6. 5: ANOM plot for ‘Completeness’

Figure 6.5 shows that Upper Decision Line (UDL) is at 1.82, Lower Decision Line (LDL) is at .68 whereas Central Line (CL) representing mean of means is at 1.25. This can be observed from the Figure 6.5 that in case of all the three academicians and practitioners, means (all three at 1.25) fall inside the Upper Decision Line and Lower Decision Line limits. Thus it can be concluded that no individual mean differs from

overall mean and all respondents are inclined towards the completeness of the proposed model.

(b) ANOM for criterion of Practicality

Figure 6.6 shows ANOM plot for 'Practicality' criterion covering questions Q5, Q6 and Q7.

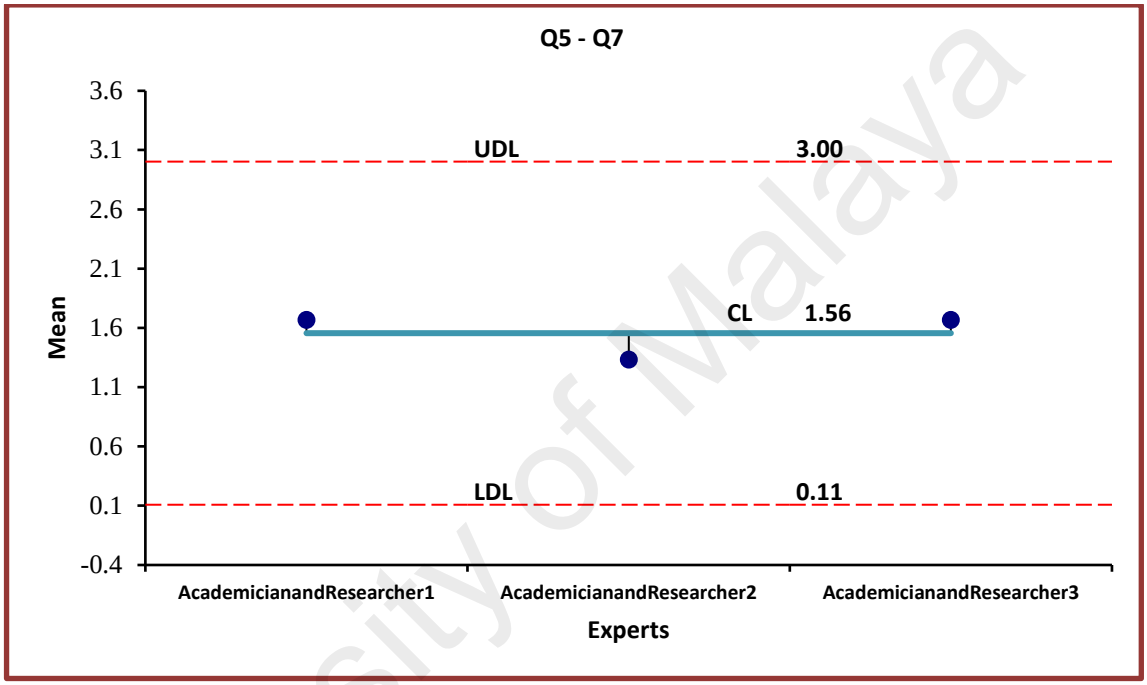

Figure 6. 6 : ANOM plot for 'Practicality'

Figure 6.6 shows that Upper Decision Line (UDL) is at 3.00, Lower Decision Line (LDL) is at .11 whereas Central Line (CL) representing mean of means is at 1.56. This can be observed from the Figure 6.6 that in case of all the three academicians and researchers, means fall within the Upper Decision Line and Lower Decision Line limits. Thus it can be concluded that no individual mean differs from overall mean and all respondents are inclined towards the practicality of the proposed model.

(c) ANOM for criterion of Usefulness

Figure 6.7 shows ANOM plot for 'Usefulness' criterion covering questions Q8, Q9 and Q10.

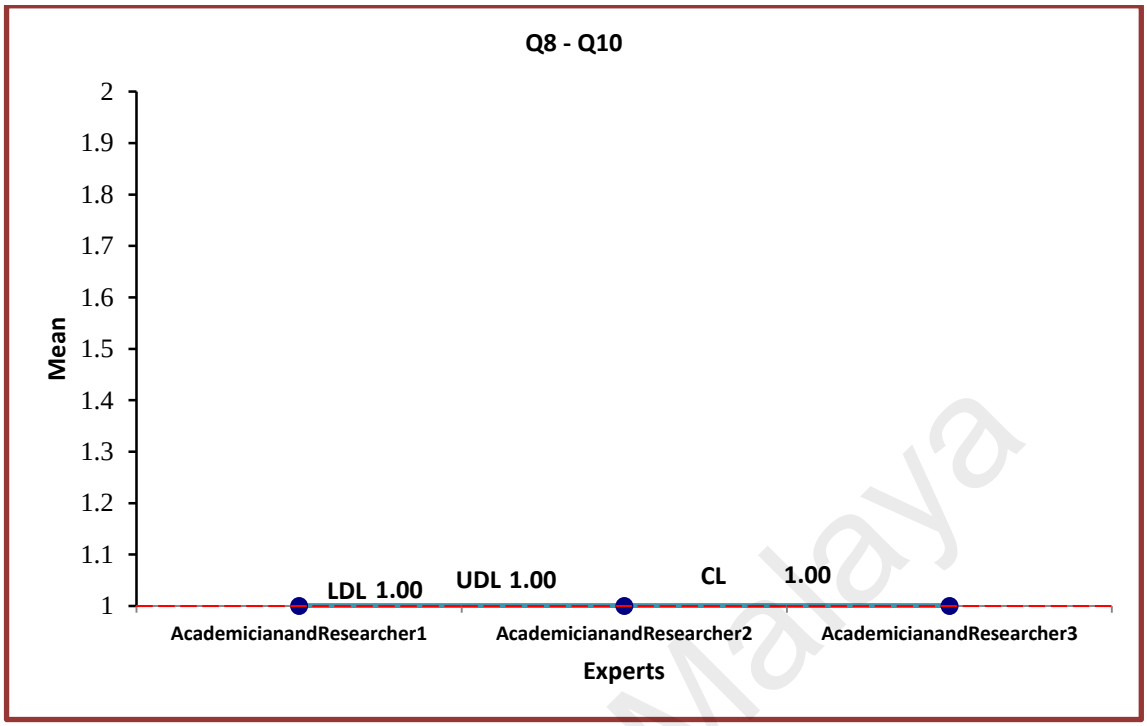

Figure 6. 7 : ANOM plot for 'Usefulness'

Figure 6.7 shows that Upper Decision Line (UDL) is at 1.00, Lower Decision Line (LDL) is also at 1.00 whereas Central Line (CL) representing mean of means is also at 1.00. This can be observed from the Figure 6.7 that in case of all the three academicians and researchers, means (all three at 1) fall inside the Upper Decision Line and Lower Decision Line limits. Thus it can be concluded that no individual mean differs from overall mean and all respondents are inclined towards the usefulness of the proposed model.

(d) Overall ANOM

Figure 6.8 shows overall ANOM plot covering questions Q1, Q2…, Q10.

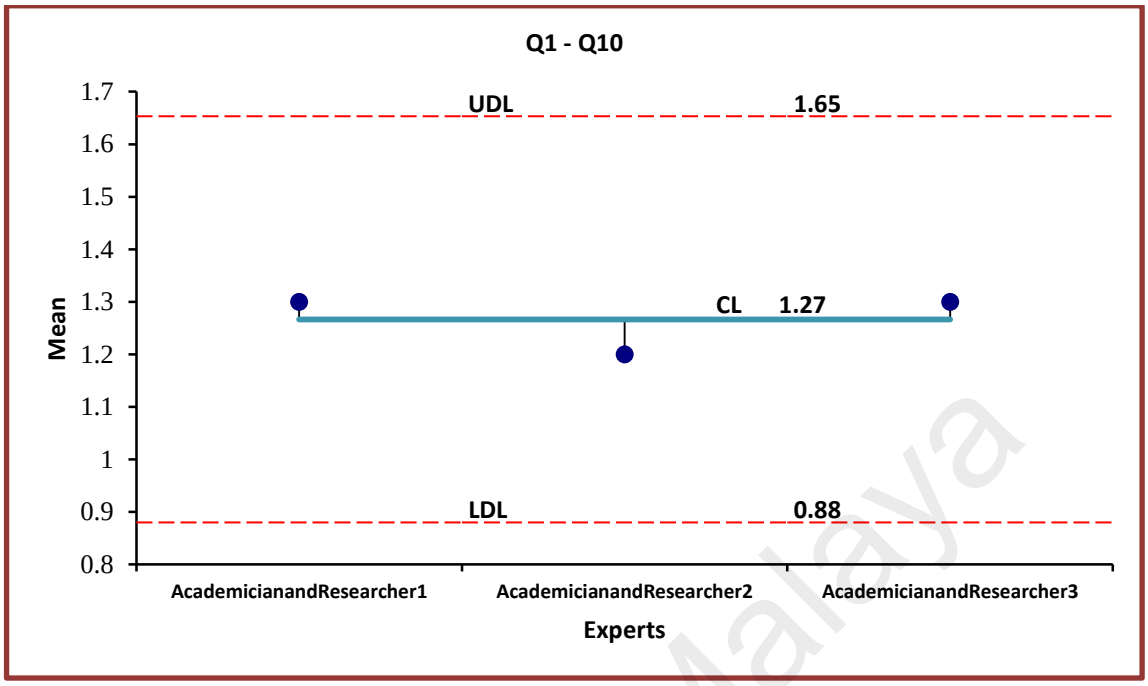

Figure 6. 8 : Combined ANOM plot

Figure 6.8 shows that Upper Decision Line (UDL) is at 1.65, Lower Decision Line (LDL) is at .88 whereas Central Line (CL) representing mean of means is at 1.27. This can be observed from the Figure 6.8 that in case of all the three academicians and researchers, means fall inside the Upper Decision Line and Lower Decision Line limits. Thus it can be concluded that no individual mean differs from overall mean and all respondents are inclined towards the completeness, practicality and usefulness of the proposed model.

6.1.3 The REP Model evaluation from the industrial perspective through SDO industry practitioners

For evaluation from the industry perspective, various studies employ different number of experienced professionals with industrial background. For example, five project managers have participated in the study (Vicinanza, Mukhopadhyay, & Prietula, 1991) as experts for estimation of the software projects' efforts whereas 6 field specialists have performed validation in study (Mathew, et al., 2011). In (Dyba, 2000), review has

been conducted by 11 SPI experts, similarly 11 professionals with field experience have been employed for validation in (Hyrkäs, Appelqvist-Schmidlechner, & Oksa, 2003), whereas 20 professionals with the industrial experience have performed validation in (Beecham, et al., 2005). During this research work, for the REP Model evaluation from the industrial perspective, a panel of 11 experienced SDO industry practitioners has been involved. Out of the 11 practitioners, 6 have SDO industry experience and also research background whereas remaining 5 practitioners have only industrial experience. Two practitioners have more than 15 years of experience whereas remaining 9 practitioners possess more than 10 years' experience. Table 6.10 provides details about the practitioners who have taken part in the REP Model industrial evaluation.

Table 6. 10 : Demographic information of SDO industry practitioners

Expert ID	Working Designation	Outsourcing Relevant Experience (Yeas)	Present Country of Working
Pract-1	Team Leader, Project Manager	More than 10 years	Canada
Pract-2	Team Leader	More than 10 years	United States of America
Pract-3	Senior Manager, Project Manager, Software Engineer, Requirements Engineer, Team Leader, Researcher	More than 15 years	Pakistan
Pract-4	Senior Manager, Project Manager.	More than 10 years	Sweden
Pract-5	Senior Manager, Software Engineer, Requirements Engineer, Researcher, Academician	More than 15 years	Germany
Pract-6	Project Manager, Software Engineer, Requirements Engineer, Team Leader, Researcher	More than 10 years	Pakistan
Pract-7	Senior Manager, Researcher, Academician	More than 10 years	United Kingdom
Pract-8	Senior Manager, Software Engineer, Researcher, Academician	More than 10 years	Canada
Pract-9	Project Manager	More than 10 years	Pakistan
Pract-10	Senior Manager, Researcher, Academician	More than 10 years	United Arab Emirates
Pract-11	Senior Manager, Project Manager, Software Engineer	More than 10 years	Pakistan

Figure 6.9 shows practitioners' present countries of working and country wise percentages.

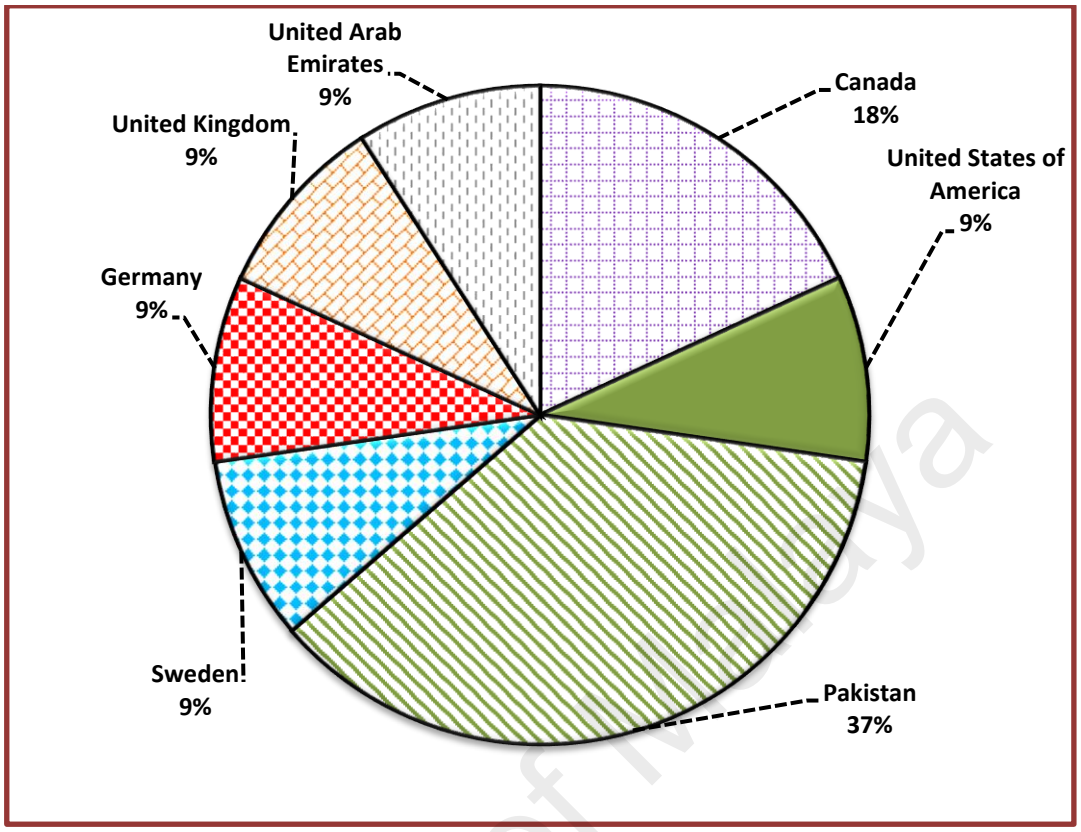

Figure 6. 9 : Countries of SDO practitioners and country wise percentages

6.1.3.1 Conducting the REP Model evaluation from the industrial perspective

For evaluation of the REP Model from the industrial perspective, a questionnaire survey (6^{th} questionnaire survey of the research work) has been conducted with the SDO industry practitioners. Guidelines provided in study (B. A. Kitchenham & Pfleeger, 2008) have been used to design and conduct the survey.

(a) Data Collection: The questionnaire, provided in Appendix A as questionnaire 6, has been used for the REP Model evaluation from SDO industry practitioners. The questionnaire and relevant guidelines for performing evaluation have been emailed to 11 (T) SDO practitioners. The survey has been conducted by using semi-supervised approach (Pfleeger & Kitchenham, 2001). Survey's objectives and respondents' queries have been made clear through Computer-Assisted Telephone Interviewing technique(Anie, et al., 1996).

(b) Questionnaire Format: The questionnaire contains two parts. The purpose of the first part is to collect data about the respondents' experience, job nature and respective organizations. The second part is for gathering data about the benefits of RE practices for addressing corresponding issues of RE process for SDO. To improve the questionnaire layout, assess the language comprehension and estimate the time required to complete the questionnaire, two rounds of pilot study have been conducted. Recommendations have been incorporated after the first round. The second round has been carried out to ensure that the changes made are according to the given suggestions.

The questionnaire includes closed-ended questions as well as open-ended questions. The closed-ended questions are to select ranks (out of the four given ranks) of the benefits of RE practices for addressing corresponding issues of RE process for SDO. The open-ended questions are intended to inquire from the respondents if they want to recommend the RE practices other than the given RE practices in the cases where recommended RE practices are considered inappropriate to address the corresponding issues.

Practitioners have been requested to rank, based on their intuition and experience, the benefits of the each set of RE practices to address corresponding issue in case of respective root cause. Four ranks or categories of perceived benefits are (Cox, et al., 2009; Niazi, et al., 2012):

i) ***High Perceived Benefits (H, 4)*:** The given set of RE practices is referred as having '**high perceived benefits'** if it can be **followed almost always** to address the corresponding issue in case of respective root cause.
ii) ***Medium Perceived Benefits (M, 3):*** The given set of RE practices is referred as having '**medium perceived benefits'** if it can be **followed often** to address the corresponding issue in case of respective root cause.

iii) ***Low Perceived Benefits (L, 2):*** The given set of RE practices is referred as having '**low perceived benefits'** if it can be **followed sometimes** to address the corresponding issue in case of respective root cause.

iv) ***Zero Perceived Benefits (Z, 1):*** The given set of RE practices is referred as having '**zero perceived benefits'** if it can be **followed rarely or never followed** to address the corresponding issue in case of respective root cause.

Practitioners have also been solicited to recommend other RE practice(s) if perceived benefits of a given set of RE practices do not fall in 'High Perceived Benefits' OR 'Medium Perceived Benefits' category**.**

(c) Sampling and population: The Convenience Sampling method has been employed for obtaining a valid sample of respondents. The 11 SDO industry practitioners having at least 10 years' experience have been identified for the REP Model evaluation from the industrial perspective. Demographic information of those SDO industry practitioners have been provided in Table 6.10. Figure 6.9 shows practitioners' present countries of working and country wise percentages.

(d) Responses: All the 11 SDO practitioners have ranked the benefits of the each set of RE practices for addressing corresponding issue in case of respective root cause.

6.1.3.2 Criterion for the REP Model evolution from the industrial perspective

The criterion for evaluation of the REP Model from the industrial perspective is 'usefulness of the recommended RE practice(s) to address the corresponding issue of the RE process for SDO in the case of the respective root cause'.

6.1.3.3 Results of REP Model evaluation from the industrial perspective

Table 6.11 shows results of the questionnaire survey for the REP Model evaluation from the industrial perspective. 'Assessed Ranks' column shows no. of the responses for High, Medium, Low and Zero benefits categories denoted by H, M, L and Z respectively.

Table 6. 11 : Results of questionnaire survey for REP Model evaluation from SDO industry practitioners

Communication Issues	Root Causes	RE Practices	No. of Valid Responses	Assessed Ranks				Case #
				H	M	L	Z	
I_1	RC_1	$P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}$	11	7	4	0	0	1
	RC_2	P_7, P_8, P_9, P_{10}	11	6	5	0	0	2
	RC_3	P_2, P_{18}, P_{73}	11	8	3	0	0	3
I_2	RC_4	$P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}$	11	8	3	0	0	4
	RC_5	$P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}$	11	2	9	0	0	5
I_3	RC_6	P_{26}, P_{27}	11	11	0	0	0	6
	RC_7	P_{28}	11	2	7	2	0	7
I_4	RC_8	P_1, P_2	11	10	1	0	0	8
	RC_2	P_7, P_8, P_9, P_{10}	11	10	1	0	0	9
	RC_9	$P_{18} P_{19}$	11	9	1	1	0	10
	RC_{10}	$P_{12}, P_{14}, P_{15}, P_{17}$	11	10	0	1	0	11
I_5	RC_8	P_1, P_2	11	8	3	0	0	12
	RC_{11}	P_3, P_6	11	8	3	0	0	13
	RC_{12}	P_4, P_5, P_6	11	1	10	0	0	14
	RC_2	P_7, P_8, P_9, P_{10}	11	6	5	0	0	15
I_6	$RC_{13}, RC_{14}, RC_{15}, RC_{16}, RC_{17}$	P_{21}	11	8	3	0	0	16
	RC_{18}	P_{70}, P_{20}	11	10	1	0	0	17
	RC_2	P_7, P_8, P_9, P_{10}	11	9	2	0	0	18
Management and coordination Issues	**Root Causes**	**RE Practices**	**No. of Valid Responses**	**H**	**M**	**L**	**Z**	**Case #**
I_7	RC_1	$P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}$	11	8	2	1	0	19
	RC_2	P_7, P_8, P_9, P_{10}	11	0	10	1	0	20
	RC_3	P_2, P_{18}, P_{73}	11	10	1	0	0	21
I_8	RC_{19}	P_{24}	11	7	4	0	0	22
	RC_{20}	$P_{22}, P_{23} P_{24}, P_{34}, P_{25}, P_{78}, P_{77}$	11	6	5	0	0	23
	RC_{21}	P_{22}, P_{23}	11	9	2	0	0	24
I_9	RC_{22}	$P_{22}, P_{23}, P_{24}, P_{34}$	11	9	2	0	0	25
	RC_{23}	P_{25}, P_{78}, P_{77}	11	7	4	0	0	26
I_{10}	RC_1	$P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}$	11	7	4	0	0	27
	RC_{24}	P_{59}	11	6	5	0	0	28
	RC_{25}	P_{68}	11	4	7	0	0	29
	RC_{26}	P_{69}	11	5	5	1	0	30
	RC_{27}	P_{118}	11	5	6	0	0	31
	RC_{28}	P_{120}	11	10	1	0	0	32
	RC_2	P_7, P_8, P_9, P_{10}	11	2	9	0	0	33
I_{11}	RC_{29}	$P_{45} P_{47} P_{48} P_{49} P_{50}, P_{56}, P_{74}, P_{75}, P_{41}$	11	7	4	0	0	34
Knowledge management and awareness Issues	**Root Causes**	**RE Practices**	**No. of Valid Responses**	**H**	**M**	**L**	**Z**	**Case #**
I_{12}	RC_{30}	P_{46}, P_{38}	11	11	0	0	0	35
	RC_{31}	P_{39}, P_{40}	11	10	1	0	0	36
	RC_{32}	P_{41}, P_{101}, P_{42}	11	2	9	0	0	37
	RC_{33}	P_{34}	11	6	4	1	0	38
	RC_{34}	$P_{41}, P_{101}, P_{42}, P_{22}$	11	8	3	0	0	39
I_{13}	RC_1	$P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}$	11	6	5	0	0	40
	$RC_{35}, RC_{36} RC_{37}$	P_{34}, P_{35}, P_{36}	11	5	6	0	0	41
	RC_{39}	P_{58}, P_{118}	11	3	8	0	0	43

Table 6.11, Continued

I_{15}	RC_{40}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}. P_{34}, P_{35}, P_{36}	11	7	4	0	0	44
	RC_{41}	P_{37} , P_{72} P_{71}, P_{36}	11	6	5	0	0	45
I_{16}	RC_{42}	P_{44}	11	5	6	0	0	46
	RC_{43}	P_{45}, P_{46}, P_{47}, P_{48}, P_{49}	11	10	1	0	0	47
	RC_{44}	P_{50}, P_{51} , P_{52}, P_{53} P_{54}, P_{55}, P_{56}	11	6	5	0	0	48
I_{17}	RC_{45}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} , P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{73}	11	4	7	0	0	49
	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} , P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	2	9	0	0	50
	RC_{46}	P_{46}, P_{38}, P_{39}, P_{40}, P_{41}, P_{101}, P_{42}, P_{34}, P_{22}. P_{43}	11	10	1	0	0	51
I_{18}	RC_{47}	P_{29} , P_{30}, P_{31}, P_{32} , P_{33}, P_6	11	6	5	0	0	52
Requirements centric Issues	**Root Causes**	**RE Practices**	**No. of Valid Responses**	**H**	**M**	**L**	**Z**	**Case #**
I_{19}	RC_{48},RC_{49}, RC_{50}, RC_{51}	P_{117} , P_{101}	11	6	5	0	0	53
	RC_7	P_{28}	11	5	6	0	0	54
I_{20}	RC_9	P_{18}, P_{19}	11	8	3	0	0	55
I_{21}	RC_{52}	P_{45},P_{57}, P_{100}, P_{58} , P_{118}	11	7	4	0	0	56
	RC_{53}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	11	6	5	0	0	57
	RC_{54}	P_{99}	11	1	1	9	0	58
I_{22}	RC_{55}	P_{19} ,P_{116}	11	3	8	0	0	59
I_{23}	RC_{52}	P_{45}, P_{57}, P_{100}, P_{58},P_{118}	11	6	5	0	0	60
	RC_{53}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	11	7	4	0	0	61
	RC_{54}	P_{99}	11	2	0	9	0	62
	RC_{56}	P_{50},P_{47}	11	9	2	0	0	63
	RC_{57}	P_{18}, P_{19}	11	10	1	0	0	64
	RC_{58}	P_{102}	11	7	4	0	0	65
	RC_{59}	P_{103}, P_{104}, P_{52}, P_{105}	11	3	8	0	0	66
	RC_{60}	P_{83}, P_{85}	11	2	9	0	0	67
	RC_{61}	P_{91}, P_{92} , P_{93} P_{94}, P_{98}	11	10	1	0	0	68
I_{24}	RC_{62}	P_{45}, P_{50}, P_{47}, P_{109}	11	9	2	0	0	69
	RC_{63}	P_{45}, P_{47}, P_{109}	11	8	3	0	0	70
	RC_{64}	P_{45}, P_{106} P_{107}, P_{108}, P_{74}, P_{75}	11	4	7	0	0	71
	RC_{60}	P_{83}, P_{85}	11	6	5	0	0	72
I_{25}	RC_{57}	P_{18}, P_{19}	11	5	6	0	0	73
	RC_{12}	P_4, P_5, P_6	11	9	2	0	0	74
	RC_{59}	P_{103}, P_{104}, P_{52}, P_{105}	11	11	0	0	0	75
	RC_{64}	P_{45}, P_{106}, P_{107}, P_{108}, P_{74}, P_{75}	11	1	10	0	0	76
I_{26}	RC_{65}	P_{110}	11	8	3	0	0	77
	RC_{66}	P_{68}, P_{111}	11	2	9	0	0	78
	RC_{25}	P_{68}	11	3	8	0	0	79
	RC_{67}	P_{112}, P_{113}, P_{114}, P_{115}	11	7	4	0	0	80
	RC_{43}	P_{45}, P_{46}, P_{47}, P_{48}, P_{49}	11	6	5	0	0	81
I_{27}	RC_{56}	P_{50}, P_{47}	11	5	6	0	0	82
	RC_{57}.	P_{18}, P_{19}	11	10	1	0	0	83
	RC_{53}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	11	2	9	0	0	84
	RC_{68}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	11	7	4	0	0	85
	RC_{58}	P_{102}	11	6	5	0	0	86
	RC_{59}	P_{103} ,P_{104},P_{52}, P_{105}	11	4	7	0	0	87
	RC_{64}	P_{45}, P_{106}, P_{107}, P_{108}, P_{74}, P_{75}	11	10	1	0	0	88
	RC_{60}	P_{83}, P_{85}	11	2	9	0	0	89

Table 6.11, Continued

Cultural diversities' Issues	Root Causes	RE Practices	No. of Valid Responses	H	M	L	Z	Case #
I_{28}	RC_{69}	P_{67}	11	5	5	1	0	90
I_{29}	RC_{11}	P_3, P_6	11	4	6	1	0	91
	RC_{70}	P_{50}, P_{47}, P_{52}, P_{89}, P_{90}, P_{60}, P_{54}, P_{53}	11	2	8	1	0	92
	RC_{39}	P_{58}, P_{118}	11	3	8	0	0	93
I_{30}	RC_5	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	4	6	1	0	94
	RC_{71}	P_1,P_2, P_{123}	11	3	7	1	0	95
	RC_4	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}	11	2	9	0	0	96
	RC_{11}	P_3, P_6	11	8	3	0	0	97
	RC_{72}	P_{61}, P_{62} ,P_{53}	11	10	1	0	0	98
	RC_{73}	P_{62} P_{64}	11	3	8	0	0	99
	RC_{74}	P_{63}	11	0	1	10	0	100
I_{31}	RC_{75}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} ,P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17},P_{123}, P_{53}, P_{61}, P_{62}, P_{63}, P_{64}	11	10	1	0	0	101
I_{32}	RC_{76}	P_{70}, P_{20}	11	6	5	0	0	102
	RC_{28}	P_{120}	11	7	4	0	0	103
	RC_{77}	P_4, P_5, P_6.P_{65}, P_{66}, P_{119}	11	9	2	0	0	104
	RC_2	P_7, P_8, P_9, P_{10}	11	4	7	0	0	105
	RC_{78}	P_{76}	11	6	5	0	0	106
Processes and tools' Issues	**Root Causes**	**RE Practices**	**No. of Valid Responses**	**H**	**M**	**L**	**Z**	**Case #**
I_{33}	RC_{79}	P_{82} , P_{81}	11	6	5	0	0	107
	RC_{74}	P_{63}	11	1	0	10	0	108
	RC_{80}	P_{121}	11	5	6	0	0	109
I_{34}	RC_{81}	P_{25}, P_{78}, P_{77}, P_{22}, P_{23}, P_{79}	11	7	4	0	0	110
	RC_{82}	P_{122}, P_{80}, P_{77},P_{81}	11	3	8	0	0	111
I_{35}	RC_{23}	P_{25}, P_{78}, P_{77}	11	6	5	0	0	112
	RC_{21}	P_{22}, P_{23}	11	5	6	0	0	113
	RC_{83}	P_{79}, P_{77}	11	10	1	0	0	114
I_{36}	RC_{23}	P_{25}, P_{78}, P_{77}	11	2	9	0	0	115
	RC_{84}	P_{77}	11	8	3	0	0	116
I_{37}	RC_{85}	P_{83}, P_{84}, P_{85}	11	8	3	0	0	117
	RC_{80}	P_{121}	11	6	5	0	0	118
Relationship among stakeholders' Issues	**Root Causes**	**RE Practices**	**No. of Valid Responses**	**H**	**M**	**L**	**Z**	**Case #**
I_{38}	RC_7	P_{28}	11	6	5	0	0	119
I_{39}	RC_{83}	P_{79}, P_{77}	11	3	8	0	0	120
	RC_{86}	P_{86}, P_{87} , P_{88} ,P_{124}	11	7	4	0	0	121
I_{40}	RC_{75}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} ,P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17} , P_{123}, P_{53}, P_{61}, P_{62}, P_{63}, P_{64}	11	6	5	0	0	122
	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} ,P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	9	2	0	0	123
	RC_5	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	10	1	0	0	124
	RC_{11}	P_3, P_6	11	3	8	0	0	125
	RC_{87}	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	2	9	0	0	126
	RC_{72}	P_{61}, P_{62}, P_{53}	11	9	2	0	0	127
I_{41}	RC_{24}	P_{59}	11	6	5	0	0	128
I_{42}	RC_{88}	P_{50} ,P_{52}, P_{53}, P_{54}, P_{89}, P_{60}	11	4	7	0	0	129
I_{43}	RC_{61}	P_{91},P_{92}, P_{93}, P_{94}, P_{98}	11	3	8	0	0	130
	RC_{18}	P_{70}, P_{20}	11	8	3	0	0	131
	RC_{89}	P_{95}, P_{96}, P_{97}	11	9	2	0	0	132

H=High, M=Medium, L=Low, Z=Zero

6.1.3.4 Measurement of Internal Consistency

To measure the internal consistency of scale, Reliability Analysis has been performed. The value of Cronbach Alpha as shown in Table 6.12 is .854. Value of Cronbach Alpha equal to .7 or higher is acceptable, greater than .8 is considered 'good' whereas greater than .9 indicates 'excellent' internal consistency (Gliem & Gliem, 2003; Santos, 1999).

Table 6. 12 : Reliability Statistics

Cronbach's Alpha	N of Items
.854	132

6.1.4 Rule of 50% to evaluate 'usefulness of the recommended RE practices'

In case of each SDO RE process issue, practitioners have been solicited to rank the matched set(s) of RE practices according to the perceived benefits of those RE practices' set(s) for addressing corresponding issue in case of respective root cause. As stated earlier in Section 6.1.3.1, perceived benefits of RE practices to address corresponding issues have been divided into four categories or ranks (Cox, et al., 2009; Niazi, et al., 2012): i) High Perceived Benefits (H), ii) Medium Perceived Benefits (M), iii) Low Perceived Benefits (L), and iv) Zero Perceived Benefits (Z). If according to the perception of 50% or more practitioners, the benefits of a recommended set of RE practices belong to 'High Perceived Benefits' and the 'Medium Perceived Benefits' categories then such set of RE practices is considered beneficial or useful for addressing the corresponding SDO RE process issue in case of respective root cause. The 50% rule has been successfully used in several studies (Cox, et al., 2009; Niazi, et al., 2005; Rainer & Hall, 2002).

The 50% rule has been used to judge the usefulness of RE practices and hence to evaluate the model as this criterion proves that such RE practices are being used by a

sufficient number of SDO practitioners or at least they recommend their usage for addressing corresponding SDO RE process issues. Therefore, such RE practices are really useful for addressing RE issues and hence must be included in the model. Thus model comprising of such RE practices would be useful for tackling the SDO RE process issues and worth using in the SDO industry.

To apply the 50% rule, percentages of responses for 'High Perceived Benefits' and 'Medium Perceived Benefits' categories should be calculated in case of each issue and each respective root cause. Prominence Level (PL) represents such percentages and is calculated in each case as:

PL= [(H+ M) / T] × 100.

6.1.4.1 Discussions and industrial evaluation results' analysis through 50% Rule

Table 6.13 shows responses for High, Medium, Low and Zero benefits categories denoted by H, M, L and Z respectively, and PL in case of each issue and respective root cause. According to 50% rule, at least 50 value of PL proves that the recommended set of RE practices is beneficial enough to address the corresponding issue in case of respective root cause. This can be observed from the Table 6.13 that out of 132 cases, only for 4 cases (case no. 58, 62,100 and 108) value of PL is less than 50. This shows that for these 4 cases, the recommended sets of RE practices are not beneficial enough to address the corresponding issues. For rest of the 128 cases (96.97%), PL value is greater than 50 indicating that for all such cases the recommended stets of RE practices meet the prominence criterion and hence are beneficial enough to address the corresponding issues of RE process for SDO in case of respective root causes. This reveals that for almost all the cases (97%), the RE Practices' sets recommended for addressing corresponding issues are considered effective by the SDO industry

practitioners. This also shows that the presented REP Model consists of only those RE Practices' sets that are really useful for tackling the SDO RE process issues. This helps us to deduce that the REP Model is applicable and feasible for addressing the RE issues encountered by the SDO practitioners.

Table 6. 13 : Industrial evaluation results' analysis through 50% rule

Communication Issues	Root Causes	RE Practices	Assessed Ranks				PL	Case #
			H	M	L	Z		
I_1	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P12, P13, P14, P15, P16, P17	7	4	0	0	100	1
	RC_2	P_7, P_8, P_9, P_{10}	6	5	0	0	100	2
	RC_3	P_2, P_{18}, P_{73}	8	3	0	0	100	3
I_2	RC_4	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}	8	3	0	0	100	4
	RC_5	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	2	9	0	0	100	5
I_3	RC_6	P_{26}, P_{27}	11	0	0	0	100	6
	RC_7	P_{28}	2	7	2	0	81.82	7
I_4	RC_8	P_1, P_2	10	1	0	0	100	8
	RC_2	P_7, P_8, P_9, P_{10}	10	1	0	0	100	9
	RC_9	P_{18} P_{19}	9	1	1	0	90.91	10
	RC_{10}	P_{12}, P_{14}, P_{15}, P_{17}	10	0	1	0	90.91	11
I_5	RC_8	P_1, P_2	8	3	0	0	100	12
	RC_{11}	P_3, P_6	8	3	0	0	100	13
	RC_{12}	P_4, P_5, P_6	1	10	0	0	100	14
	RC_2	P_7, P_8, P_9, P_{10}	6	5	0	0	100	15
I_6	RC_{13}, RC_{14}, RC_{15}, RC_{16}, RC_{17}	P_{21}	8	3	0	0	100	16
	RC_{18}	P_{70}, P_{20}	10	1	0	0	100	17
	RC_2	P_7, P_8, P_9, P_{10}	9	2	0	0	100	18
Management and coordination Issues	**Root Causes**	**RE Practices**	**H**	**M**	**L**	**Z**	**PL**	**Case #**
I_7	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	8	2	1	0	90.91	19
	RC_2	P_7, P_8, P_9, P_{10}	0	10	1	0	90.91	20
	RC_3	P_2, P_{18}, P_{73}	10	1	0	0	100	21
I_8	RC_{19}	P_{24}	7	4	0	0	100	22
	RC_{20}	P_{22}, P_{23} P_{24}, P_{34}, P_{25}, P_{78}, P_{77}	6	5	0	0	100	23
	RC_{21}	P_{22}, P_{23}	9	2	0	0	100	24
I_9	RC_{22}	P_{22}, P_{23}, P_{24}, P_{34}	9	2	0	0	100	25
	RC_{23}	P_{25}, P_{78}, P_{77}	7	4	0	0	100	26
I_{10}	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	7	4	0	0	100	27
	RC_{24}	P_{59}	6	5	0	0	100	28
	RC_{25}	P_{68}	4	7	0	0	100	29
	RC_{26}	P_{69}	5	5	1	0	90.91	30
	RC_{27}	P_{118}	5	6	0	0	100	31
	RC_{28}	P_{120}	10	1	0	0	100	32
	RC_2	P_7, P_8, P_9, P_{10}	2	9	0	0	100	33
I_{11}	RC_{29}	P_{45} P_{47} P_{48} P_{49} P_{50}, P_{56}, P_{74}, P_{75}, P_{41}	7	4	0	0	100	34

Table 6.13, Continued

Knowledge management and awareness Issues	Root Causes	RE Practices	H	M	L	Z	PL	Case #
I_{12}	RC_{30}	P_{46}, P_{38}	11	0	0	0	100	35
	RC_{31}	P_{39} , P_{40}	10	1	0	0	100	36
	RC_{32}	P_{41}, P_{101} , P_{42}	2	9	0	0	100	37
	RC_{33}	P_{34}	6	4	1	0	90.91	38
	RC_{34}	P_{41}, P_{101} , P_{42}, P_{22}	8	3	0	0	100	39
I_{13}	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	6	5	0	0	100	40
	RC_{35} ,RC_{36} RC_{37}	P_{34}, P_{35}, P_{36}	5	6	0	0	100	41
I_{14}	RC_{38}	P_{45} , P_{57} , P_{100}	9	2	0	0	100	42
	RC_{39}	P_{58}, P_{118}	3	8	0	0	100	43
I_{15}	RC_{40}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} , P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}. P_{34}, P_{35}, P_{36}	7	4	0	0	100	44
	RC_{41}	P_{37} , P_{72} P_{71}, P_{36}	6	5	0	0	100	45
I_{16}	RC_{42}	P_{44}	5	6	0	0	100	46
	RC_{43}	P_{45}, P_{46}, P_{47}, P_{48}, P_{49}	10	1	0	0	100	47
	RC_{44}	P_{50}, P_{51} ,P_{52}, P_{53} P_{54}, P_{55}, P_{56}	6	5	0	0	100	48
I_{17}	RC_{45}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} ,P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{73}	4	7	0	0	100	49
	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} ,P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	2	9	0	0	100	50
	RC_{46}	P_{46}, P_{38}, P_{39}, P_{40}, P_{41}, P_{101}, P_{42}, P_{34}, P_{22}. P_{43}	10	1	0	0	100	51
I_{18}	RC_{47}	P_{29} , P_{30}, P_{31}, P_{32} , P_{33}, P_6	6	5	0	0	100	52
Requirements centric Issues	**Root Causes**	**RE Practices**	**H**	**M**	**L**	**Z**	**PL**	**Case #**
I_{19}	RC_{48},RC_{49}, RC_{50}, RC_{51}	P_{117} , P_{101}	6	5	0	0	100	53
	RC_7	P_{28}	5	6	0	0	100	54
I_{20}	RC_9	P_{18}, P_{19}	8	3	0	0	100	55
I_{21}	RC_{52}	P_{45},P_{57}, P_{100}, P_{58} , P_{118}	7	4	0	0	100	56
	RC_{53}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	6	5	0	0	100	57
	RC_{54}	P_{99}	1	1	9	0	18.18	58
I_{22}	RC_{55}	P_{19} ,P_{116}	3	8	0	0	100	59
I_{23}	RC_{52}	P_{45}, P_{57}, P_{100}, P_{58},P_{118}	6	5	0	0	100	60
	RC_{53}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	7	4	0	0	100	61
	RC_{54}	P_{99}	2	0	9	0	18.18	62
	RC_{56}	P_{50},P_{47}	9	2	0	0	100	63
	RC_{57}.	P_{18}, P_{19}	10	1	0	0	100	64
	RC_{58}	P_{102}	7	4	0	0	100	65
	RC_{59}	P_{103}, P_{104}, P_{52}, P_{105}	3	8	0	0	100	66
	RC_{60}	P_{83}, P_{85}	2	9	0	0	100	67
	RC_{61}	P_{91}, P_{92} , P_{93} P_{94}, P_{98}	10	1	0	0	100	68
I_{24}	RC62	P_{45}, P_{50}, P_{47}, P_{109}	9	2	0	0	100	69
	RC63	P45, P47, P109	8	3	0	0	100	70
	RC64	P_{45}, P_{106} P_{107}, P_{108}, P_{74}, P_{75}	4	7	0	0	100	71
	RC60	P_{83}, P_{85}	6	5	0	0	100	72
I_{25}	RC_{57}	P_{18}, P_{19}	5	6	0	0	100	73
	RC_{12}	P_4, P_5, P_6	9	2	0	0	100	74
	RC_{59}	P_{103}, P_{104}, P_{52}, P_{105}	11	0	0	0	100	75
	RC_{64}	P_{45}, P_{106}, P_{107}, P_{108}, P_{74}, P_{75}	1	10	0	0	100	76

Table 6.13, Continued

I_{26}	RC_{65}	P_{110}	8	3	0	0	100	77
	RC_{66}	P_{68}, P_{111}	2	9	0	0	100	78
	RC_{25}	P_{68}	3	8	0	0	100	79
	RC_{67}	$P_{112,}$ $P_{113,}$ $P_{114,}$ P_{115}	7	4	0	0	100	80
	RC_{43}	P_{45}, P_{46}, P_{47}, P_{48}, P_{49}	6	5	0	0	100	81
I_{27}	RC_{56}	P_{50}, P_{47}	5	6	0	0	100	82
	RC_{57}.	P_{18}, P_{19}	10	1	0	0	100	83
	RC_{53}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	2	9	0	0	100	84
	RC_{68}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	7	4	0	0	100	85
	RC_{58}	P_{102}	6	5	0	0	100	86
	RC_{59}	P_{103} ,P_{104},P_{52}, P_{105}	4	7	0	0	100	87
	RC_{64}	P_{45}, P_{106}, P_{107}, P_{108}, P_{74}, P_{75}	10	1	0	0	100	88
	RC_{60}	P_{83}, P_{85}	2	9	0	0	100	89
Cultural diversities' Issues	**Root Causes**	**RE Practices**	**H**	**M**	**L**	**Z**	**PL**	**Case #**
I_{28}	RC_{69}	P_{67}	5	5	1	0	90.91	90
I_{29}	RC_{11}	P_{3}, P_{6}	4	6	1	0	90.91	91
	RC_{70}	P_{50}, P_{47}, P_{52}, $P_{89,}$ $P_{90,}$ $P_{60,}$ P_{54}, P_{53}	2	8	1	0	90.91	92
	RC_{39}	P_{58}, P_{118}	3	8	0	0	100	93
I_{30}	RC_{5}	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	4	6	1	0	90.91	94
	RC_{71}	P_{1},$P_{2,}$ P_{123}	3	7	1	0	90.91	95
	RC_{4}	P_{1}, P_{2}, P_{3}, P_{4}, P_{5}, P_{6}, P_{7}, P_{8}, P_{9}, P_{10}	2	9	0	0	100	96
	RC_{11}	P_{3}, P_{6}	8	3	0	0	100	97
	RC_{72}	$P_{61,}$ P_{62} ,P_{53}	10	1	0	0	100	98
	RC_{73}	P_{62} P_{64}	3	8	0	0	100	99
	RC_{74}	P_{63}	0	1	10	0	9.09	100
I_{31}	RC_{75}	P_{1}, P_{2}, P_{3}, P_{4}, P_{5}, P_{6}, P_{7}, P_{8}, P_{9}, P_{10} ,P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17},P_{123}, P_{53}, P_{61}, P_{62}, P_{63}, P_{64}	10	1	0	0	100	101
I_{32}	RC_{76}	P_{70}, P_{20}	6	5	0	0	100	102
	RC_{28}	P_{120}	7	4	0	0	100	103
	RC_{77}	P_{4}, P_{5}, P_{6}.$P_{65,}$ $P_{66,}$ P_{119}	9	2	0	0	100	104
	RC_{2}	P_{7}, P_{8}, P_{9}, P_{10}	4	7	0	0	100	105
	RC_{78}	P_{76}	6	5	0	0	100	106
Processes and tools' Issues	**Root Causes**	**RE Practices**	**H**	**M**	**L**	**Z**	**PL**	**Case #**
I_{33}	RC_{79}	P_{82} , P_{81}	6	5	0	0	100	107
	RC_{74}	P_{63}	1	0	10	0	9.09	108
	RC_{80}	P_{121}	5	6	0	0	100	109
I_{34}	RC_{81}	P_{25}, P_{78}, P_{77}, P_{22}, P_{23}, P_{79}	7	4	0	0	100	110
	RC_{82}	$P_{122,}$ P_{80}, P_{77},P_{81}	3	8	0	0	100	111
I_{35}	RC_{23}	P_{25}, P_{78}, P_{77}	6	5	0	0	100	112
	RC_{21}	P_{22}, P_{23}	5	6	0	0	100	113
	RC_{83}	P_{79}, P_{77}	10	1	0	0	100	114
I_{36}	RC_{23}	$P_{25,}$ P_{78}, P_{77}	2	9	0	0	100	115
	RC_{84}	P_{77}	8	3	0	0	100	116
I_{37}	RC_{85}	$P_{83,}$ $P_{84,}$ P_{85}	8	3	0	0	100	117
	RC_{80}	P_{121}	6	5	0	0	100	118
Relationship among stakeholders' Issues	**Root Causes**	**RE Practices**	**H**	**M**	**L**	**Z**	**PL**	**Case #**
I_{38}	RC_{7}	P_{28}	6	5	0	0	100	119
I_{39}	RC_{83}	$P_{79,}$ P_{77}	3	8	0	0	100	120
	RC_{86}	$P_{86,}$ P_{87} , P_{88} ,P_{124}	7	4	0	0	100	121

Table 6.13, Continued

I_{40}	RC_{75}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{123}, P_{53}, P_{61}, P_{62}, P_{63}, P_{64}	6	5	0	0	100	122
	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	9	2	0	0	100	123
	RC_5	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	10	1	0	0	100	124
	RC_{11}	P_3, P_6	3	8	0	0	100	125
	RC_{87}	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	2	9	0	0	100	126
	RC_{72}	P_{61}, P_{62}, P_{53}	9	2	0	0	100	127
I_{41}	RC_{24}	P_{59}	6	5	0	0	100	128
I_{42}	RC_{88}	P_{50} ,P_{52}, P_{53}, P_{54}, P_{89}, P_{60}	4	7	0	0	100	129
I_{43}	RC_{61}	P_{91},P_{92}, P_{93}, P_{94}, P_{98}	3	8	0	0	100	130
	RC_{18}	P_{70}, P_{20}	8	3	0	0	100	131
	RC_{89}	P_{95}, P_{96}, P_{97}	9	2	0	0	100	132

H=High, M=Medium, L=Low, Z=Zero, PL= Prominence Level

6.1.5 Discussions and industrial evaluation results' analysis through Content Validity Index (CVI)

Content Validity Index (CVI) measures the degree to which an instrument or scale has an appropriate sample or set of items to represent the construct of interest (Polit & Beck, 2004, 2006; Polit, Beck, & Owen, 2007). The maximum value of CVI is 1 (Polit & Beck, 2004; Polit, et al., 2007). In this research work, CVI has been calculated to know or evaluate that up to which degree the REP Model has appropriate set of RE practices to address the corresponding issues in case of respective root causes. For this purpose, CVIs have been calculated for each case, at each category level and at the model level. Two types of CVIs are computed (Lynn, 1986; Polit & Beck, 2006). The first type deals with content validity of individual items and is called Item-level Content Validity Index (I-CVI) whereas second type deals with overall content validity and is called Scale-level Content Validity Index(S-CVI) (Lynn, 1986; Polit & Beck, 2006).

CVI computation is based on the number of those ratings or response values in case of which experts agree to choose ratings showing comparatively higher relevancy or beneficialness. Number of such ratings or response values may be called as 'Number of responses in agreement' or in other words number of ratings or responses having value

3 or 4 is called 'Number of responses in agreement' (Polit & Beck, 2006) as typically a four-point Likert Scale is used for rating (Waltz & Bausell, 1981) although 3 or 5 point-scales might also be used. A frequently used four-point scale is (Davis, 1992): i) Not Relevant (1), ii) Somewhat Relevant (2), iii) Quite Relevant (3), and iv) Highly Relevant (4). With this scale, ratings having value 3(Quite Relevant) or 4(Quite Relevant) are considered for computing CVI.

As mentioned in Section 6.1.3.1, this research work uses four-point Likert Scale for evaluation of the REP Model from the industry practitioners. The four categories of perceived benefits are: i) High (H, 4), ii) Medium (M, 3), iii) Low (L, 2), and iv) Zero (Z, 1). The number of responses in case of which 'Medium' or 'High' categories have been selected by the practitioners are called 'Number of responses in agreement' in case of each issue and respective root cause. This 'Number of responses in agreement' is used for computing CVI.

To calculate CVI, a panel of at least three experts is required for evaluation (Lynn, 1986). For six or more experts acceptable value of I-CVI is at least .78 (Lynn, 1986; Polit & Beck, 2006). The minimum acceptable value of S-CVI is .80 (Davis, 1992; Polit & Beck, 2004).

I-CVI is calculated in each case by dividing the 'Number of responses in agreement' by 'Number of valid responses' (Polit & Beck, 2006). A type of S-CVI is S-CVI/Ave (Ave stands for Average) which can be calculated in three different ways (Polit & Beck, 2006):

i) By finding 'Proportion of responses in agreement' in case of each expert and then averaging all of them.

ii) By finding average of I-CVIs.

iii) By finding 'Proportion of the total number of responses in agreement' by dividing 'Total number of responses in agreement' by the 'Total no. of valid responses'.

In this research work S-CVI has been calculated by using options (ii) and (iii).

6.1.5.1 Analysis of responses about communication issues through CVI

Number of valid responses and 'Number of responses in agreement' for each communication issue and each respective root cause can be extracted from Table 6.11. Table 6.14 shows results.

Table 6. 14 : Based on industrial evaluation, number of valid and 'in agreement' responses for communication issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses	No. of Responses In Agreement	I-CVI	Case #
I_1	RC_1	$P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}$	11	11	11/11=1	1
	RC_2	P_7, P_8, P_9, P_{10}	11	11	11/11=1	2
	RC_3	P_2, P_{18}, P_{73}	11	11	11/11=1	3
I_2	RC_4	$P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}$.	11	11	11/11=1	4
	RC_5	$P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}$	11	11	11/11=1	5
I_3	RC_6	P_{26}, P_{27}	11	11	11/11=1	6
	RC_7	P_{28}	11	9	9/11= .82	7
I_4	RC_8	P_1, P_2	11	11	11/11=1	8
	RC_2	P_7, P_8, P_9, P_{10}.	11	11	11/11=1	9
	RC_9	$P_{18} P_{19}$	11	10	10/11=.91	10
	RC_{10}	$P_{12}, P_{14}, P_{15}, P_{17}$	11	10	10/11=.91	11
I_5	RC_8	P_1, P_2	11	11	11/11=1	12
	RC_{11}	P_3, P_6	11	11	11/11=1	13
	RC_{12}	P_4, P_5, P_6	11	11	11/11=1	14
	RC_2	P_7, P_8, P_9, P_{10}	11	11	11/11=1	15
I_6	$RC_{13}, C_{14}, RC_{15}, RC_{16}, RC_{17}$	P_{21}	11	11	11/11=1	16
	RC_{18}	P_{70}, P_{20}	11	11	11/11=1	17
	RC_2	P_7, P_8, P_9, P_{10}	11	11	11/11=1	18
Total			**198**	**194**	**17.64**	**18**
S-CVI/Ave				**194/198 =.98**	**17.64/18= .98**	

CVI= Item-level Content Validity Index, S-CVI/Ave= Scale-level Content Validity Index, Ave= Average

This can be observed from the Table 6.14 that I-CVI is greater than .78 in all the 18 cases. This proves that for all the 18 cases, the recommended RE practices are beneficial enough to address the corresponding communication issues of RE process for SDO and hence must be included in the model. Similarly S-CVI, computed by two ways, is

greater than .80. This shows that, on average, the recommended RE practices in case of communication issues are beneficial enough for addressing the corresponding issues.

6.1.5.2 Analysis of responses about management and coordination issues through CVI

Number of valid responses and 'number of responses in agreement' for each management and coordination issue, and each respective root cause can be extracted from Table 6.11. Table 6.15 shows results.

Table 6. 15 : Based on industrial evaluation, number of valid and 'in agreement' responses for management and coordination issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses	No. of Responses In Agreement	I-CVI	Case #
I_7	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	10	.91	19
	RC_2	P_7, P_8, P_9, P_{10}	11	10	.91	20
	RC_3	P_2, P_{18}, P_{73}	11	11	1	21
I_8	RC_{19}	P_{24}	11	11	1	22
	RC_{20}	P_{22} , P_{23} P_{24},P_{34}, P_{25} , P_{78} , P_{77}	11	11	1	23
	RC_{21}	P_{22}, P_{23}	11	11	1	24
I_9	RC_{22}	P_{22}, P_{23}, P_{24}, P_{34}	11	11	1	25
	RC_{23}	P_{25}, P_{78}, P_{77}	11	11	1	26
I_{10}	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	11	1	27
	RC_{24}	P_{59}	11	11	1	28
	RC_{25}	P_{68}	11	11	1	29
	RC_{26}	P_{69}	11	10	.91	30
	RC_{27}	P_{118}	11	11	1	31
	RC_{28}	P_{120}	11	11	1	32
	RC_2	P_7, P_8, P_9, P_{10}	11	11	1	33
I_{11}	RC_{29}	P_{45} P_{47} P_{48} P_{49} P_{50} ,P_{56} ,P_{74} , P_{75}, P_{41}	11	11	1	34
Total			**176**	**173**	**15.73**	**16**
S-CVI/Ave				**173/176=.98**	**15.73/16=.98**	

CVI= Item-level Content Validity Index, S-CVI/Ave= Scale-level Content Validity Index, Ave= Average

This can be observed from the Table 6.15 that I-CVI is greater than .78 in all the 16 cases. This proves that for all the 16 cases, the recommended RE practices are beneficial enough to address the corresponding management and coordination issues of RE process for SDO and hence must be included in the model. Similarly S-CVI, computed

by two ways, is greater than .80. This shows that, on average, the recommended RE practices in case of management and coordination issues are beneficial enough for addressing the corresponding issues.

6.1.5.3 Analysis of responses about knowledge management and awareness issues through CVI

Number of valid responses and 'number of responses in agreement' for each knowledge management and awareness issue, and each respective root cause can be extracted from Table 6.11. Table 6.16 shows results.

Table 6. 16 : Based on industrial evaluation, number of valid and 'in agreement' responses for knowledge management and awareness issues

Issue ID	Root Cause	RE Practices	No. of Valid Responses	No. of Responses In Agreement	I-CVI	Case #
I_{12}	RC_{30}	P_{46}, P_{38}	11	11	1	35
	RC_{31}	P_{39} , P_{40}	11	11	1	36
	RC_{32}	P_{41}, P_{101} , P_{42}	11	11	1	37
	RC_{33}	P_{34}	11	10	.91	38
	RC_{34}	P_{41}, P_{101}, P_{42}, P_{22}	11	11	1	39
I_{13}	RC_{1}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} , P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	11	1	40
	RC_{35} ,RC_{36} RC_{37}	P_{34}, P_{35}, P_{36}	11	11	1	41
I_{14}	RC_{38}	P_{45} , P_{57} , P_{100}	11	11	1	42
	RC_{39}	P_{58}, P_{118}	11	11	1	43
I_{15}	RC_{40}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}. P_{34}, P_{35}, P_{36}	11	11	1	44
	RC_{41}	P_{37}, P_{72} P_{71}, P_{36}	11	11	1	45
I_{16}	RC_{42}	P_{44}	11	11	1	46
	RC_{43}	P_{45}, P_{46}, P_{47}, P_{48}, P_{49}	11	11	1	47
	RC_{44}	P_{50}, P_{51} ,P_{52}, P_{53},P_{54}, P_{55}, P_{56}	11	11	1	48
I_{17}	RC_{45}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10},P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{73}	11	11	1	49
	RC_{1}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	11	1	50
	RC_{46}	P_{46}, P_{38}, P_{39}, P_{40}, P_{41}, P_{101}, P_{42}, P_{34}, P_{22}, P_{43}	11	11	1	51
I_{18}	RC_{47}	P_{29}, P_{30}, P_{31}, P_{32}, P_{33}, P_6	11	11	1	52
Total			**198**	**197**	**17.91**	**18**
S-CVI/Ave				**197/198=.99**	**17.91/18=.99**	

CVI= Item-level Content Validity Index, S-CVI/Ave= Scale-level Content Validity Index, Ave= Average

This can be observed from the Table 6.16 that I-CVI is greater than .78 in all the 18 cases. This proves that for all the 18 cases, the recommended RE practices are beneficial enough to address the corresponding knowledge management and awareness issues of RE process for SDO and hence must be included in the model. Similarly S-CVI, computed by two ways, is greater than .80. This shows that, on average, the recommended RE practices in case of knowledge management and awareness issues are beneficial enough for addressing the corresponding issues.

6.1.5.4 Analysis of responses about requirements centric issues through CVI

Number of valid responses and 'number of responses in agreement' for each requirements centric issue and each respective root cause can be extracted from Table 6.11. Table 6.17 shows results.

Table 6. 17 : Based on industrial evaluation, number of valid and 'in agreement' responses for requirements centric issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses	No. of Responses In Agreement	I-CVI	Case #
I_{19}	RC_{48},RC_{49}, RC_{50}, RC_{51}	P_{117}, P_{101}	11	11	1	53
	RC_{7}	P_{28}	11	11	1	54
I_{20}	RC_{9}	P_{18}, P_{19}	11	11	1	55
I_{21}	RC_{52}	P_{45},P_{57}, P_{100}, P_{58} , P_{118}	11	11	1	56
	RC_{53}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	11	11	1	57
	RC_{54}	P_{99}	11	2	.18	58
I_{22}	RC_{55}	P_{19} ,P_{116}	11	11	1	59
I_{23}	RC_{52}	P_{45}, P_{57}, P_{100}, P_{58},P_{118}	11	11	1	60
	RC_{53}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	11	11	1	61
	RC_{54}	P_{99}	11	2	.18	62
	RC_{56}	P_{50},P_{47}	11	11	1	63
	RC_{57}	P_{18}, P_{19}	11	11	1	64
	RC_{58}	P_{102}	11	11	1	65
	RC_{59}	P_{103}, P_{104}, P_{52}, P_{105}	11	11	1	66
	RC_{60}	P_{83}, P_{85}	11	11	1	67
	RC_{61}	P_{91}, P_{92}, P_{93} P_{94}, P_{98}	11	11	1	68
I_{24}	RC_{62}	P_{45}, P_{50}, P_{47}, P_{109}	11	11	1	69
	RC_{63}	P_{45}, P_{47}, P_{109}	11	11	1	70
	RC_{64}	P_{45}, P_{106} P_{107}, P_{108}, P_{74}, P_{75}	11	11	1	71
	RC_{60}	P_{83}, P_{85}	11	11	1	72

Table 6.17, Continued

Issue ID	Root Causes	RE Practices	No. of Valid Responses	No. of Responses In Agreement	I-CVI	Case #
I_{25}	RC_{57}	P_{18}, P_{19}	11	11	1	73
	RC_{12}	P_4, P_5, P_6	11	11	1	74
	RC_{59}	P_{103}, P_{104}, P_{52}, P_{105}	11	11	1	75
	RC_{64}	P_{45}, P_{106}, P_{107}, P_{108}, P_{74}, P_{75}	11	11	1	76
I_{26}	RC_{65}	P_{110}	11	11	1	77
	RC_{66}	P_{68}, P_{111}	11	11	1	78
	RC_{25}	P_{68}	11	11	1	79
	RC_{67}	P_{112}, P_{113}, P_{114}, P_{115}	11	11	1	80
	RC_{43}	P_{45}, P_{46}, P_{47}, P_{48}, P_{49}	11	11	1	81
I_{27}	RC_{56}	P_{50}, P_{47}	11	11	1	82
	RC_{57}	P_{18}, P_{19}	11	11	1	83
	RC_{53}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	11	11	1	84
	RC_{68}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	11	11	1	85
	RC_{58}	P_{102}	11	11	1	86
	RC_{59}	P_{103} ,P_{104},P_{52}, P_{105}	11	11	1	87
	RC_{64}	P_{45}, P_{106}, P_{107}, P_{108}, P_{74}, P_{75}	11	11	1	88
	RC_{60}	P_{83}, P_{85}	11	11	1	89
Total			**407**	**389**	**35.36**	**37**
S-CVI/Ave				**389/407=.96**	**35.36/37=.96**	

CVI= Item-level Content Validity Index, S-CVI/Ave= Scale-level Content Validity Index, Ave= Average

This can be observed from the Table 6.17 that out of the 37 cases, I-CVI is greater than .78 for 35 cases. For two cases which are case no. 58 and case no. 62, I-CVI is less than .78. This proves that except case no. 58 and 62, for all the other cases recommended RE practices are beneficial enough to address the corresponding requirements centric issues of RE process for SDO and hence must be included in the model. Cases no. 58 and 62 require other RE practices to address corresponding issues. S-CVI, computed by two ways, is greater than .80. This shows that, on average, the recommended RE practices in case of requirements centric issues are beneficial enough for addressing corresponding issues.

6.1.5.5 Analysis of responses about cultural diversities' issues through CVI

Number of valid responses and 'number of responses in agreement' for each issue about cultural diversities, and each respective root cause can be extracted from Table 6.11. Table 6.18 shows results.

Table 6. 18 : Based on industrial evaluation, number of valid and 'in agreement' responses for cultural diversities' issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses	No. of Responses In Agreement	I-CVI	Case #
I_{28}	RC_{69}	P_{67}	11	10	.91	90
I_{29}	RC_{11}	P_3, P_6	11	10	.91	91
	RC_{70}	P_{50}, P_{47}, P_{52}, P_{89}, P_{90}, P_{60}, P_{54}, P_{53}	11	10	.91	92
	RC_{39}	P_{58}, P_{118}	11	11	1	93
I_{30}	RC_5	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	10	.91	94
	RC_{71}	P_1,P_2, P_{123}	11	10	.91	95
	RC_4	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}	11	11	1	96
	RC_{11}	P_3, P_6	11	11	1	97
	RC_{72}	P_{61}, P_{62} ,P_{53}	11	11	1	98
	RC_{73}	P_{62} P_{64}	11	11	1	99
	RC_{74}	P_{63}	11	1	.09	100
I_{31}	RC_{75}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{16},P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{123}, P_{53}, P_{61}, P_{62}, P_{63}, P_{64}	11	11	1	101
I_{32}	RC_{76}	P_{70}, P_{20}	11	11	1	102
	RC_{28}	P_{120}	11	11	1	103
	RC_{77}	P_4, P_5, P_6.P_{65}, P_{66}, P_{119}	11	11	1	104
	RC_2	P_7, P_8, P_9, P_{10}	11	11	1	105
	RC_{78}	P_{76}	11	11	1	106
Total			**187**	**172**	**15.64/17=.92**	**17**
S-CVI/Ave				**172/187=.92**		

CVI= Item-level Content Validity Index, S-CVI/Ave= Scale-level Content Validity Index, Ave= Average

This can be observed from the Table 6.18 that out of the 17 cases, I-CVI is greater than .78 for 16 cases. For one case which is case no. 100, I-CVI is less than .78. This proves that except case no. 100 for all the other cases, the recommended RE practices are beneficial enough to address the corresponding cultural diversities' issues of RE process for SDO and hence must be included in the model. Case no. 100 requires other RE practices to address corresponding issue. S-CVI, computed by two ways, is greater than .80. This shows that, on average, the recommended RE practices in case of cultural diversities' issues are beneficial enough for addressing corresponding issues.

6.1.5.6 Analysis of responses about processes and tools' issues through CVI

Number of valid responses and 'number of responses in agreement' for each issue about processes and tools, and each respective root cause can be extracted from Table 6.11. Table 6.19 shows results.

Table 6. 19 : Based on industrial evaluation, number of valid and 'in agreement' responses for processes and tools' issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses	No. of Responses In Agreement	I-CVI	Case #
I_{33}	RC_{79}	P_{82}, P_{81}	11	11	1	107
	RC_{74}	P_{63}	11	1	.09	108
	RC_{80}	P_{121}	11	11	1	109
I_{34}	RC_{81}	P_{25}, P_{78}, P_{77}, P_{22}, P_{23}, P_{79}	11	11	1	110
	RC_{82}	P_{122}, P_{80}, P_{77},P_{81}	11	11	1	111
I_{35}	RC_{23}	P_{25}, P_{78}, P_{77}	11	11	1	112
	RC_{21}	P_{22}, P_{23}	11	11	1	113
	RC_{83}	P_{79}, P_{77}	11	11	1	114
I_{36}	RC_{23}	P_{25}, P_{78}, P_{77}	11	11	1	115
	RC_{84}	P_{77}	11	11	1	116
I_{37}	RC_{85}	P_{83}, P_{84}, P_{85}	11	11	1	117
	RC_{80}	P_{121}	11	11	1	118
Total			**132**	**122**	**11.09**	**12**
S-CVI/Ave				**122/132 =.92**	**11.09/12=.92**	

CVI= Item-level Content Validity Index, S-CVI/Ave= Scale-level Content Validity Index, Ave= Average

This can be observed from the Table 6.19 that out of the 12 cases, I-CVI is greater than .78 for 11 cases. For one case which is case no. 108, I-CVI is less than .78. This proves that except case no. 108 for all the other cases, recommended RE practices are beneficial enough to address the corresponding processes and tools' issues of RE process for SDO and hence must be included in the model. Case no. 108 requires other RE practices to address corresponding issue. S-CVI, computed by two ways, is greater than .80. This shows that, on average, the recommended RE practices in case of processes and tools' issues are beneficial enough for addressing the corresponding issues.

6.1.5.7 Analysis of responses about relationship among stakeholders' issues through CVI

Number of valid responses and 'number of responses in agreement' for each issue about relationship among stakeholders, and each respective root cause can be extracted from Table 6.11. Table 6.20 shows results.

Table 6. 20 : Based on industrial evaluation, number of valid and 'in agreement' responses for relationship among stakeholders' issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses	No. of Responses In Agreement	I-CVI	Case #
I_{38}	RC_7	P_{28}	11	11	1	119
I_{39}	RC_{83}	P_{79}, P_{77}	11	11	1	120
	RC_{86}	P_{86}, P_{87}, P_{88}, P_{124}	11	11	1	121
I_{40}	RC_{75}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17} P_{123}, P_{53}, P_{61}, P_{62}, P_{63}, P_{64}	11	11	1	122
	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	11	1	123
	RC_5	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	11	1	124
	RC_{11}	P_3, P_6	11	11	1	125
	RC_{87}	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	11	1	126
	RC_{72}	P_{61}, P_{62}, P_{53}	11	11	1	127
I_{41}	RC_{24}	P_{59}	11	11	1	128
I_{42}	RC_{88}	P_{50}, P_{52}, P_{53}, P_{54}, P_{89}, P_{60}	11	11	1	129
I_{43}	RC_{61}	P_{91},P_{92}, P_{93}, P_{94}, P_{98}	11	11	1	130
	RC_{18}	P_{70}, P_{20}	11	11	1	131
	RC_{89}	P_{95}, P_{96}, P_{97}	11	11	1	132
Total			**154**	**154**	**14**	**14**
S-CVI/Ave				**154/154=1**	**14/14=1**	

CVI= Item-level Content Validity Index, S-CVI/Ave= Scale-level Content Validity Index, Ave= Average

This can be observed from the Table 6.20 that I-CVI is greater than .78 for all the 14 cases. This proves that for all the 14 cases, the recommended RE practices are beneficial enough to address the corresponding relationship among stakeholders' issues of RE process for SDO and hence must be included in the model. Similarly S-CVI, computed by two ways, is greater than .80. This shows that, on average, the recommended RE practices in case of relationship among stakeholders' issues are beneficial enough for addressing the corresponding issues.

6.1.5.8 Analysis of responses about issues of all categories through CVI

To evaluate overall appropriateness of the recommended sets of RE practices to address the corresponding issues or to evaluate the overall appropriateness of the contents of REP Model, overall S-CVI/Ave can be calculated.

Overall S-CVI/Ave can be calculated by dividing '*Total no. of responses in agreement (for all categories)*' by '*Total no. of valid responses (for all categories)*'.

By using Table 6.14 to Table 6.20, Table 6.21 presents category-wise total no. of 'valid responses', no. and percentages of 'responses in agreement', and no. and percentages of the responses which are 'not in agreement'.

Table 6. 21 : Category-wise details of 'valid', 'in agreement' and 'not in agreement' responses

Sr.#	Category Name	Total no. of Valid Responses	Responses In agreement		Responses Not In Agreement	
			No.	%age	No.	%age
1.	Communication	198	194	97.98	4	2.02
2.	Management and coordination	176	173	98.30	3	1.70
3.	Knowledge management and awareness	198	197	99.49	1	.51
4.	Requirements centric	407	389	95.58	18	4.42
5.	Cultural diversities	187	172	91.98	15	8.02
6.	Processes and tools	132	122	92.42	10	7.58
7.	Relationship among stakeholders	154	154	100	0	0
Total		**1452**	**1401**		**51**	
Overall S-CVI/Ave			**1401/1452=.96**			

S-CVI/Ave= Scale-level Content Validity Index, Ave= Average

The overall S-CVI/Ave is greater than .80. This proves overall appropriateness of the REP Model contents. This means that, on average, the recommended RE practices for addressing the corresponding issues of RE process for SDO are beneficial enough for addressing the respective issues.

Figure 6.10 shows the percentages of 'responses in agreement' and percentages of 'responses not in agreement' in case of each category.

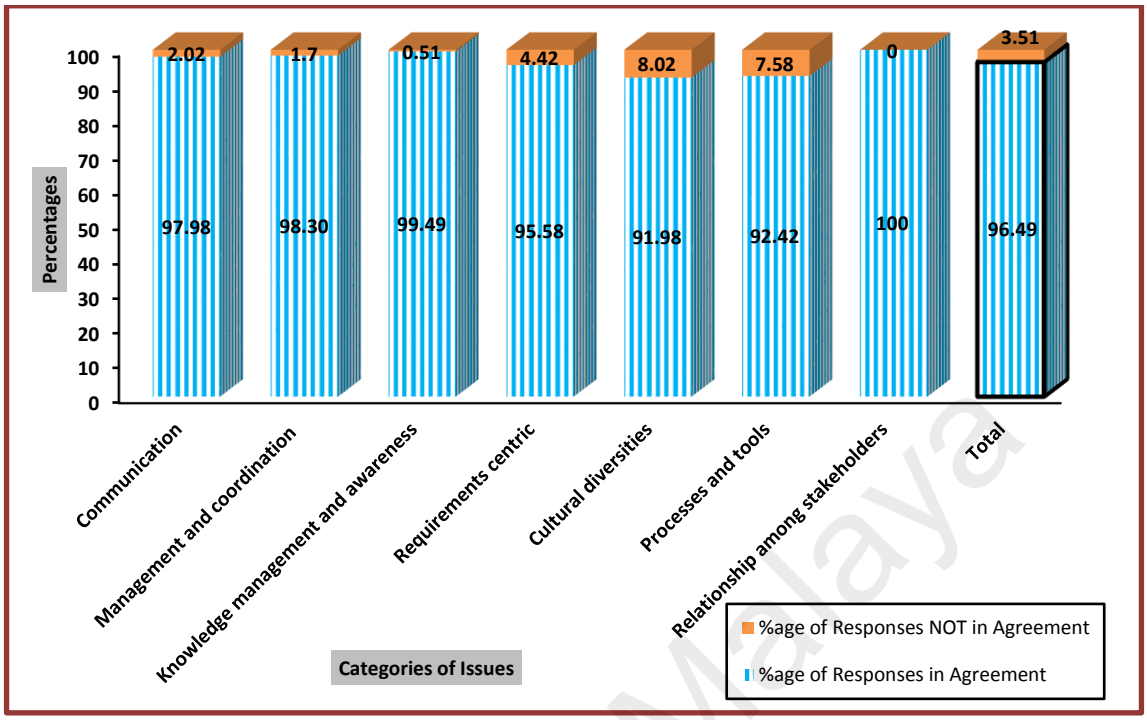

Figure 6. 10 : Category-wise percentages of 'responses in agreement' and 'responses not in agreement'

6.1.6 Discussions and industrial evaluation results' analysis through Confidence Interval (CI)

As mentioned in Section 6.1.3.1, four-point Likert Scale has been used for evaluation of the REP Model from SDO industry practitioners. The four categories of perceived benefits are: i) High (H, 4), ii) Medium (M, 3), iii) Low (L, 2), and iv) Zero (Z, 1). The responses in case of which 'Zero Perceived Benefits' or 'Low Perceived Benefits' categories have been selected by the practitioners are called 'Critical Responses (L+Z)' whereas the responses in case of which 'Medium Perceived Benefits' or 'High Perceived Benefits' categories have been selected by the practitioners are called 'Supportive Responses (H+M)'. The proportion of the supportive responses ($\hat{p}$) in case of each issue and each respective root cause has been analyzed for its Confidence Interval (CI). CI provides expected range within which true value is likely to fall (Ross, 2003). According to ("Confidence Intervals, Statistical glossary," 2015), CI provides an

estimated range of values which is likely to include an unknown population parameter whereas estimated range is calculated from a given set of sample data. Several methods are employed to calculate CI for a proportion (He, 2009). Keeping in view sample size (11), Wilson Score Confidence Interval method has been adopted as it can be used for any combination of n (no. of valid responses) and $\hat{p}$ values (Beecham, et al., 2005), and almost with all sample sizes (Agresti & Coull, 1998). In the study (Beecham, et al., 2005), similar method has been used. The formula for Wilson Score CI is (Beecham, et al., 2005; Wilson, 1927):

$$\left(\hat{p}+\frac{z^2_{\alpha/2}}{2n} \pm z_{\alpha/2}\sqrt{[\hat{p}(1-\hat{p})+z^2_{\alpha/2}/4n]/n}\right)/(1+z^2_{\alpha/2}/n)$$

Where $\hat{p}$ denotes proportion of supportive responses,

$z_{\alpha/2}$ computes critical value, α=0.05 for 95% CI and $z_{\alpha/2}$ = 1.96,

and n denotes no. of valid responses.

Calculating CI by using Wilson Score method can be explained with the help of an example.

(a) Calculating CI using Wilson Score Method.

Consider a case in which valid responses are 18, there is 1 critical response and supportive responses are 17.

So n (no. of valid responses) = 18

No. of supportive responses = 17

$\hat{p}$(Proportion of supportive responses)= 17/18

=.9444

For 95% CI, α=1‗ .95 =.05 and α/2= .025

Using standard normal distribution table, $Z_{\alpha/2} = 1.96$

Thus

$$\frac{1}{1+\left(\frac{Z_{\frac{\alpha}{2}}^{2}}{n}\right)}\left[\left(\hat{p}+\frac{Z_{\frac{\alpha}{2}}^{2}}{2n}\right)\pm\left(Z_{\frac{\alpha}{2}}\sqrt{\frac{\hat{p}\left(1-\hat{p}\right)+\frac{Z_{\frac{\alpha}{2}}^{2}}{4n}}{n}}\right)\right]$$

$$=\frac{1}{1+\frac{3.8416}{18}}\left[\left(.9444+\frac{3.8416}{36}\right)\pm\left(1.96\sqrt{\frac{.9444(.0556)+\frac{3.8416}{72}}{18}}\right)\right]$$

$$=\frac{1}{1+.2134}\left[\left(1.0511\right)\pm\left(1.96\sqrt{\frac{.0525+.0534}{18}}\right)\right]$$

$$=\frac{1}{1.2134}\left[1.0511\pm.1503\right]$$

$$=.8241\left[1.0511-.1503,1.0511+.1503\right]$$

$$=.8241\left[.9008,1.2014\right]$$

$$=\left[.7423,.9900\right]$$

$$=\left[74,99\right]$$

Now [74, 99] ⇒ Lower Limit (LL) for CI= 74%

Upper Limit (UL) for CI= 99%

This means one can be 95% confident that percentage or proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 99%. Table 6.22 summarizes the results.

Table 6. 22 : Finding Confidence Interval by using Wilson Score method

No. of Valid Responses(n)	Critical Responses		Supportive Responses		$\hat{p}$	Confidence Interval 95%	
	No.	%age	No.	%age		LL	UL
18	1	$5.55 \approx 6$	17	$94.44 \approx 94$	$17/18=.9444 \approx .94$	[74,99]	

The percentage of supportive responses is well within the CI range.

There are seven categories for the issues of RE process for SDO. Considering all the categories one by one, CI for the proportion of supportive responses has been analyzed in case of each issue and each respective root cause. The acceptable threshold for supportive responses is 80% (Beecham, et al., 2005; El Emam & Jung, 2001). If CI in any case does not include 80% or above, it indicates that the recommended set of RE practices is not beneficial enough to address the corresponding issue of RE process for SDO (Beecham, et al., 2005).

6.1.6.1 Analysis of responses about communication issues through CI

No. of valid responses, critical responses and supportive responses for communication issues can be extracted from Table 6.11. Table 6.23 shows results.

Table 6. 23 : Based on industrial evaluation, number of valid, critical and supportive responses for communication issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses (n)	Critical Responses		Supportive Responses		$p\hat{}$	Confidence Interval 95%		Case #
				No.	%age	No.	%age		LL	UL	
I_1	RC_1	P_1,P_2,P_3,P_4,P_5, P_6,P_7,P_8,P_9,P_{10}, P_{11}, P12, P13, P14, P15, P16, P17	11	0	0	11	100	1	[74,100]		1
	RC_2	P_7, P_8, P_9, P_{10}	11	0	0	11	100	1	[74,100]		2
	RC_3	P_2, P_{18} , P_{73}	11	0	0	11	100	1	[74,100]		3
I_2	RC_4	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}	11	0	0	11	100	1	[74,100]		4
	RC_5	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16} ,P_{17}	11	0	0	11	100	1	[74,100]		5
I_3	RC_6	P_{26} , P_{27}	11	0	0	11	100	1	[74,100]		6
	RC_7	P_{28}	11	2	18	9	82	.82	[52,95]		7
I_4	RC_8	P_1, P_2	11	0	0	11	100	1	[74,100]		8
	RC_2	P_7, P_8, P_9, P_{10}	11	0	0	11	100	1	[74,100]		9
	RC_9	P_{18} P_{19}	11	1	9	10	91	.91	[62,98]		10
	RC_{10}	P_{12}, P_{14}, P_{15}, P_{17}	11	1	9	10	91	.91	[62,98]		11
I_5	RC_8	P_1, P_2	11	0	0	11	100	1	[74,100]		12
	RC_{11}	P_3, P_6	11	0	0	11	100	1	[74,100]		13
	RC_{12}	P_4, P_5, P_6	11	0	0	11	100	1	[74,100]		14
	RC_2	P_7, P_8, P_9, P_{10}	11	0	0	11	100	1	[74,100]		15
I_6	RC_{13}, RC_{14}, RC_{15}, RC_{16} , RC_{17}	P_{21}	11	0	0	11	100	1	[74,100]		16
	RC_{18}	P_{70} , P_{20}	11	0	0	11	100	1	[74,100]		17
	RC_2	P_7, P_8, P_9, P_{10}	11	0	0	11	100	1	[74,100]		18

Communication category contains six issues which are I_1, I_2, I_3, I_4, I_5 and I_6.

(a) Critical and supportive responses for issue I_1

In case of issue **I_1** that is 'Delayed responses' there are three root causes RC_1, RC_2 and RC_3. For all the three root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_1 or RC_2 or RC_3 for issue **I_1**, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that the recommended set of RE practices in case of RC_1 or RC_2 or RC_3, is beneficial enough for addressing issue **I_1**. Figure 6.11 shows %ages of critical and supportive responses in case of all three root causes for issue I_1.

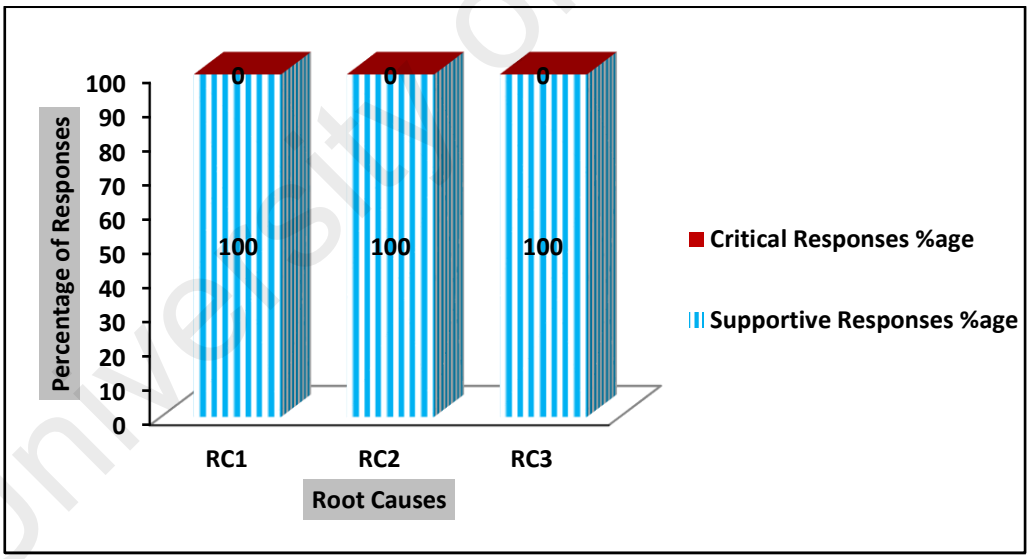

Figure 6. 11 : Percentages of critical and supportive responses for root causes of issue I_1

(b) Critical and supportive responses for issue I_2

In case of issue **I_2** that is 'Lack of informal communication' there are two root causes RC_4 and RC_5. For both root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for

CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_4 or RC_5 for issue **I_2**, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_4 or RC_5, is beneficial enough for addressing issue **I_2**. Figure 6.12 shows %ages of critical and supportive responses in case of both root causes for issue I_2.

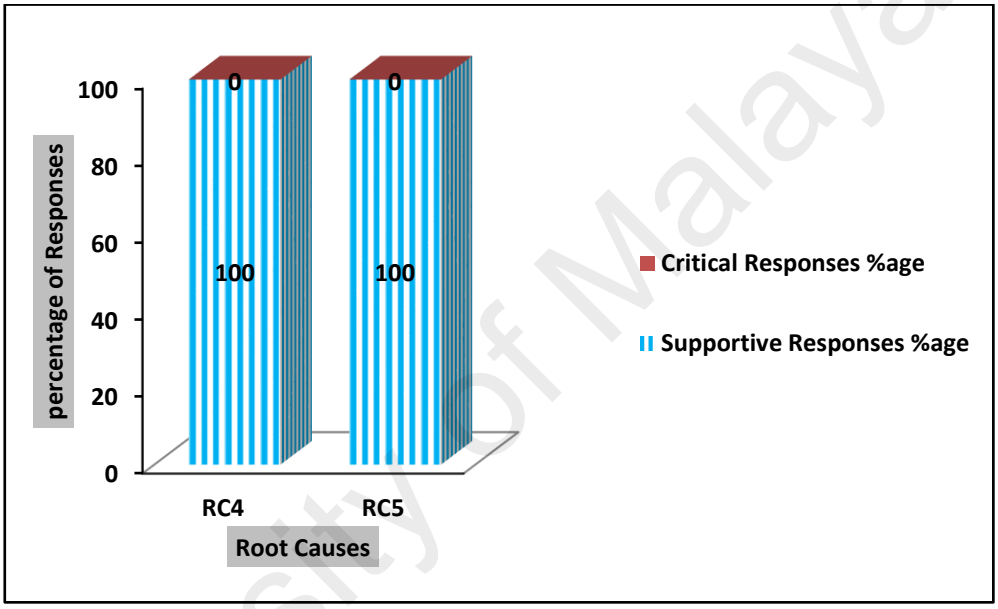

Figure 6. 12 : Percentages of critical and supportive responses for root causes of issue I_2

(c) Critical and supportive responses for issue I_3

Issue I_3 is 'Usually commitments made during videoconferencing or telephonic conversation cannot be referred if required'. For issue I_3 there are two root causes RC_6 and RC_7. For root cause RC_6, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_6 for issue **I_3**, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that

recommended set of RE practices in case of RC_6, is beneficial enough for addressing issue $\mathbf{I_3}$. For root cause RC_7, percentage of critical responses is 18 whereas for supportive responses percentage is 82 which is well within CI as LL for CI is 52% and UL is 95%. The [52, 95] with CI 95% means one can be 95% confident that in case of RC_7 for issue $\mathbf{I_3}$, proportion of supportive responses in case of whole population of experts will fall within the range of 52% to 95%. This shows that recommended set of RE practices in case of RC_7, is beneficial enough for addressing issue $\mathbf{I_3}$.

Figure 6.13 shows %ages of critical and supportive responses in case of both root causes for issue I_3.

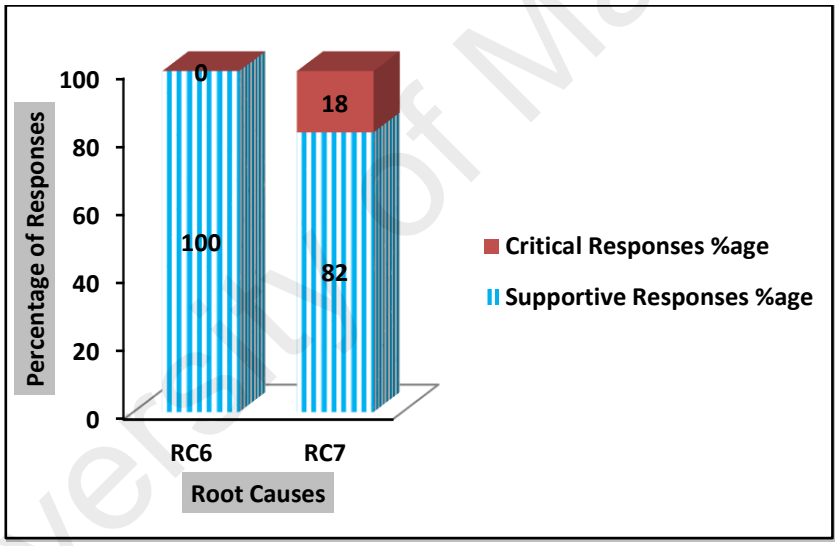

Figure 6. 13 : Percentages of critical and supportive responses for root causes of issue I_3

(d) Critical and supportive responses for issue I_4

In case of issue $\mathbf{I_4}$ that is 'Lack of synchronous communication' there are four root causes RC_8, RC_2, RC_9 and RC_{10}. For root causes RC_8 and RC_2, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_8 or RC_2 for issue $\mathbf{I_4}$, proportion of supportive responses

in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_8 or RC_2, is beneficial enough for addressing issue $\mathbf{I_4}$. For root cause RC_9 and RC_{10}, percentage of critical responses is 9 whereas for supportive responses percentage is 91 which is well within CI as LL for CI is 62% and UL is 98%. The [62, 98] with CI 95% means one can be 95% confident that in case of RC_9 or RC_{10} for issue $\mathbf{I_4}$, proportion of supportive responses in case of whole population of experts will fall within the range of 62% to 98%. This shows that recommended set of RE practices in case of RC_9 or RC_{10}, is beneficial enough for addressing issue $\mathbf{I_4}$.

Figure 6.14 shows %ages of critical and supportive responses in case of all the four root causes for issue I_4.

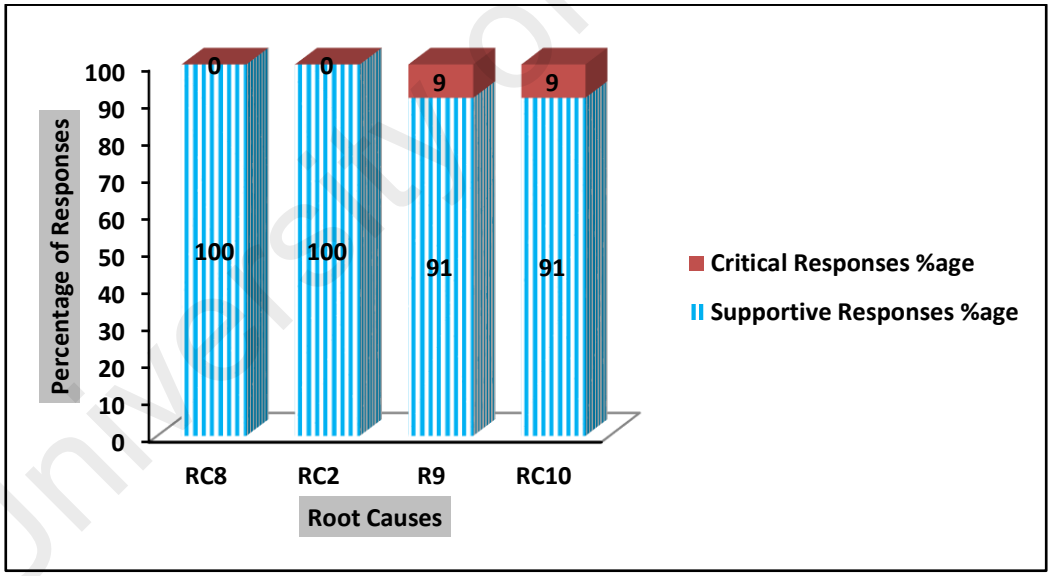

Figure 6. 14 : Percentages of critical and supportive responses for root causes of issue I_4

(e) Critical and supportive responses for issue $\mathbf{I_5}$

In case of issue $\mathbf{I_5}$ that is 'Infrequent and constrained communication among the stakeholders' there are four root causes RC_8, RC_{11}, RC_{12} and RC_2. For all the four root causes, percentage of critical responses is 0 whereas for supportive responses percentage

is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_8 or RC_{11} or RC_{12} or RC_2 for issue **I_5**, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_8 or RC_{11} or RC_{12} or RC_2, is beneficial enough for addressing issue **I_5**. Figure 6.15 shows %ages of critical and supportive responses in case of all the four root causes for issue I_5.

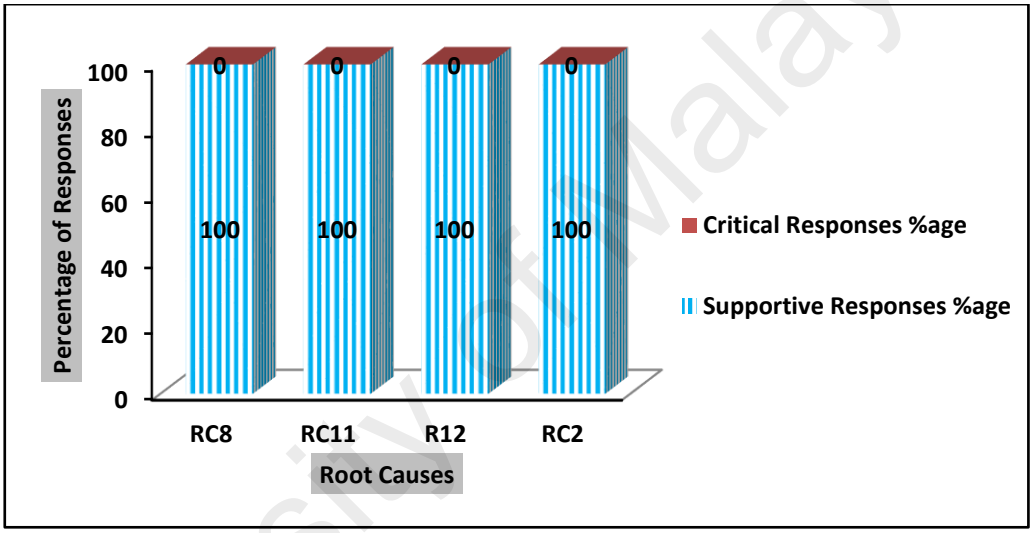

Figure 6. 15 : Percentages of critical and supportive responses for root causes of issue I_5

(f) Critical and supportive responses for issue I_6

For issue **I_6** that is 'Meetings that are held to take decisions about the requirements are unproductive' there are seven root causes RC_{13}, RC_{14}, RC_{15}, RC_{16}, RC_{17}, RC_{18} and RC_2. In case of all the seven root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{13} or RC_{14} or RC_{15} or RC_{16} or RC_{17} or RC_{18} or RC_2 for issue **I_6**, proportion of supportive responses in case of whole population of experts will fall within

the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{13}, RC_{14}, RC_{15}, RC_{16} and RC_{17} or RC_{18} or RC_2, is beneficial enough for addressing issue $\mathbf{I}_6$. Figure 6.16 shows %ages of critical and supportive responses in case of all the seven root causes for issue I_6.

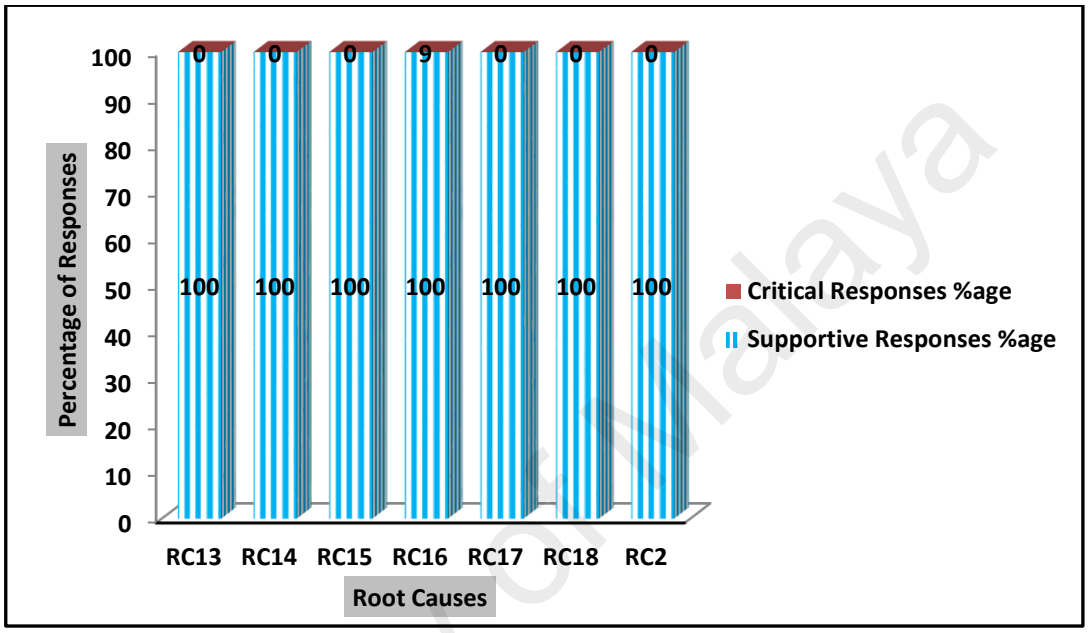

Figure 6. 16 : Percentages of critical and supportive responses for root causes of issue I_6

6.1.6.2 Analysis of responses about management and coordination issues through CI

No. of valid responses, critical responses and supportive responses for management and coordination issues can be extracted from Table 6.11. Table 6.24 shows results.

Table 6. 24 : Based on industrial evaluation, number of valid, critical and supportive responses for management and coordination issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses (n)	Critical Responses		Supportive Responses		$p\hat{}$	Confidence Interval 95%		Case #
				No.	%age	No.	%age		LL	UL	
I_7	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	1	9	10	91	.91	[62,98]		19
	RC_2	P_7, P_8, P_9, P_{10}	11	1	9	10	91	.91	[62,98]		20
	RC_3	P_2, P_{18}, P_{73}	11	0	0	11	100	1	[74,100]		21
I_8	RC_{19}	P_{24}	11	0	0	11	100	1	[74,100]		22
	RC_{20}	P_{22} ,P_{23} P_{24},P_{34}, P_{25} , P_{78} , P_{77}	11	0	0	11	100	1	[74,100]		23
	RC_{21}	P_{22}, P_{23}	11	0	0	11	100	1	[74,100]		24
I_9	RC_{22}	P_{22}, P_{23}, P_{24}, P_{34}	11	0	0	11	100	1	[74,100]		25
	RC_{23}	P_{25}, P_{78}, P_{77}	11	0	0	11	100	1	[74,100]		26
I_{10}	RC_1	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	0	0	11	100	1	[74,100]		27
	RC_{24}	P_{59}	11	0	0	11	100	1	[74,100]		28
	RC_{25}	P_{68}	11	0	0	11	100	1	[74,100]		29
	RC_{26}	P_{69}	11	1	9	10	91	.91	[62,98]		30
	RC_{27}	P_{118}	11	0	0	11	100	1	[74,100]		31
	RC_{28}	P_{120}	11	0	0	11	100	1	[74,100]		32
	RC_2	P_7, P_8, P_9, P_{10}	11	0	0	11	100	1	[74,100]		33
I_{11}	RC_{29}	P_{45} P_{47} P_{48} P_{49} P_{50} ,P_{56} ,P_{74} , P_{75}, P_{41}	11	0	0	11	100	1	[74,100]		34

Management and coordination category contains five issues which are I_7, I_8, I_9, I_{10}, and I_{11}.

(a) Critical and supportive responses for issue I_7

In case of issue **I_7** that is 'Delay in clarifications about requirements and decision making' there are three root causes RC_1, RC_2 and RC_3. For root causes RC_1 and RC_2, percentage of critical responses is 9 whereas for supportive responses percentage is 91 which is well within CI as LL for CI is 62% and UL is 98%. The [62, 98] with CI 95% means one can be 95% confident that in case of RC_1 or RC_2 for issue **I_7**, proportion of supportive responses in case of whole population of experts will fall within the range of 62% to 98%. This shows that recommended set of RE practices in case of RC_1 or RC_2, is beneficial enough for addressing issue **I_7**. For root cause RC_3, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable

with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_3 for issue **I_7**, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_3, is beneficial enough for addressing issue **I_7**. Figure 6.17 shows %ages of critical and supportive responses in case of all three root causes for issue I_7.

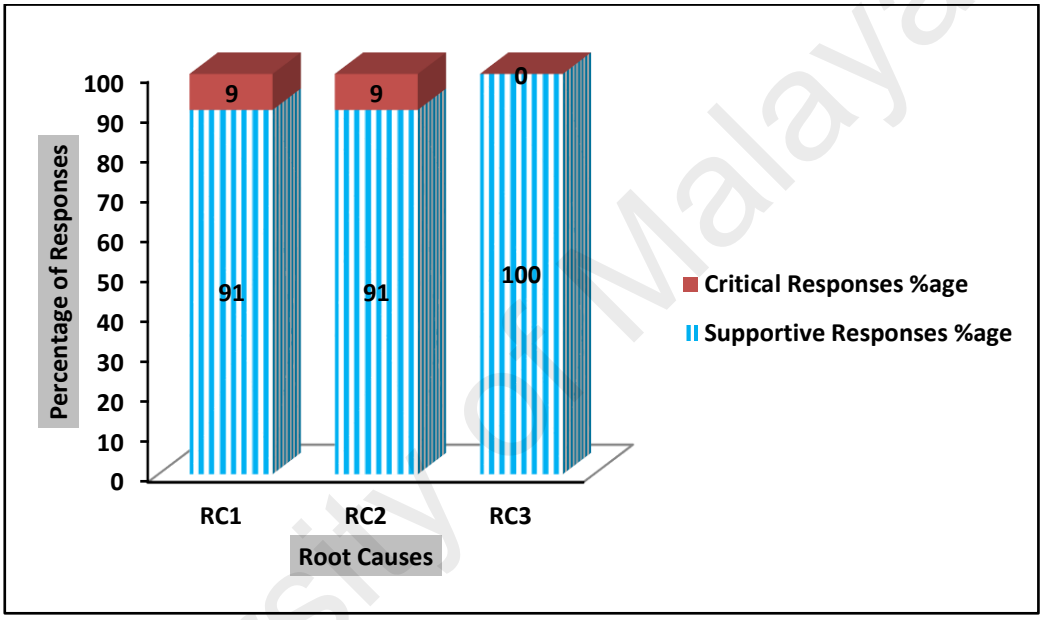

Figure 6. 17 : Percentages of critical and supportive responses for root causes of issue I_7

(b) Critical and supportive responses for issue I_8

Issue I_8 is 'Nonperformance of a Requirements Engineering related task as everybody presumes that this is the responsibility of somebody else'. In case of issue I_8, there are three root causes RC_{19}, RC_{20} and RC_{21}. For all the three root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{19} or RC_{20} or RC_{21} for issue I_8, proportion of supportive responses in case of whole population of experts will fall

within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{19} or RC_{20} or RC_{21}, is beneficial enough for addressing issue $\mathbf{I}_{8.}$ Figure 6.18 shows %ages of critical and supportive responses in case of all three root causes for issue I_8.

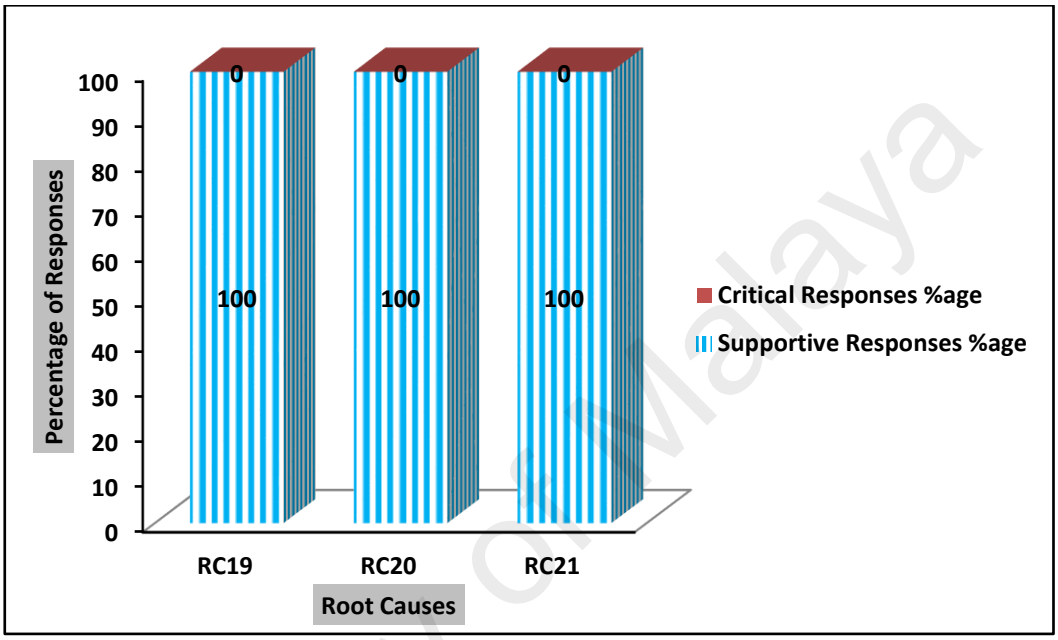

Figure 6. 18 : Percentages of critical and supportive responses for root causes of issue I_8

(c) Critical and supportive responses for issue I_9

In case of issue $\mathbf{I_9}$ that is 'Poorly defined or undefined responsibilities' there are two root causes RC_{22} and RC_{23}. In case of both the root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{22} or RC_{23} for issue $\mathbf{I_9}$, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{22} or RC_{23}, is beneficial enough for addressing issue $\mathbf{I}_{9.}$ Figure 6.19 shows %ages of critical and supportive responses in case of both root causes for issue I_9.

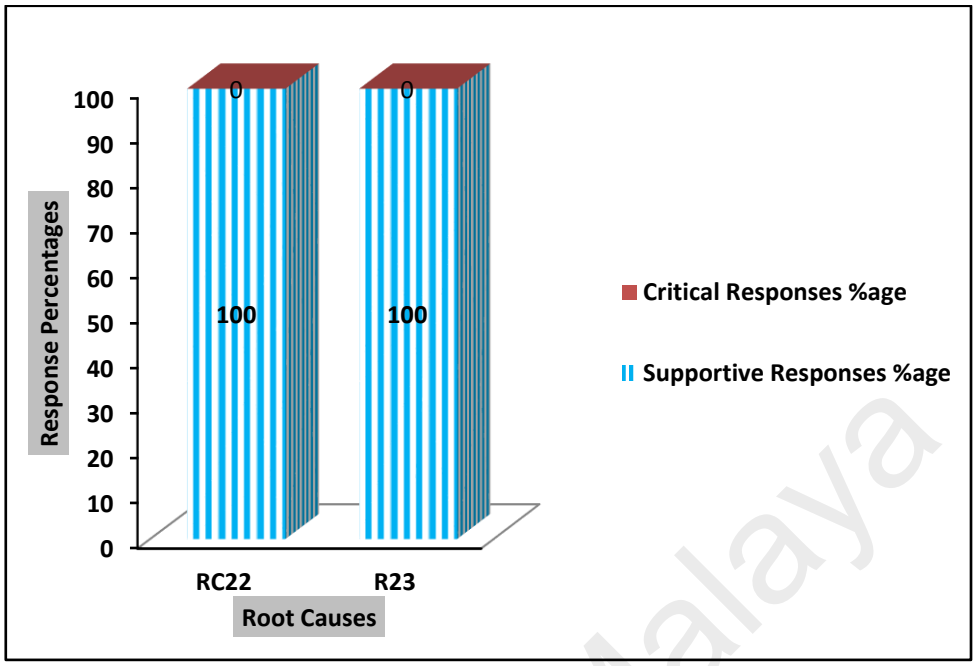

Figure 6. 19 : Percentages of critical and supportive responses for root causes of issue I_9

(d) Critical and supportive responses for issue I_{10}

Issue I_{10} is 'Difficulties in comprehending information, reasons and activities that are required for common Requirements Understanding (RU) among the dispersed stakeholders'. In case of issue **I_{10}** there are seven root causes RC_1, RC_{24}, RC_{25}, RC_{26}, RC_{27}, RC_{28} and RC_2. Except root cause RC_{26} for rest of six root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_1 or RC_{24} or RC_{25} or RC_{26} or RC_{27} or RC_{28} or RC_2 for issue **I_{10}**, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_1 or RC_{24} or RC_{25} or RC_{27} or RC_{28} or RC_2, is beneficial enough for addressing issue **I_{10}**. For root cause RC_{26}, percentage of critical responses is 9 whereas for supportive responses percentage is 91 which is well within CI

as LL for CI is 62% and UL is 98%. The [62, 98] with CI 95% means one can be 95% confident that in case of RC_{26} for issue $\mathbf{I_{10}}$, proportion of supportive responses in case of whole population of experts will fall within the range of 62% to 98%. This shows that recommended set of RE practices in case of RC_{26}, is beneficial enough for addressing issue $\mathbf{I}_{10}$. Figure 6.20 shows %ages of critical and supportive responses in case of all the seven root causes for issue I_{10}.

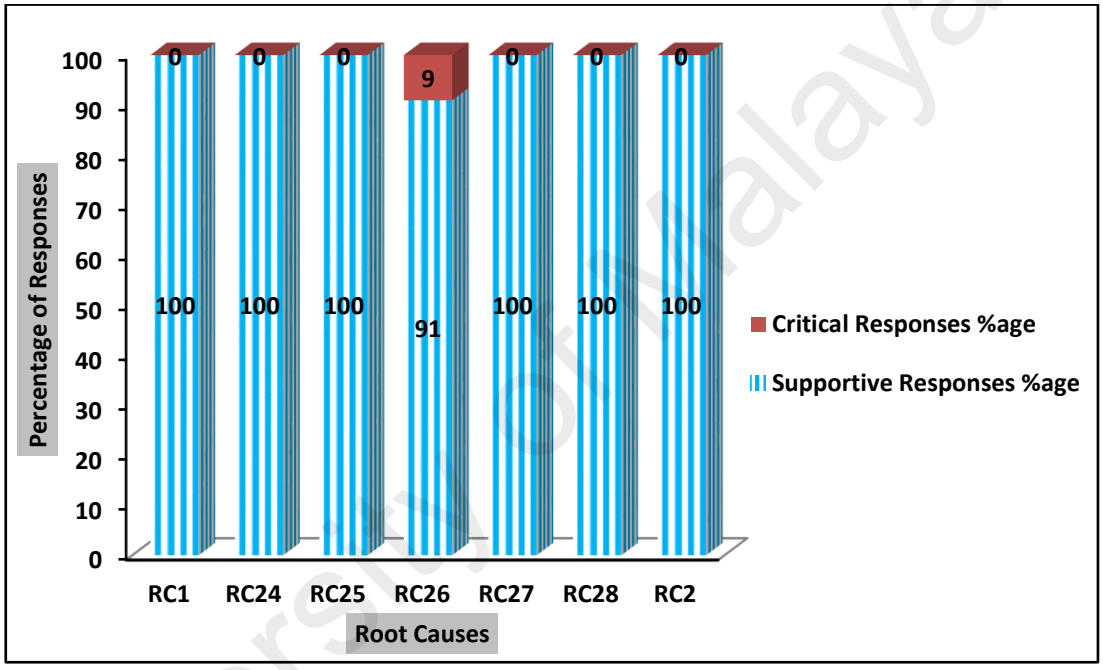

Figure 6. 20 : Percentages of critical and supportive responses for root causes of issue I_{10}

(e) Critical and supportive responses for issue I_{11}

In case of issue $\mathbf{I_{11}}$ that is 'Need for adjustment of actual requirements to interact with other software(s)' there is only one root cause RC_{29}. For the root cause RC_{29}, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{29} for issue $\mathbf{I_{11}}$, proportion of supportive responses in case of whole population of experts will fall within the range of

74% to 100%. This shows that recommended set of RE practices in case of RC_{29}, is beneficial enough for addressing issue $\mathbf{I}_{11.}$ Figure 6.21 shows %ages of critical and supportive responses in case of single root cause for issue I_{11}.

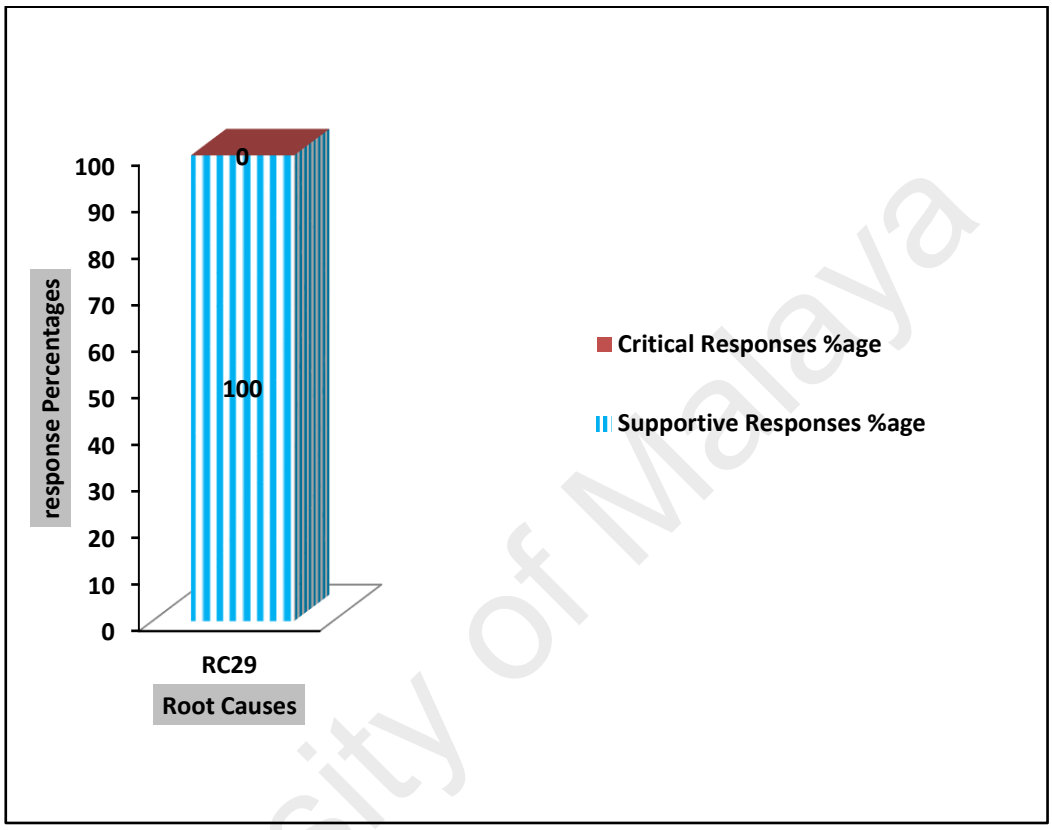

Figure 6. 21 : Percentages of critical and supportive responses for root causes of issue I_{11}

6.1.6.3 Analysis of responses about knowledge management and awareness issues through CI

No. of valid responses, critical responses and supportive responses for knowledge management and awareness issues can be extracted from Table 6.11. Table 6.25 shows results.

Table 6. 25 : Based on industrial evaluation, number of valid, critical and supportive responses for knowledge management and awareness issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses (n)	Critical Responses		Supportive Responses		$p^{\wedge}$	Confidence Interval 95%	Case #
				No.	%age	No.	%age		LL UL	
I_{12}	RC_{30}	P_{46}, P_{38}	11	0	0	11	100	1	[74,100]	35
	RC_{31}	P_{39} , P_{40}	11	0	0	11	100	1	[74,100]	36
	RC_{32}	P_{41}, P_{101} , P_{42}	11	0	0	11	100	1	[74,100]	37
	RC_{33}	P_{34}	11	1	9	10	91	.91	[62,98]	38
	RC_{34}	P_{41}, P_{101} , P_{42}, P_{22}	11	0	0	11	100	1	[74,100]	39
I_{13}	RC_{1}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	0	0	11	100	1	[74,100]	40
	RC_{35}, RC_{36}, RC_{37}	P_{34}, P_{35}, P_{36}	11	0	0	11	100	1	[74,100]	41
I_{14}	RC_{38}	P_{45} , P_{57} , P_{100}	11	0	0	11	100	1	[74,100]	42
	RC_{39}	P_{58}, P_{118}	11	0	0	11	100	1	[74,100]	43
I_{15}	RC_{40}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}. P_{34}, P_{35}, P_{36}	11	0	0	11	100	1	[74,100]	44
	RC_{41}	P_{37} , P_{72} P_{71}, P_{36}	11	0	0	11	100	1	[74,100]	45
I_{16}	RC_{42}	P_{44}	11	0	0	11	100	1	[74,100]	46
	RC_{43}	P_{45}, P_{46}, P_{47}, P_{48}, P_{49}	11	0	0	11	100	1	[74,100]	47
	RC_{44}	P_{50}, P_{51} , P_{52}, P_{53} P_{54}, P_{55}, P_{56}	11	0	0	11	100	1	[74,100]	48
I_{17}	RC_{45}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{73}	11	0	0	11	100	1	[74,100]	49
	RC_{1}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	0	0	11	100	1	[74,100]	50
	RC_{46}	P_{46}, P_{38}, P_{39}, P_{40}, P_{41}, P_{101}, P_{42}, P_{34}, P_{22}, P_{43}	11	0	0	11	100	1	[74,100]	51
I_{18}	RC_{47}	P_{29} , P_{30}, P_{31}, P_{32} , P_{33}, P_6	11	0	0	11	100	1	[74,100]	52

Knowledge management and awareness category contains seven issues which are I_{12}, I_{13}, I_{14}, I_{15}, I_{16}, I_{17}, and I_{18}.

(a) Critical and supportive responses for issue I_{12}

In case of issue I_{12} that is 'Poor requirements change management' there are five root causes RC_{30}, RC_{31}, RC_{32}, RC_{33} and RC_{34}. Except root cause RC_{33} for rest of four root

causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{30} or RC_{31} or RC_{32} or RC_{34} for issue $\mathbf{I_{12}}$, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{30} or RC_{31} or RC_{32} or RC_{34}, is beneficial enough for addressing issue $\mathbf{I}_{12.}$ For root cause RC_{33}, percentage of critical responses is 9 whereas for supportive responses percentage is 91 which is well within CI as LL for CI is 62% and UL is 98%. The [62, 98] with CI 95% means one can be 95% confident that in case of RC_{33} for issue $\mathbf{I_{12}}$, proportion of supportive responses in case of whole population of experts will fall within the range of 62% to 98%. This shows that recommended set of RE practices in case of RC_{33}, is beneficial enough for addressing issue $\mathbf{I}_{12.}$ Figure 6.22 shows %ages of critical and supportive responses in case of all the five root causes for issue I_{12}.

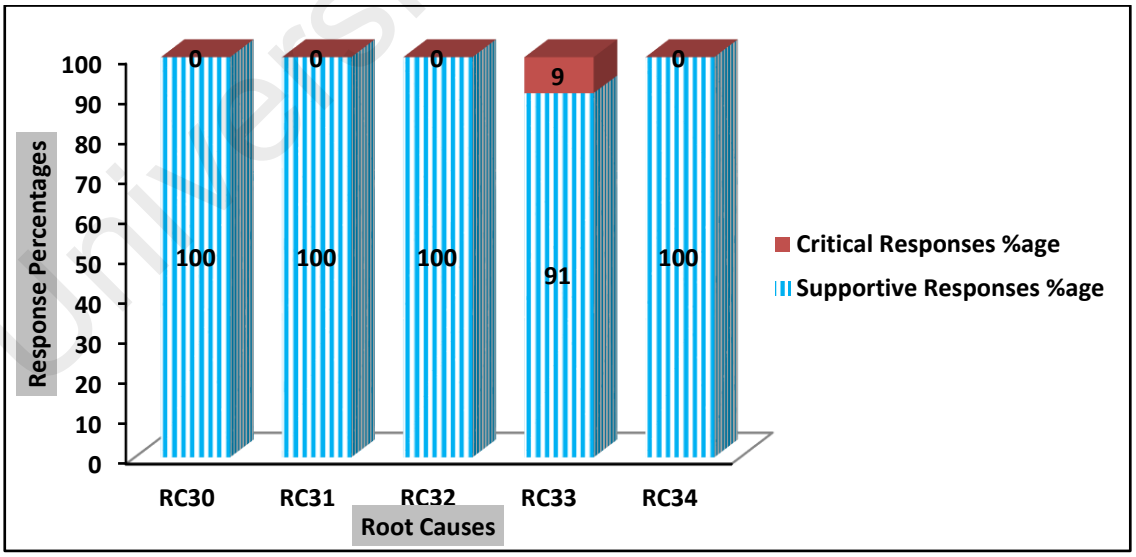

Figure 6. 22 : Percentages of critical and supportive responses for root causes of issue I_{12}

(b) Critical and supportive responses for issue I_{13}

In case of issue I_{13} that is 'Unawareness of the stakeholders from current or latest information about requirements' there are four root causes RC_1, RC_{35}, RC_{36} and RC_{37}. For all the four root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_1 or RC_{35} or RC_{36} or RC_{37} for issue I_{13}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_1 or RC_{35} or RC_{36} or RC_{37}, is beneficial enough for addressing issue $\mathbf{I}_{13}$. Figure 6.23 shows %ages of critical and supportive responses in case of all the four root causes for issue I_{13}.

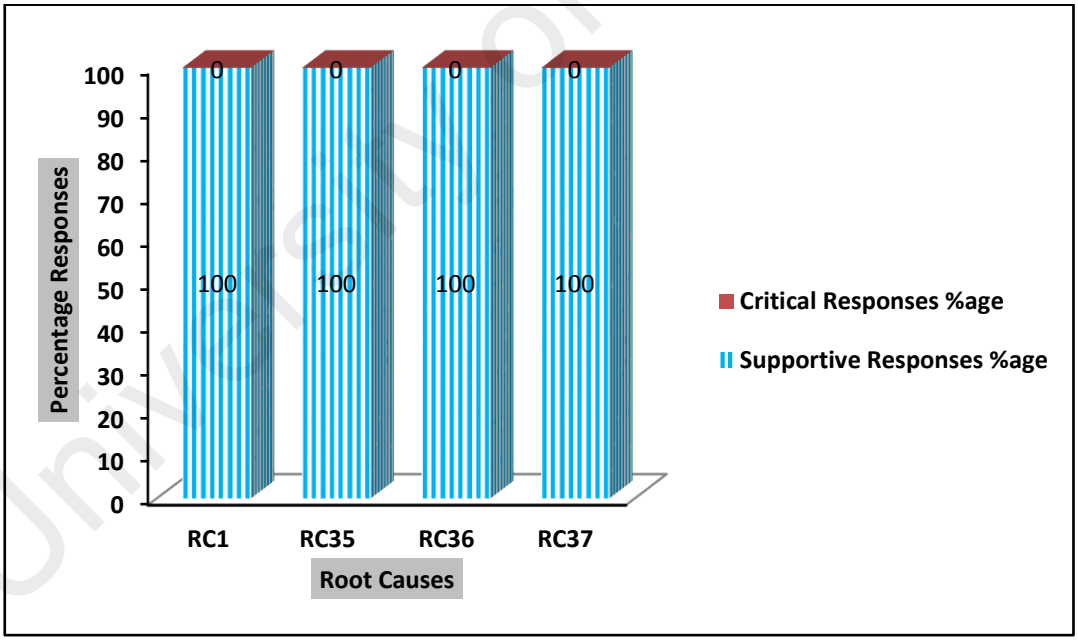

Figure 6. 23 : Percentages of critical and supportive responses for root causes of issue I_{13}

(c) Critical and supportive responses for issue I_{14}

In case of issue $\mathbf{I}_{14}$ that is 'Unawareness from or not accessing all requirements sources' there are two root causes RC_{38} and RC_{39}. For both the root causes, percentage of critical

responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{38} or RC_{39} for issue **I_{14}**, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{38} or RC_{39}, is beneficial enough for addressing issue **I_{14}**. Figure 6.24 shows %ages of critical and supportive responses in case of both root causes for issue I_{14}.

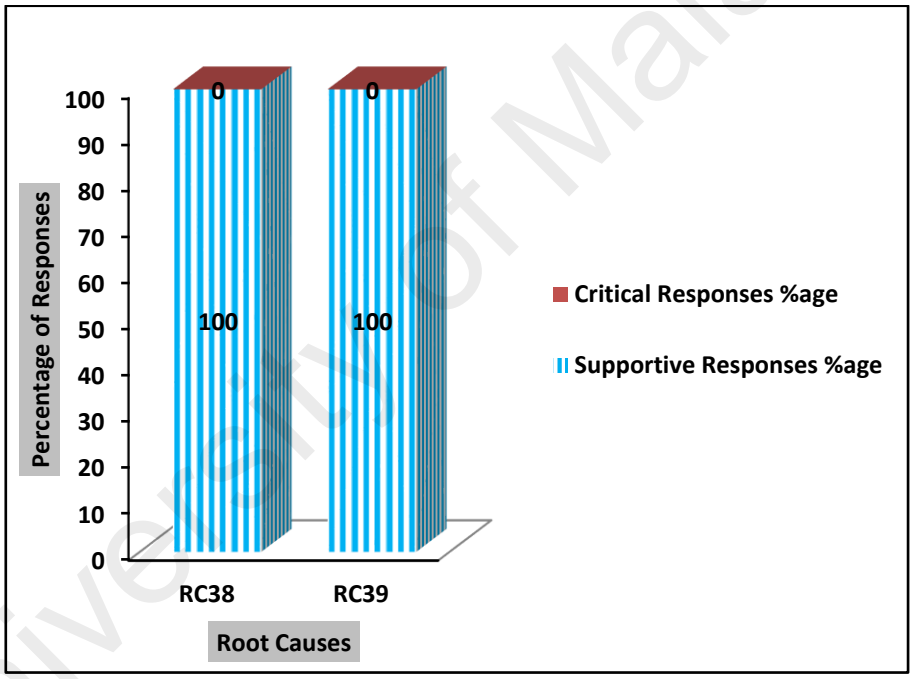

Figure 6. 24 : Percentages of critical and supportive responses for root causes of issue I_{14}

(d) Critical and supportive responses for issue I_{15}

In case of issue **I_{15}** that is 'Reopening of the already discussed and seemingly settled issues' there are two root causes RC_{40} and RC_{41}. For both the root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{40} or RC_{41} for issue **I_{15}**,

proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{40} or RC_{41}, is beneficial enough for addressing issue $\mathbf{I}_{15}$. Figure 6.25 shows %ages of critical and supportive responses in case of both root causes for issue I_{15}.

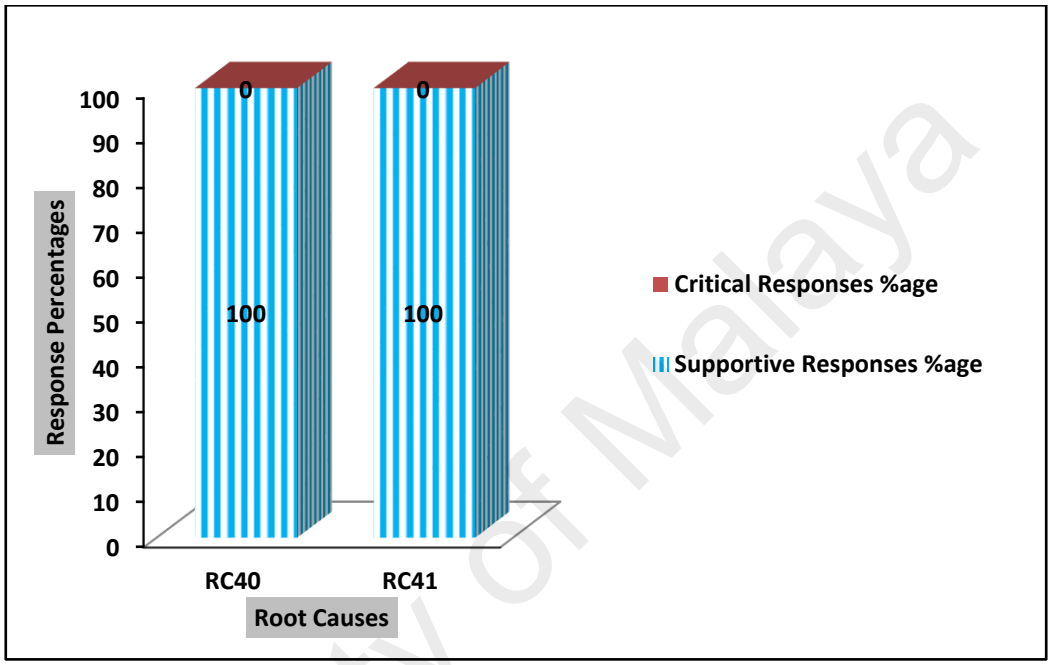

Figure 6. 25 : Percentages of critical and supportive responses for root causes of issue I_{15}

(e) Critical and supportive responses for issue I_{16}

In case of issue $\mathbf{I_{16}}$ that is 'Unawareness of requirements engineers from the effects of new system implementation on the client organization' there are three root causes RC_{42}, RC_{43} and RC_{44}. For all the three root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{42} or RC_{43} or RC_{44} for issue $\mathbf{I_{16}}$, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{42} or RC_{43} or RC_{44},

is beneficial enough for addressing issue **I**$_{16.}$ Figure 6.26 shows %ages of critical and supportive responses in case of all the three root causes for issue I_{16}.

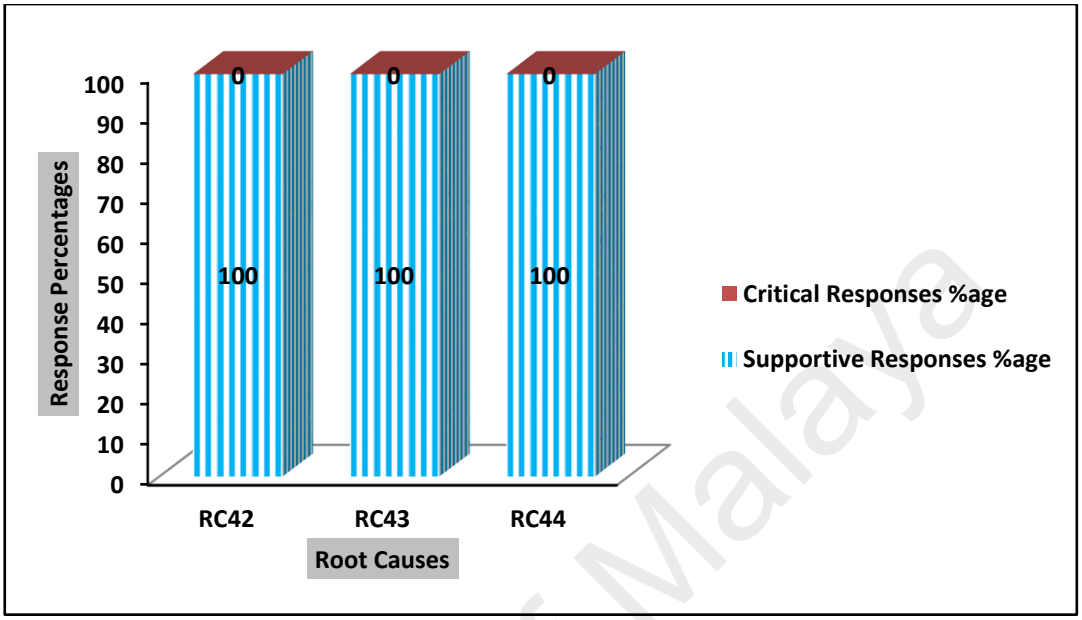

Figure 6. 26 : Percentages of critical and supportive responses for root causes of issue I_{16}

(f) Critical and supportive responses for issue I_{17}

In case of issue **I**$_{17}$ that is 'Working on obsolete requirements' there are three root causes RC_{45}, RC_1 and RC_{46}. For all the three root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{45} or RC_1 or RC_{46} for issue **I**$_{17}$, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{45} or RC_1 or RC_{46}, is beneficial enough for addressing issue **I**$_{17.}$ Figure 6.27 shows %ages of critical and supportive responses in case of all the three root causes for issue I_{17}.

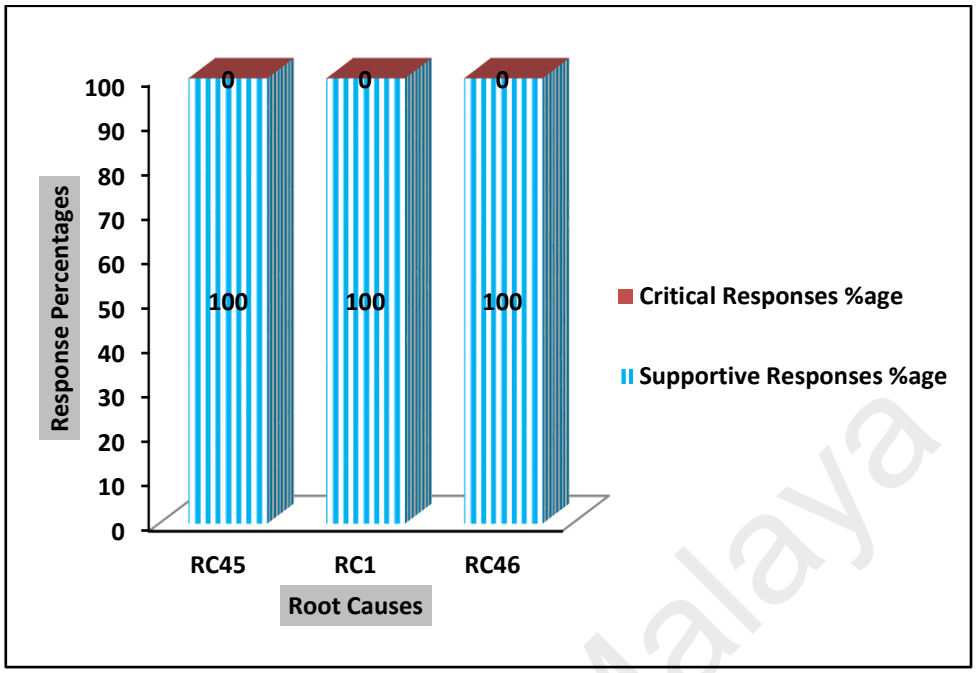

Figure 6. 27 : Percentages of critical and supportive responses for root causes of issue I_{17}

(g) Critical and supportive responses for issue I_{18}

In case of issue **I_{18}** that is 'Hindrance in circulation of requirements knowledge from or to organizations' there is only one root cause RC_{47}. For the root cause RC_{47}, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{47} for issue **I_{18}**, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{47}, is beneficial enough for addressing issue **$I_{18.}$** Figure 6.28 shows %ages of critical and supportive responses in case of single root cause for issue I_{18}.

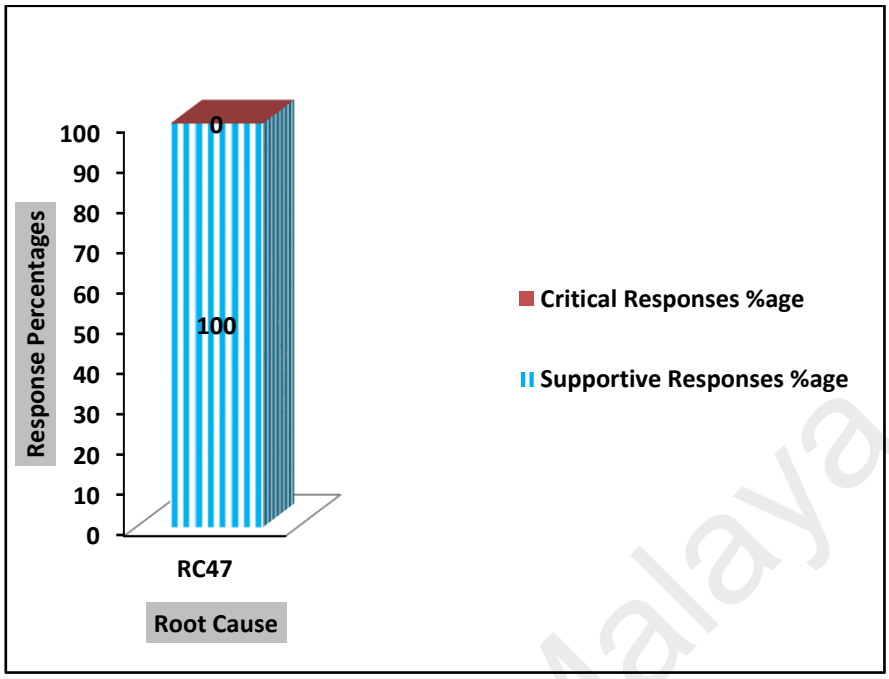

Figure 6. 28 : Percentages of critical and supportive responses for root causes of issue I_{18}

6.1.6.4 Analysis of responses about requirements centric issues through CI

No. of valid responses, critical responses and supportive responses for requirements centric issues can be extracted from Table 6.11. Table 6.26 shows results.

Table 6. 26 : Based on industrial evaluation, number of valid, critical and supportive responses for requirements centric issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses (n)	Critical Responses		Supportive Responses		$p\hat{}$	Confidence Interval 95%	Case #
				No.	%age	No.	%age		LL UL	
I_{19}	RC_{48},RC_{49}, RC_{50}, RC_{51}	P_{117} , P_{101}	11	0	0	11	100	1	[74,100]	53
	RC_7	P_{28}	11	0	0	11	100	1	[74,100]	54
I_{20}	RC_9	P_{18}, P_{19}.	11	0	0	11	100	1	[74,100]	55
I_{21}	RC_{52}	P_{45},P_{57}, P_{100}, P_{58} , P_{118}	11	0	0	11	100	1	[74,100]	56
	RC_{53}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	11	0	0	11	100	1.00	[74,100]	57
	RC_{54}	P_{99}	11	9	82	2	18	.18	[5,48]	58
I_{22}	RC_{55}	P_{19} ,P_{116}	11	0	0	11	100	1	[74,100]	59
I_{23}	RC_{52}	P_{45}, P_{57}, P_{100}, P_{58}, P_{118}	11	0	0	11	100	1	[74,100]	60
	RC_{53}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	11	0	0	11	100	1	[74,100]	61
	RC_{54}	P_{99}	11	9	82	2	18	.18	[5,48]	62
	RC_{56}	P_{50},P_{47}	11	0	0	11	100	1	[74,100]	63
	RC_{57}	P_{18}, P_{19}	11	0	0	11	100	1	[74,100]	64
	RC_{58}	P_{102}	11	0	0	11	100	1	[74,100]	65
	RC_{59}	P_{103}, P_{104}, P_{52}, P_{105}	11	0	0	11	100	1	[74,100]	66
	RC_{60}	P_{83}, P_{85}	11	0	0	11	100	1	[74,100]	67
	RC_{61}	P_{91}, P_{92} , P_{93} P_{94}, P_{98}	11	0	0	11	100	1	[74,100]	68

Table 6.26,Continued

Issue ID	Root Causes	RE Practices	No. of Valid Responses (n)	Critical Responses		Supportive Responses		$p\hat{}$	Confidence Interval 95%	Case #
				No.	%age	No.	%age		LL UL	
I_{24}	RC_{62}	P_{45}, P_{50}, P_{47}, P_{109}	11	0	0	11	100	1	[74,100]	69
	RC_{63}	P_{45}, P_{47}, P_{109}	11	0	0	11	100	1	[74,100]	70
	RC_{64}	P_{45}, P_{106} P_{107}, P_{108}, P_{74}, P_{75}	11	0	0	11	100	1	[74,100]	71
	RC_{60}	P_{83}, P_{85}	11	0	0	11	100	1	[74,100]	72
I_{25}	RC_{57}	P_{18}, P_{19}	11	0	0	11	100	1	[74,100]	73
	RC_{12}	P_4, P_5, P_6	11	0	0	11	100	1	[74,100]	74
	RC_{59}	P_{103}, P_{104}, P_{52}, P_{105}	11	0	0	11	100	1	[74,100]	75
	RC_{64}	P_{45}, P_{106}, P_{107}, P_{108}, P_{74}, P_{75}	11	0	0	11	100	1	[74,100]	76
I_{26}	RC_{65}	P_{110}	11	0	0	11	100	1	[74,100]	77
	RC_{66}	P_{68}, P_{111}	11	0	0	11	100	1	[74,100]	78
	RC_{25}	P_{68}	11	0	0	11	100	1	[74,100]	79
	RC_{67}	P_{112}, P_{113}, P_{114}, P_{115}	11	0	0	11	100	1	[74,100]	80
	RC_{43}	P_{45}, P_{46}, P_{47}, P_{48}, P_{49}	11	0	0	11	100	1	[74,100]	81
I_{27}	RC_{56}	P_{50}, P_{47}	11	0	0	11	100	1	[74,100]	82
	RC_{57}	P_{18}, P_{19}	11	0	0	11	100	1	[74,100]	83
	RC_{53}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	11	0	0	11	100	1	[74,100]	84
	RC_{68}	P_{45},P_{46}, P_{57}, P_{100}, P_{58}	11	0	0	11	100	1	[74,100]	85
	RC_{58}	P_{102}	11	0	0	11	100	1	[74,100]	86
	RC_{59}	P_{103} ,P_{104}, P_{52}, P_{105}	11	0	0	11	100	1	[74,100]	87
	RC_{64}	P_{45}, P_{106}, P_{107}, P_{108}, P_{74}, P_{75}	11	0	0	11	100	1	[74,100]	88
	RC_{60}	P_{83}, P_{85}	11	0	0	11	100	1	[74,100]	89

Requirements centric category contains nine issues which are I_{19}, I_{20}, I_{21}, I_{22}, I_{23}, I_{24}, I_{25}, I_{26} and I_{27}.

(a) Critical and supportive responses for issue I_{19}

In case of issue **I_{19}** that is 'Client's insistence on adding new requirements after settlement of cost and time' there are five causes RC_{48}, RC_{49}, RC_{50}, RC_{51} and RC_7. For all the five root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{48} or RC_{49} or RC_{50} or RC_{51} or RC_7 for issue **I_{19}**, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{48}, RC_{49}, RC_{50} and RC_{51} or RC_7, is

beneficial enough for addressing issue **I**$_{19.}$ Figure 6.29 shows %ages of critical and supportive responses in case of all the five root causes for issue I_{19}.

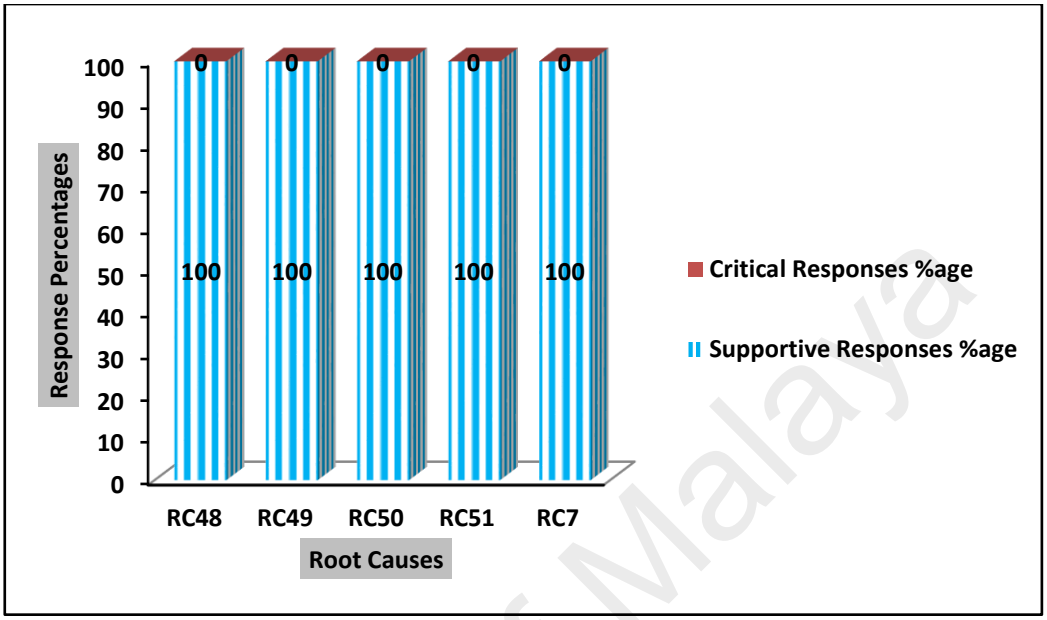

Figure 6. 29 : Percentages of critical and supportive responses for root causes of issue I_{19}

(b) Critical and supportive responses for issue I_{20}

In case of issue **I**$_{20}$ that is 'Not providing information or providing intentionally ambiguous information about requirements' there is only one root cause RC_9. For the root cause RC_9, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_9 for issue **I**$_{20}$, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_9, is beneficial enough for addressing issue **I**$_{20.}$ Figure 6.30 shows %ages of critical and supportive responses in case of single root cause for issue I_{20}.

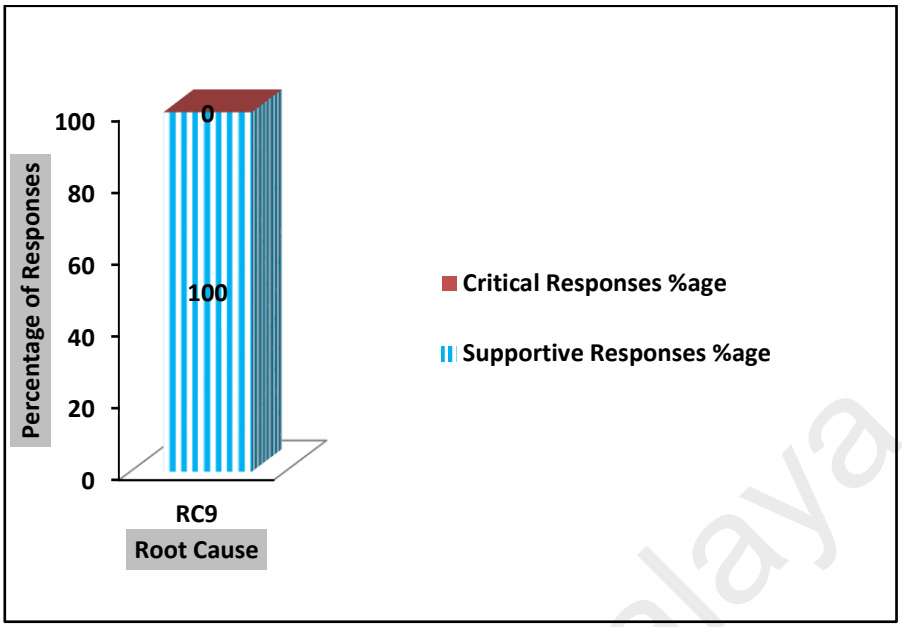

Figure 6. 30 : Percentages of critical and supportive responses for root causes of issue I_{20}

(c) Critical and supportive responses for issue I_{21}

Issue I_{21} is 'Finalizing requirements for all stakeholders based on the requirements gathered or information obtained from the available stakeholders.' In case of issue I_{21} there are three root causes RC_{52}, RC_{53} and RC_{54}. For root causes RC_{52} and RC_{53}, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{52} or RC_{53} for issue **I_{21}**, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{52} or RC_{53}, is beneficial enough for addressing issue **I_{21}**. For the root cause RC_{54}, percentage of critical responses is 82 whereas for supportive responses percentage is 18. LL for CI is 5% and UL is 48% whereas acceptable threshold for supportive responses is 80% (El Emam & Jung, 2001). As CI does not include 80% or above, it indicates that recommended RE practices in case of RC_{54} for addressing issue I_{21} are not

beneficial enough to address I_{21} (Beecham, et al., 2005). Figure 6.31 shows %ages of critical and supportive responses in case of all the three root causes for issue I_{21}.

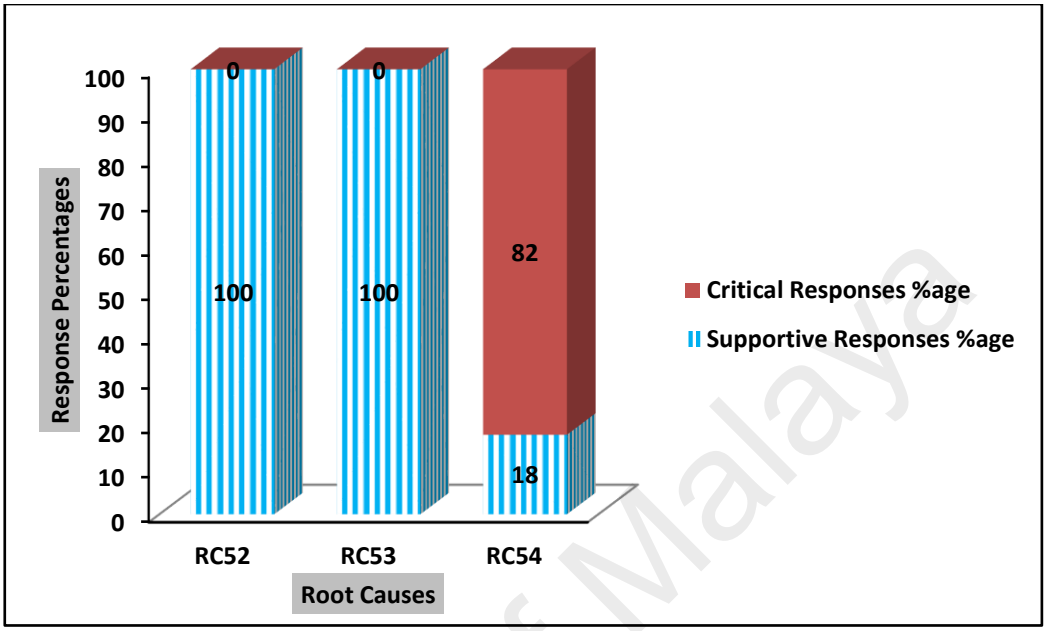

Figure 6. 31 : Percentages of critical and supportive responses for root causes of issue I_{21}

(d) Critical and supportive responses for issue I_{22}

Issue I_{22} is 'Pressure on Requirements Engineers to hide certain information about requirements, resulting in compromised requirements elicitation and specification'. In case of issue I_{22} there is only one root cause RC_{55}. For the root cause RC_{55}, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{55} for issue I_{22}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{55}, is beneficial enough for addressing issue $\mathbf{I}_{22}$. Figure 6.32 shows %ages of critical and supportive responses in case of single root cause for issue I_{22}.

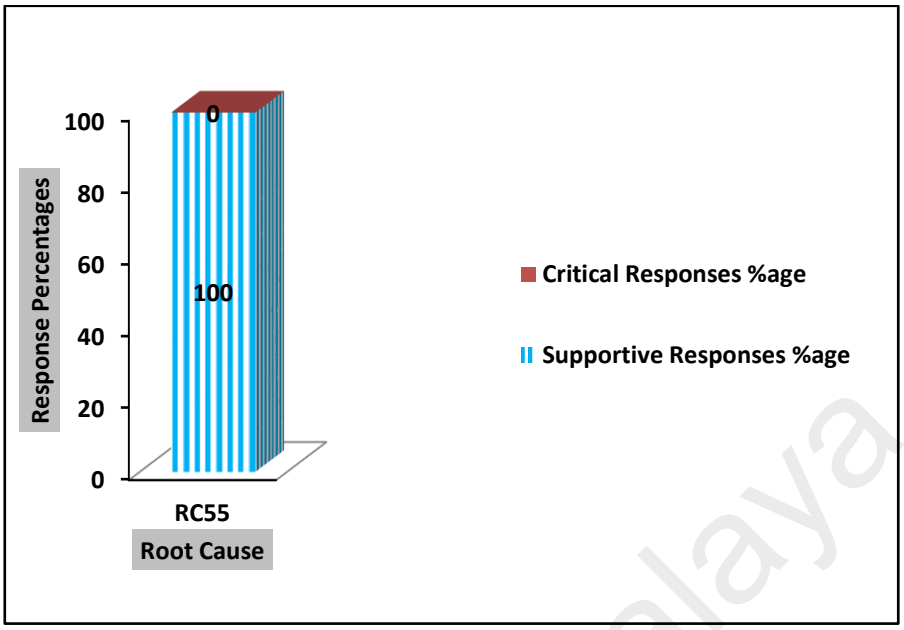

Figure 6. 32 : Percentages of critical and supportive responses for root causes of issue I_{22}

(e) Critical and supportive responses for issue I_{23}

In case of issue I_{23} that is 'Incomplete requirements' there are nine root causes RC_{52}, RC_{53} ,RC_{54}, RC_{56} ,RC_{57}, RC_{58} ,RC_{59}, RC_{60} and RC_{61}. Except RC_{54} for rest of 8 root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{52} or RC_{53} or RC_{56} or RC_{57} or RC_{58} or RC_{59} or RC_{60} or RC_{61} for issue $\mathbf{I_{23}}$, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{52} or RC_{53} or RC_{56} or RC_{57} or RC_{58} or RC_{59} or RC_{60} or RC_{61}, is beneficial enough for addressing issue $\mathbf{I_{23}}$.

For the root cause RC_{54}, percentage of critical responses is 82 whereas for supportive responses percentage is 18. LL for CI is 5% and UL is 48% whereas acceptable threshold for supportive responses is 80% (El Emam & Jung, 2001). As CI does not include 80% or above, it indicates that recommended RE practices in case of RC_{54} for addressing issue

I_{23} are not beneficial enough to address the I_{23} (Beecham, et al., 2005). Figure 6.33 shows %ages of critical and supportive responses in case of all the nine root causes for issue I_{23}.

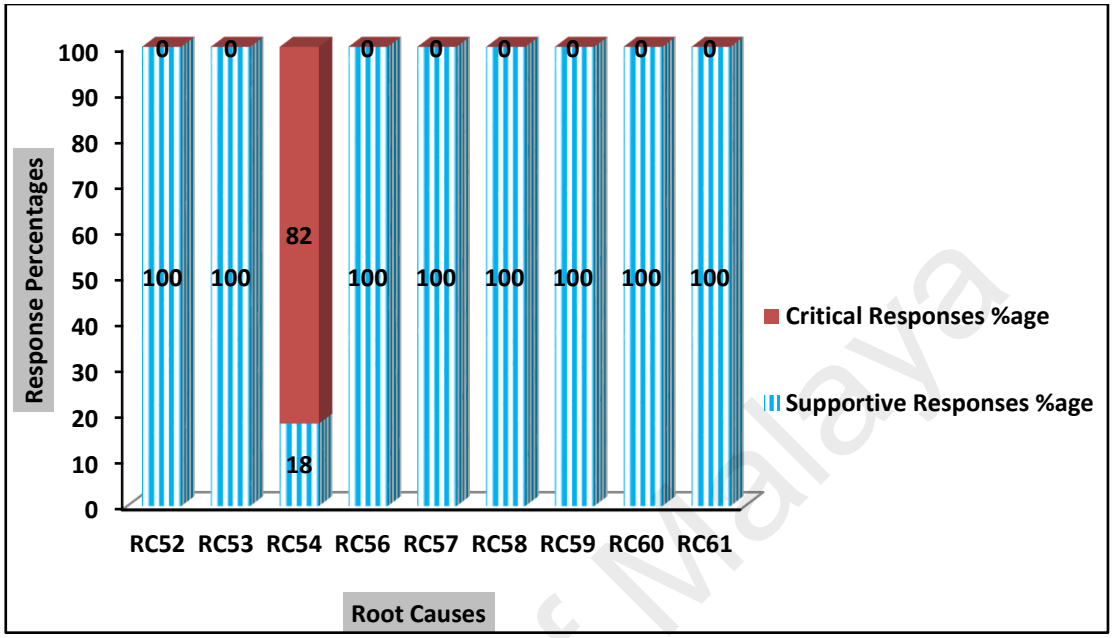

Figure 6. 33 : Percentages of critical and supportive responses for root causes of issue I_{23}

(f) Critical and supportive responses for issue I_{24}

In case of issue I_{24} that is 'Gold plating or extra requirements' there are four root causes RC_{62}, RC_{63}, RC_{64} and RC_{60}. For all the four root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{62} or RC_{63} or RC_{64} or RC_{60} for issue I_{24}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{62} or RC_{63} or RC_{64} or RC_{60}, is beneficial enough for addressing issue $\mathbf{I}_{24}$. Figure 6.34 shows %ages of critical and supportive responses in case of all the four root causes for issue I_{24}.

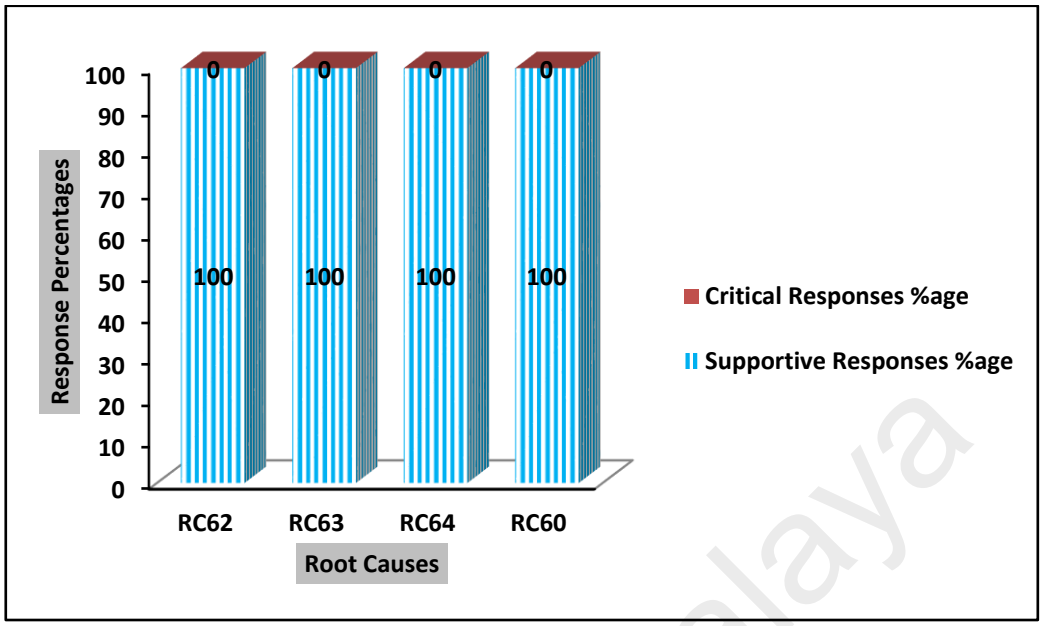

Figure 6. 34 : Percentages of critical and supportive responses for root causes of issue I_{24}

(g) Critical and supportive responses for issue I_{25}

In case of issue I_{25} that is 'Applying suppositions for finalizing requirements' there are four root causes RC_{57}, RC_{12}, RC_{59} and RC_{64}. For all the four root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{57} or RC_{12} or RC_{59} or RC_{64} for issue I_{25}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{57} or RC_{12} or RC_{59} or RC_{64}, is beneficial enough for addressing issue $\mathbf{I}_{25}$. Figure 6.35 shows %ages of critical and supportive responses in case of all the four root causes for issue I_{25}.

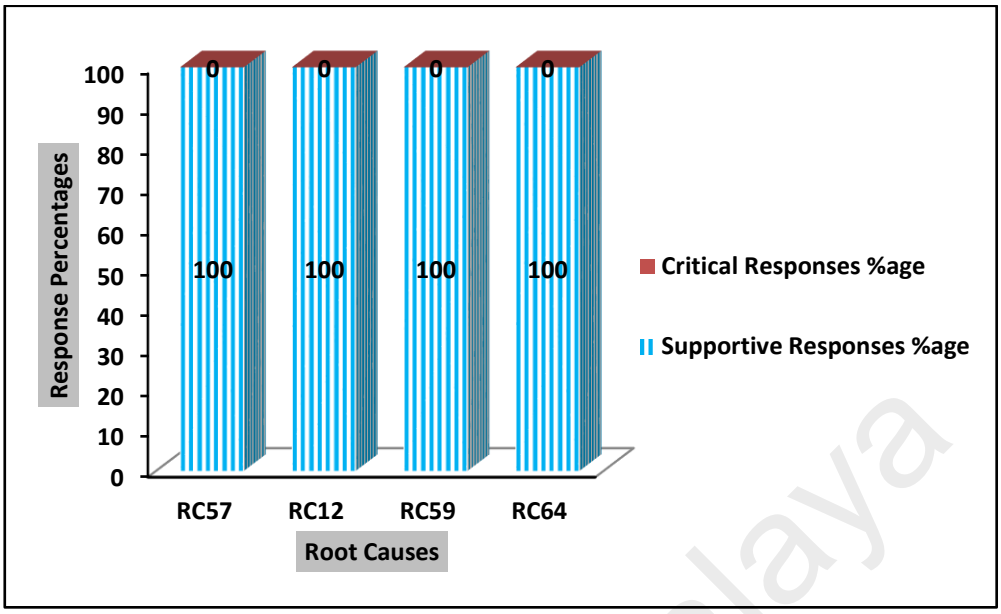

Figure 6. 35 : Percentages of critical and supportive responses for root causes of issue I_{25}

(h) Critical and supportive responses for issue I_{26}

In case of issue I_{26} that is 'Poor or ambiguous requirements specification' there are five root causes RC_{65}, RC_{66}, RC_{25}, RC_{67} and RC_{43}. For all the five root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{65} or RC_{66} or RC_{25} or RC_{67} or RC_{43} for issue I_{26}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{65} or RC_{66} or RC_{25} or RC_{67} or RC_{43}, is beneficial enough for addressing issue $\mathbf{I}_{26.}$ Figure 6.36 shows %ages of critical and supportive responses in case of all the five root causes for issue I_{26}.

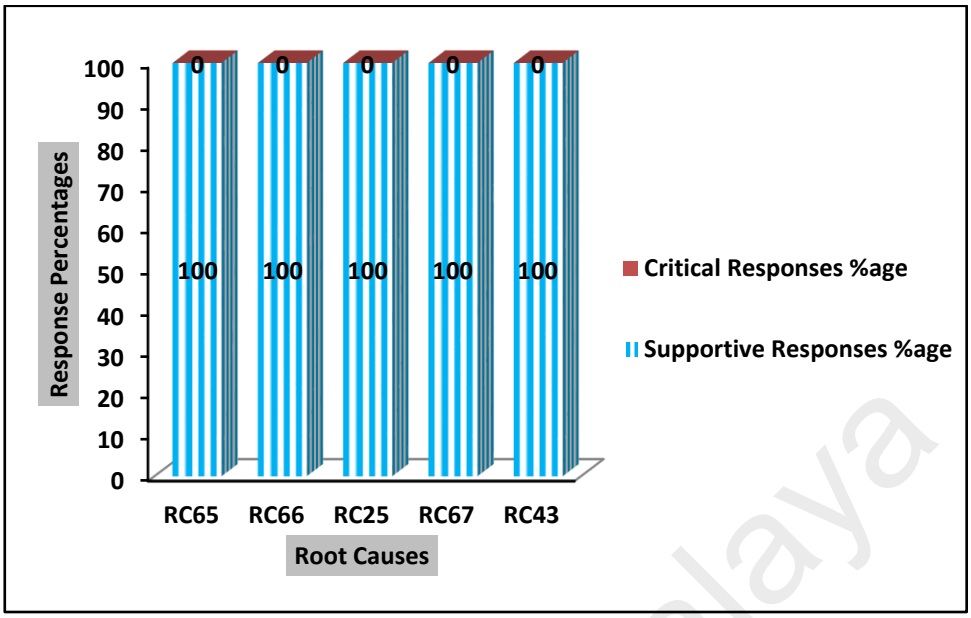

Figure 6. 36 : Percentages of critical and supportive responses for root causes of issue I_{26}

(i) Critical and supportive responses for issue I_{27}

In case of issue I_{27} that is 'Incorrect or false requirements' there are eight root causes RC_{56}, RC_{57}, RC_{53}, RC_{68} ,RC_{58}, RC_{59}, RC_{64}, and RC_{60}. For all the eight root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{56} or RC_{57} or RC_{53} or RC_{68} or RC_{58} or RC_{59} or RC_{64} or RC_{60} for issue I_{27}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{56} or RC_{57} or RC_{53} or RC_{68} or RC_{58} or RC_{59} or RC_{64} or RC_{60}, is beneficial enough for addressing issue $\mathbf{I}_{27}$. Figure 6.37 shows %ages of critical and supportive responses in case of all the eight root causes for issue I_{27}.

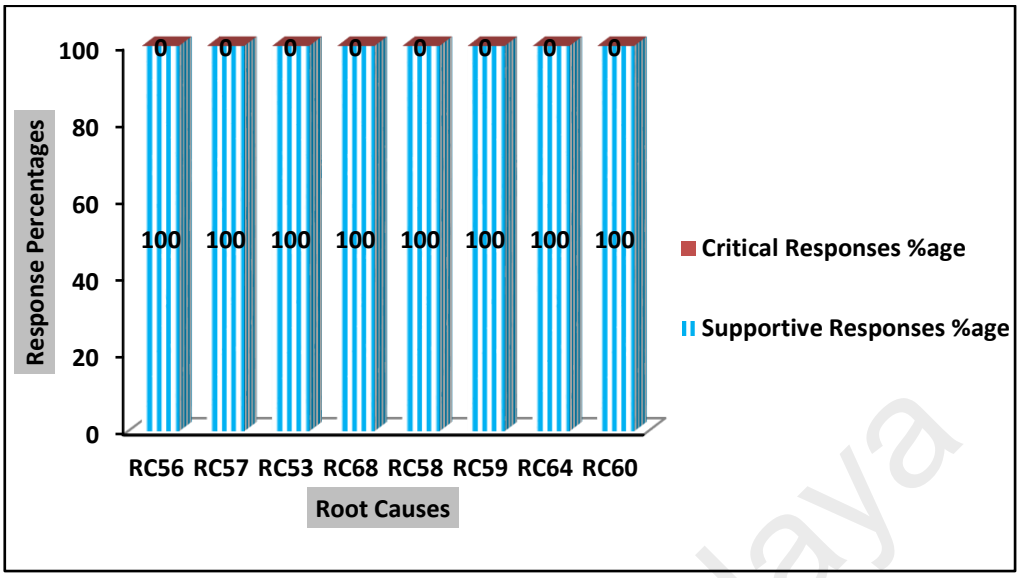

Figure 6. 37 : Percentages of critical and supportive responses for root causes of issue I_{27}

6.1.6.5 Analysis of responses about cultural diversities' issues through CI

No. of valid responses, critical responses and supportive responses for cultural diversities' issues can be extracted from Table 6.11. Table 6.27 shows results.

Table 6. 27 : Based on industrial evaluation, number of valid, critical and supportive responses for cultural diversities' issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses (n)	Critical Responses		Supportive Responses		$p\hat{}$	Confidence Interval 95%	Case #
				No.	%age	No.	%age		LL UL	
I_{28}	RC_{69}	P_{67}	11	1	9	10	91	.91	[62,98]	90
I_{29}	RC_{11}	P_3, P_6	11	1	9	10	91	.91	[62,98]	91
	RC_{70}	P_{50}, P_{47}, P_{52}, P_{89}, P_{90}, P_{60}, P_{54}, P_{53}	11	1	9	10	91	.91	[62,98]	92
	RC_{39}	P_{58}, P_{118}	11	0	0	11	100	1	[74,100]	93
I_{30}	RC_5	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	1	9	10	91	.91	[62,98]	94
	RC_{71}	P_1,P_2, P_{123}	11	1	9	10	91	.91	[62,98]	95
	RC_4	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}	11	0	0	11	100		[74,100]	96
	RC_{11}	P_3, P_6	11	0	0	11	100	1	[74,100]	97
	RC_{72}	P_{61}, P_{62} ,P_{53}	11	0	0	11	100	1	[74,100]	98
	RC_{73}	P_{62} P_{64}	11	0	0	11	100	1	[74,100]	99
	RC_{74}	P_{63}	11	10	91	1	9	.09	[2,38]	100
I_{31}	RC_{75}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17} P_{123}, P_{53}, P_{61}, P_{62}, P_{63}, P_{64}	11	0	0	11	100	1	[74,100]	101
I_{32}	RC_{76}	P_{70}, P_{20}	11	0	0	11	100	1	[74,100]	102
	RC_{28}	P_{120}	11	0	0	11	100	1	[74,100]	103
	RC_{77}	P_4, P_5, P_6.P_{65}, P_{66}, P_{119}	11	0	0	11	100	1	[74,100]	104
	RC_2	P_7, P_8, P_9, P_{10}	11	0	0	11	100	1	[74,100]	105
	RC_{78}	P_{76}	11	0	0	11	100	1	[74,100]	106

There are five issues about cultural diversities. These issues are I_{28}, I_{29}, I_{30}, I_{31} and I_{32}.

(a) Critical and supportive responses for issue I_{28}

Issue I_{28} is 'Difficulties in setting realistic expectations about response time.' In case of I_{28} there is only one root cause RC_{69}. For the root cause RC_{69}, percentage of critical responses is 9 whereas for supportive responses percentage is 91 which is well within CI as LL for CI is 62% and UL is 98%. The [62, 98] with CI 95% means one can be 95% confident that in case of RC_{69} for issue I_{28}, proportion of supportive responses in case of whole population of experts will fall within the range of 62% to 98%. This shows that recommended set of RE practices in case of RC_{69}, is beneficial enough for addressing issue $\mathbf{I}_{28}$. Figure 6.38 shows %ages of critical and supportive responses in case of single root cause for issue I_{28}.

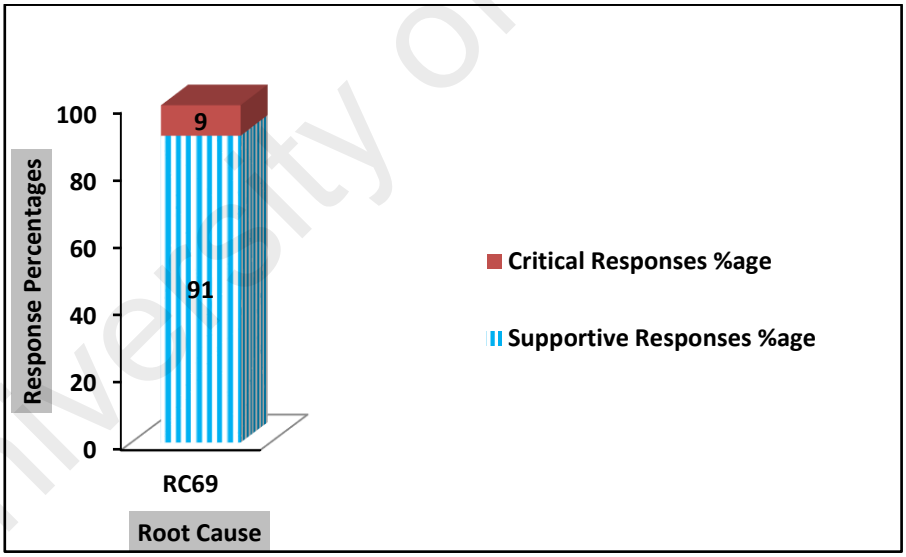

Figure 6. 38 : Percentages of critical and supportive responses for root causes of issue I_{28}

(b) Critical and supportive responses for issue I_{29}

In case of issue I_{29} that is 'Difficulties in achieving consensus on requirements' there are three root causes RC_{11}, RC_{70} and RC_{39}. For root cause RC_{39}, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means

one can be 95% confident that in case of RC_{39} for issue I_{29}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. %. This shows that recommended set of RE practices in case of RC_{39}, is beneficial enough for addressing issue $\mathbf{I}_{29.}$ For root causes RC_{11} and RC_{70}, percentage of critical responses is 9 whereas for supportive responses percentage is 91 which is well within CI as LL for CI is 62% and UL is 98%. The [62, 98] with CI 95% means one can be 95% confident that in case of RC_{11} or RC_{70} for issue I_{29}, proportion of supportive responses in case of whole population of experts will fall within the range of 62% to 98%. This shows that recommended set of RE practices in case of RC_{11} or RC_{70}, is beneficial enough for addressing issue $\mathbf{I}_{29.}$ Figure 6.39 shows %ages of critical and supportive responses in case of all the three root causes for issue I_{29}.

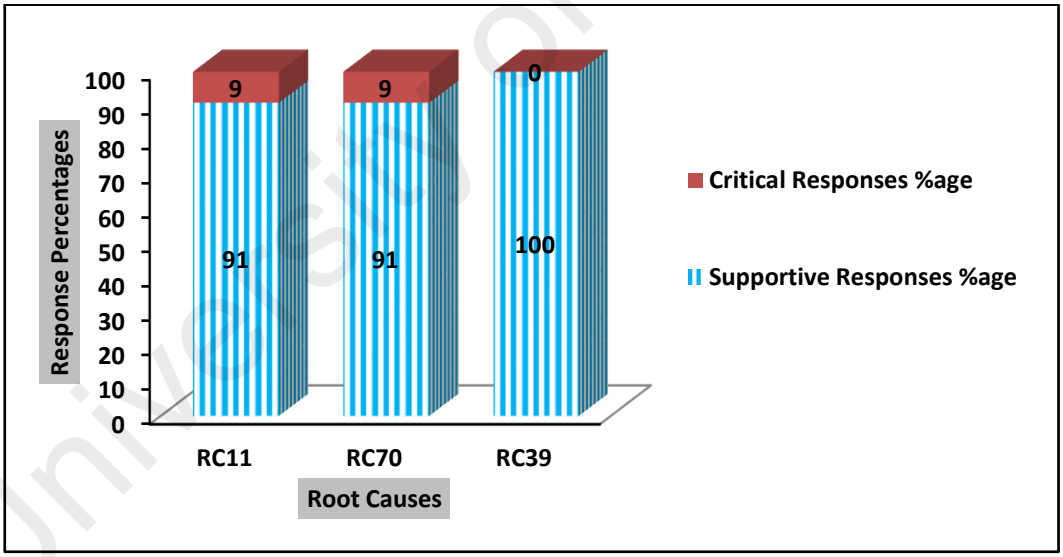

Figure 6. 39 : Percentages of critical and supportive responses for root causes of issue I_{29}

(c) Critical and supportive responses for issue I_{30}

In case of issue I_{30} that is 'Lack of trust' there are seven root causes RC_5, RC_{71}, RC_4, RC_{11}, RC_{72}, RC_{73} and RC_{74}. For root causes RC_5 and RC_{71}, percentage of critical responses is 9 whereas for supportive responses percentage is 91 which is well within CI as LL for CI is 62% and UL is 98%. The [62, 98] with CI 95% means one can be 95%

confident that in case of RC_5 or RC_{71} for issue I_{30}, proportion of supportive responses in case of whole population of experts will fall within the range of 62% to 98%. This shows that recommended set of RE practices in case of RC_5 or RC_{71}, is beneficial enough for addressing issue $\mathbf{I}_{30.}$ In case of root causes RC_4, RC_{11}, RC_{72} and RC_{73}, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_4 or RC_{11} or RC_{72} or RC_{73} for issue I_{30}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_4 or RC_{11} or RC_{72} or RC_{73}, is beneficial enough for addressing issue $\mathbf{I}_{30.}$ For the root cause RC_{74}, percentage of critical responses is 91 whereas for supportive responses percentage is 9. LL for CI is 2% and UL is 38% whereas acceptable threshold for supportive responses is 80% (El Emam & Jung, 2001). As CI does not include 80% or above, it indicates that recommended RE practices in case of RC_{74} for addressing issue I_{30} are not beneficial enough to address the I_{30} (Beecham, et al., 2005). Figure 6.40 shows %ages of critical and supportive responses in case of all the seven root causes for issue I_{30}.

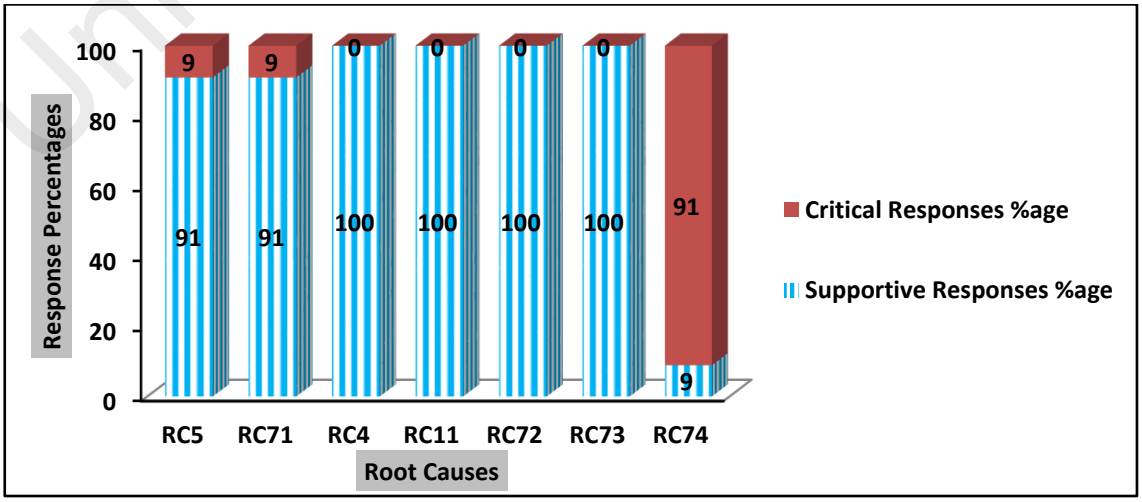

Figure 6. 40 : Percentages of critical and supportive responses for root causes of issue I_{30}

(d) Critical and supportive responses for issue I_{31}

In case of issue I_{31} that is 'Avoidance of the commitments from the stakeholders' there is only one root cause RC_{75}. For the root cause RC_{75}, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{75} for issue I_{31}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{75}, is beneficial enough for addressing issue $\mathbf{I}_{31}$.Figure 6.41 shows %ages of critical and supportive responses in case of single root cause for issue I_{31}.

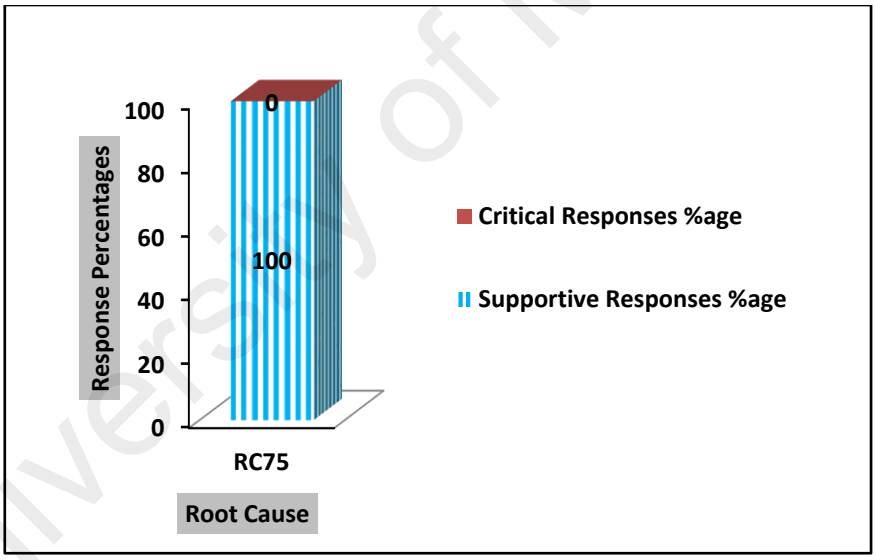

Figure 6. 41 : Percentages of critical and supportive responses for root causes of issue I_{31}

(e) Critical and supportive responses for issue I_{32}

In case of issue I_{32} that is 'Nonparticipation or exclusion of stakeholders from RE activities' there are five root causes RC_{76}, RC_{28}, RC_{77}, RC_2 and RC_{78}. For all the five root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{76} or RC_{28} or

RC_{77} or RC_2 or RC_{78} for issue I_{32}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{76} or RC_{28} or RC_{77} or RC_2 or RC_{78}, is beneficial enough for addressing issue $\mathbf{I}_{32}$. Figure 6.42 shows %ages of critical and supportive responses in case of all the five root causes for issue I_{32}.

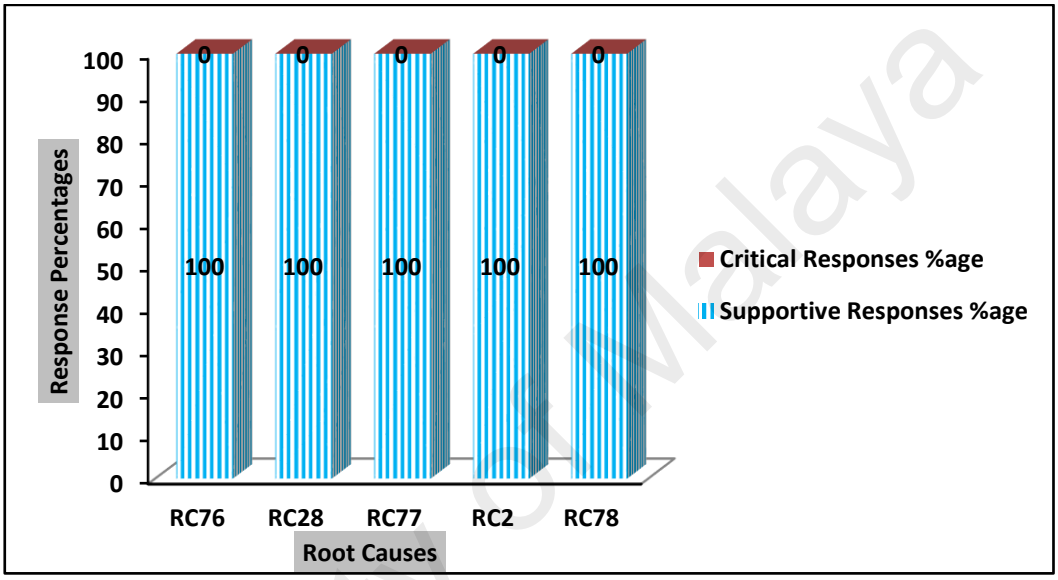

Figure 6. 42 : Percentages of critical and supportive responses for root causes of issue I_{32}

6.1.6.6 Analysis of responses about processes and tools' issues through CI

No. of valid responses, critical responses and supportive responses for processes and tools' issues can be extracted from Table 6.11. Table 6.28 shows results.

Table 6. 28 : Based on industrial evaluation, number of valid, critical and supportive responses for processes and tools' issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses (n)	Critical Responses		Supportive Responses		$\hat{p}$	Confidence Interval 95%	Case #
				No.	%age	No.	%age		LL UL	
I_{33}	RC_{79}	P_{82}, P_{81}	11	0	0	11	100	1	[74,100]	107
	RC_{74}	P_{63}	11	10	91	1	9	.09	[2,38]	108
	RC_{80}	P_{121}	11	0	0	11	100	1	[74,100]	109
I_{34}	RC_{81}	P_{25}, P_{78}, P_{77}, P_{22}, P_{23}, P_{79}	11	0	0	11 7	100	1	[74,100]	110
	RC_{82}	P_{122}, P_{80}, P_{77},P_{81}	11	0	0	11	100	1	[74,100]	111
I_{35}	RC_{23}	P_{25}, P_{78}, P_{77}	11	0	0	11	100	1	[74,100]	112
	RC_{21}	P_{22}, P_{23}	11	0	0	11	100	1	[74,100]	113
	RC_{83}	P_{79}, P_{77}	11	0	0	11	100	1	[74,100]	114
I_{36}	RC_{23}	P_{25}, P_{78}, P_{77}	11	0	0	11	100	1	[74,100]	115
	RC_{84}	P_{77}	11	0	0	11	100	1	[74,100]	116
I_{37}	RC_{85}	P_{83}, P_{84}, P_{85}	11	0	0	11	100	1	[74,100]	117
	RC_{80}	P_{121}	11	0	0	11	100	1	[74,100]	118

There are five issues about processes and tools. These issues are I_{33}, I_{34}, I_{35}, I_{36} and I_{37}.

(a) Critical and supportive responses for issue I_{33}

In case of issue I_{33} that is 'Selection of inappropriate RE tool(s)' there are three root causes RC_{79}, RC_{74} and RC_{80}. In case of root causes RC_{79} and RC_{80}, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{79} or RC_{80} for issue I_{33}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{79} or RC_{80}, is beneficial enough for addressing issue $\mathbf{I}_{33}$. For the root cause RC_{74}, percentage of critical responses is 91 whereas for supportive responses percentage is 9. LL for CI is 2% and UL is 38% whereas acceptable threshold for supportive responses is 80% (El Emam & Jung, 2001). As CI does not include 80% or above, it indicates that recommended RE practices in case of RC_{74} for addressing issue I_{33} are not beneficial enough to address the I_{33} (Beecham, et al., 2005). Figure 6.43 shows %ages of critical and supportive responses in case of all the three root causes for issue I_{33}.

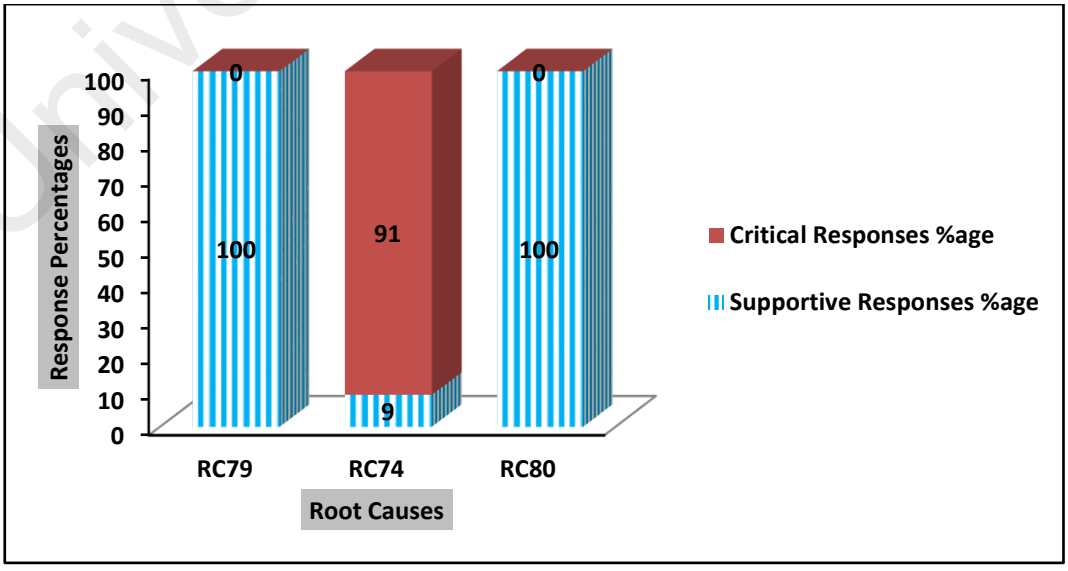

Figure 6. 43 : Percentages of critical and supportive responses for root causes of issue I_{33}

(b) Critical and supportive responses for issue I_{34}

In case of issue **I_{34}** that is 'RE rework or data loss during transfer from one tool to other' there are two root causes RC_{81} and RC_{82}. In case of both the root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{81} or RC_{82} for issue **I_{34}**, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{81} or RC_{82}, is beneficial enough for addressing issue **I_{34}**. Figure 6.44 shows %ages of critical and supportive responses in case of both root causes for issue I_{34}.

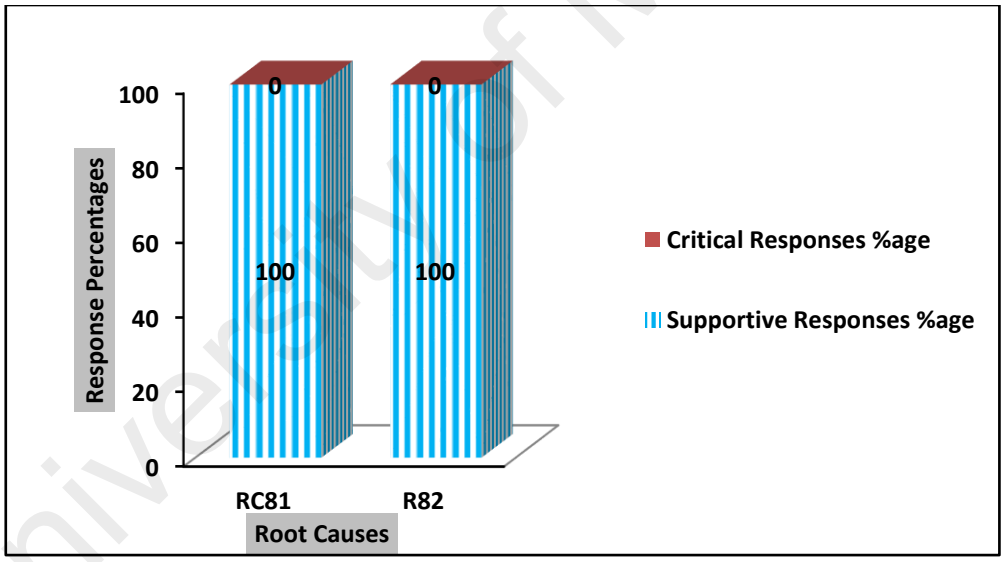

Figure 6. 44 : Percentages of critical and supportive responses for root causes of issue I_{34}

(c) Critical and supportive responses for issue I_{35}

Issue I_{35} is 'Use of different RE processes, resulting in usage of different templates and methodologies, at the different locations of client'. In case of I_{35} there are three root causes RC_{23}, RC_{21} and RC_{83}. For all the three root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be

95% confident that in case of RC_{23} or RC_{21} or RC_{83} for issue I_{35}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{23} or RC_{21} or RC_{83}, is beneficial enough for addressing issue $\mathbf{I}_{35}$. Figure 6.45 shows %ages of critical and supportive responses in case of all the three root causes for issue I_{35}.

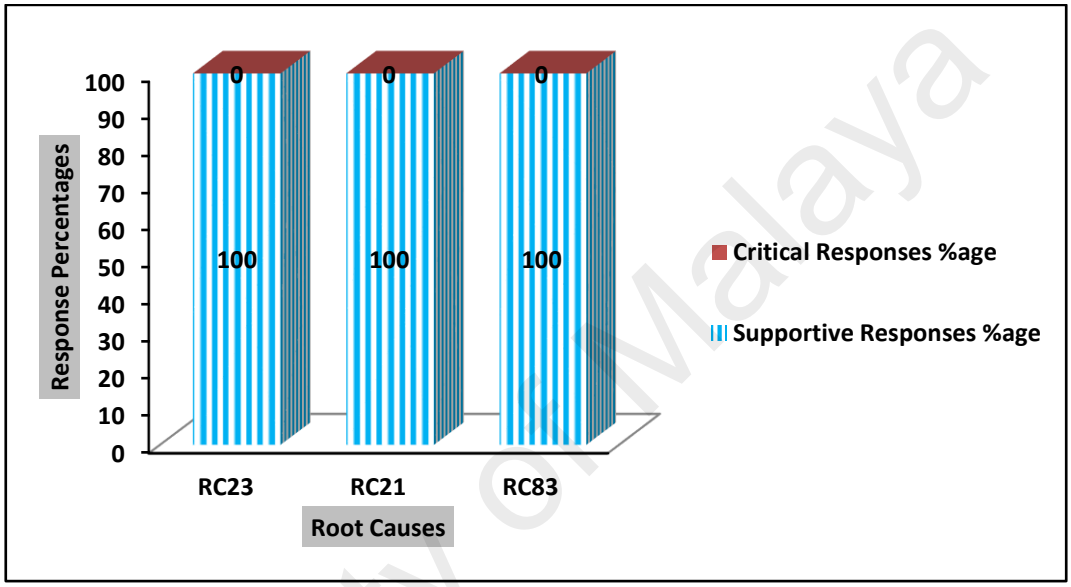

Figure 6. 45 : Percentages of critical and supportive responses for root causes of issue I_{35}

(d) Critical and supportive responses for issue I_{36}

In case of issue I_{36} that is 'Use of unsuitable RE processes' ' there are two root causes RC_{23} and RC_{84}. In case of both the root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{23} or RC_{84} for issue I_{36}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{23} or RC_{84}, is beneficial enough for addressing issue $\mathbf{I}_{36}$. Figure 6.46 shows %ages of critical and supportive responses in case of both root causes for issue I_{36}.

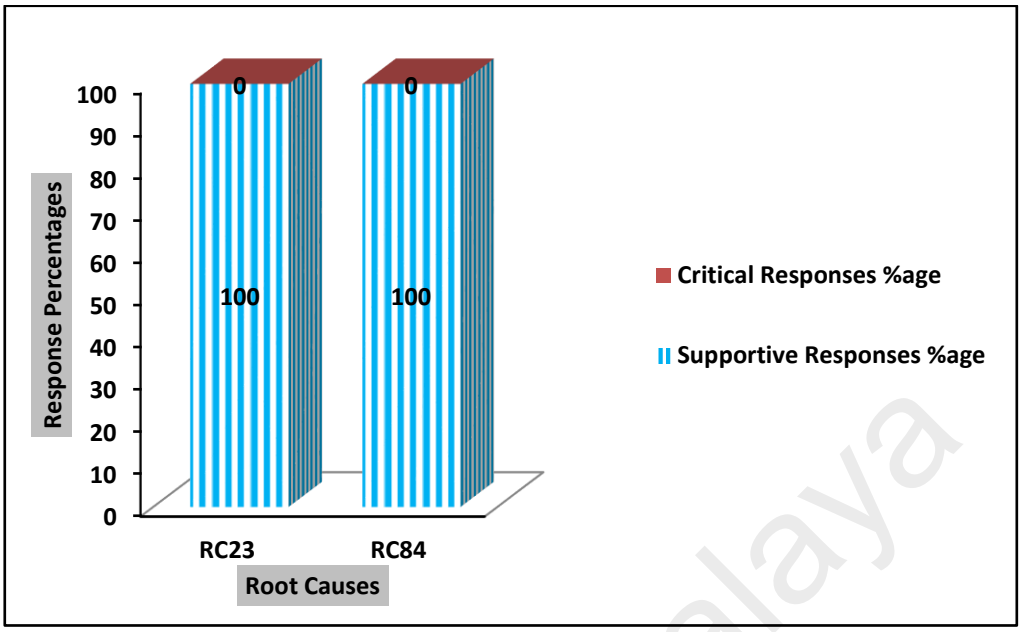

Figure 6. 46 : Percentages of critical and supportive responses for root causes of issue I_{36}

(e) Critical and supportive responses for issue I_{37}

In case of issue I_{37} that is 'Use of unsuitable requirements elicitation technique' there are two root causes RC_{85} and RC_{80}. In case of both the root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{85} or RC_{80} for issue I_{37}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{85} or RC_{80}, is beneficial enough for addressing issue $\mathbf{I}_{37}$. Figure 6.47 shows %ages of critical and supportive responses in case of both root causes for issue I_{37}.

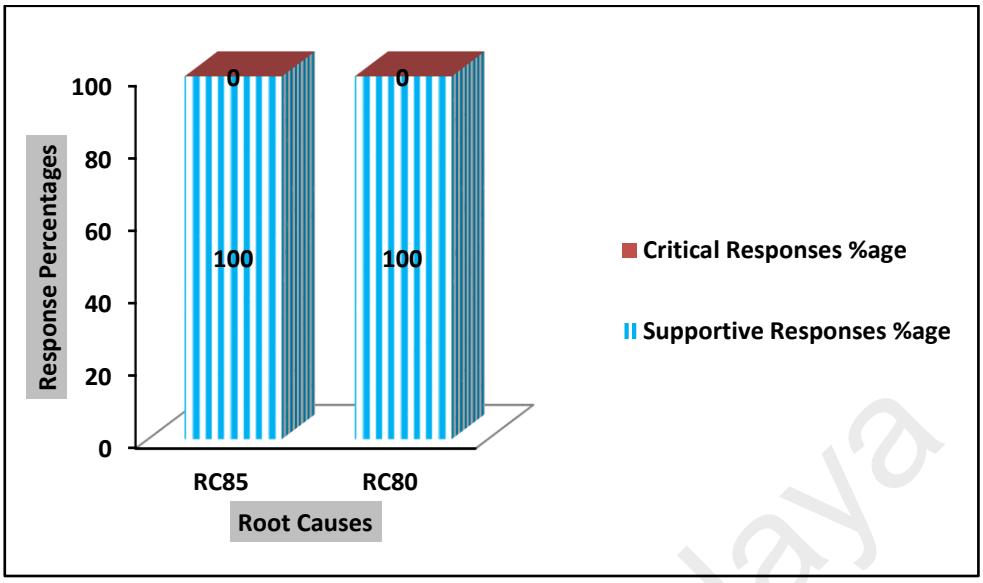

Figure 6. 47 : Percentages of critical and supportive responses for root causes of issue I_{37}

6.1.6.7 Analysis of responses about relationship among stakeholders' issues through CI

No. of valid responses, critical responses and supportive responses for relationship among stakeholders' issues can be extracted from Table 6.11. Table 6.29 shows results.

Table 6. 29 : Based on industrial evaluation, number of valid, critical and supportive responses for relationship among stakeholders' issues

Issue ID	Root Causes	RE Practices	No. of Valid Responses (n)	Critical Responses		Supportive Responses		$p\hat{}$	Confidence Interval 95%	Case #
				No.	%age	No.	%age		LL UL	
I_{38}	RC_{7}	P_{28}	11	0	0	11	100	1	[74,100]	119
I_{39}	RC_{83}	P_{79}, P_{77}	11	0	0	11	100	1	[74,100]	120
	RC_{86}	P_{86}, P_{87}, P_{88}, P_{124}	11	0	0	11	100	1	[74,100]	121
I_{40}	RC_{75}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17} P_{123}, P_{53}, P_{61}, P_{62}, P_{63}, P_{64}	11	0	0	11	100	1	[74,100]	122
	RC_{1}	P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	0	0	11	100	1	[74,100]	123
	RC_{5}	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	0	0	11	100	1	[74,100]	124
	RC_{11}	P_3, P_6	11	0	0	11	100	1	[74,100]	125
	RC_{87}	P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}	11	0	0	11	100	1	[74,100]	126
	RC_{72}	P_{61}, P_{62}, P_{53}	11	0	0	11	100	1	[74,100]	127
I_{41}	RC_{24}	P_{59}	11	0	0	11	100	1	[74,100]	128
I_{42}	RC_{88}	P_{50} ,P_{52}, P_{53}, P_{54}, P_{89}, P_{60}	11	0	0	11	100	1	[74,100]	129
I_{43}	RC_{61}	P_{91},P_{92}, P_{93}, P_{94}, P_{98}	11	0	0	11	100	1	[74,100]	130
	RC_{18}	P_{70}, P_{20}	11	0	0	11	100	1	[74,100]	131
	RC_{89}	P_{95}, P_{96}, P_{97}	11	0	0	11	100	1	[74,100]	132

There are six issues about relationship among stakeholders. These issues are I_{38}, I_{39}, I_{40}, I_{41}, I_{42}, and I_{43}.

(a) Critical and supportive responses for issue I_{38}

In case of issue I_{38} that is 'Issues in signing-off requirements engineering deliverables' there is only one root cause RC_7. For the root cause RC_7, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_7 for issue I_{38}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_7, is beneficial enough for addressing issue **I_{38}**. Figure 6.48 shows %ages of critical and supportive responses in case of single root cause for issue I_{38}.

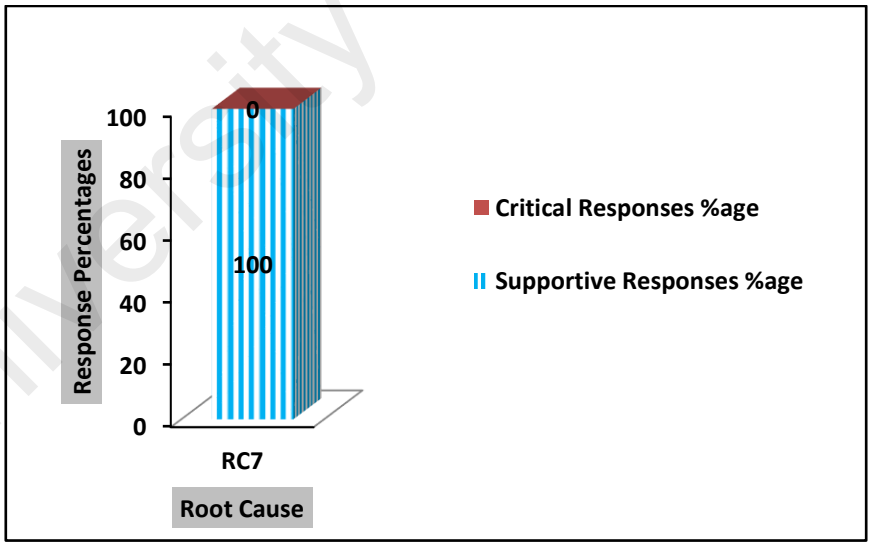

Figure 6. 48 : Percentages of critical and supportive responses for root causes of issue I_{38}

(b) Critical and supportive responses for issue I_{39}

In case of issue I_{39} that is 'Use of different requirements documentation standards by customer and vendor' there are two root causes RC_{83} and RC_{86}. In case of both the root causes, percentage of critical responses is 0 whereas for supportive responses percentage

is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{83} or RC_{86} for issue I_{39}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{83} or RC_{86}, is beneficial enough for addressing issue **I_{39}**. Figure 6.49 shows %ages of critical and supportive responses in case of both root causes for issue I_{39}.

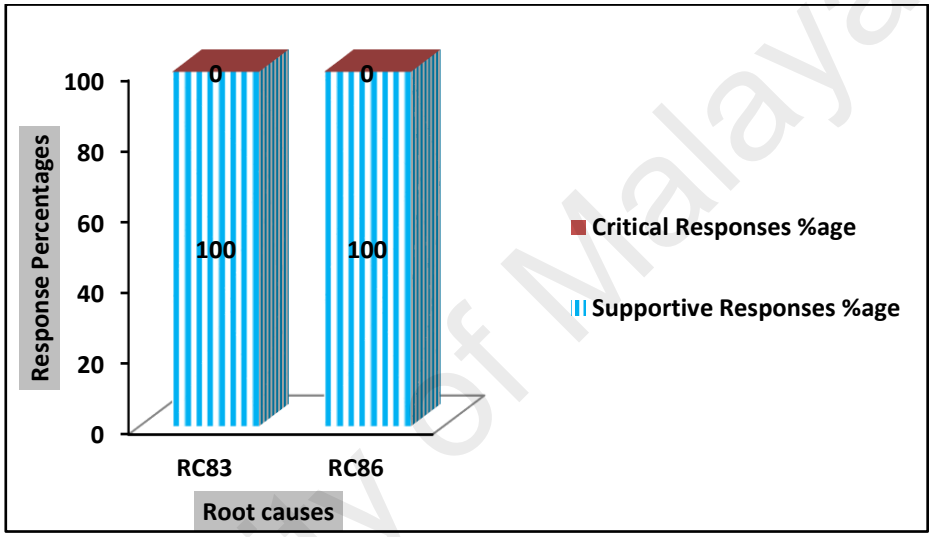

Figure 6. 49 : Percentages of critical and supportive responses for root causes of issue I_{39}

(c) Critical and supportive responses for issue I_{40}

In case of issue I_{40} that is 'Lack of firm relationship among stakeholders' there are six root causes RC_{75}, RC_1, RC_5, RC_{11}, RC_{87} and RC_{72}. For all the six root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{75} or RC_1 or RC_5 or RC_{11} or RC_{87} or RC_{72} for issue I_{40}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{75} or RC_1 or RC_5 or RC_{11} or RC_{87} or RC_{72}, is beneficial enough

for addressing issue **I**$_{40.}$ Figure 6.50 shows %ages of critical and supportive responses in case of all the six root causes for issue I_{40}.

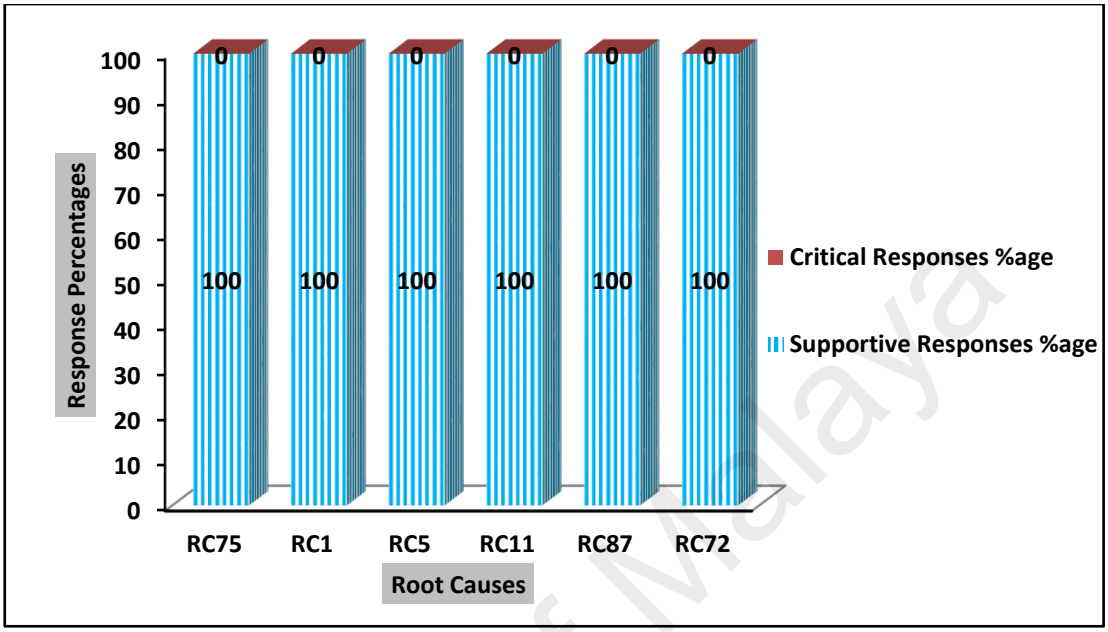

Figure 6. 50 : Percentages of critical and supportive responses for root causes of issue I_{40}

(d) Critical and supportive responses for issue I_{41}

In case of issue I_{41} that is 'Misconceptions of the vendor teams about client's working practices' there is only one root cause RC_{24}. For the root cause RC_{24}, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{24} for issue I_{41}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{24}, is beneficial enough for addressing issue **I**$_{41.}$ Figure 6.51 shows %ages of critical and supportive responses in case of single root cause for issue I_{41}.

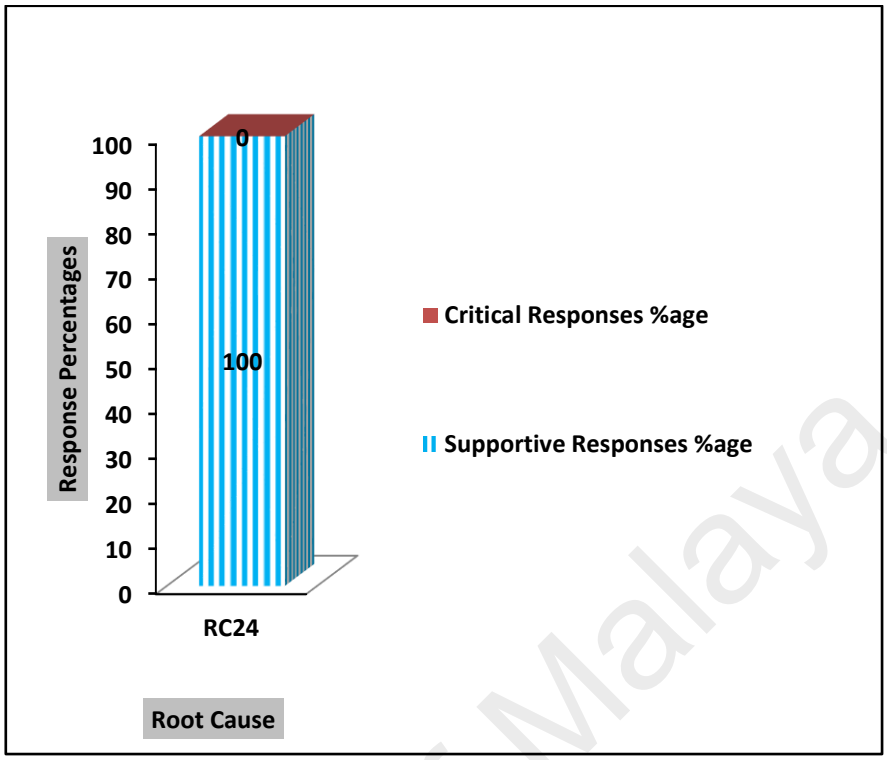

Figure 6. 51 : Percentages of critical and supportive responses for root causes of issue I_{41}

(e) Critical and supportive responses for issue I_{42}

In case of issue I_{42} that is 'Different priorities of client and vendor for collecting and finalizing requirements' there is only one root cause RC_{88}. For the root cause RC_{88}, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{88} for issue I_{42}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{88}, is beneficial enough for addressing issue $\mathbf{I}_{42}$. Figure 6.52 shows %ages of critical and supportive responses in case of single root cause for issue I_{42}.

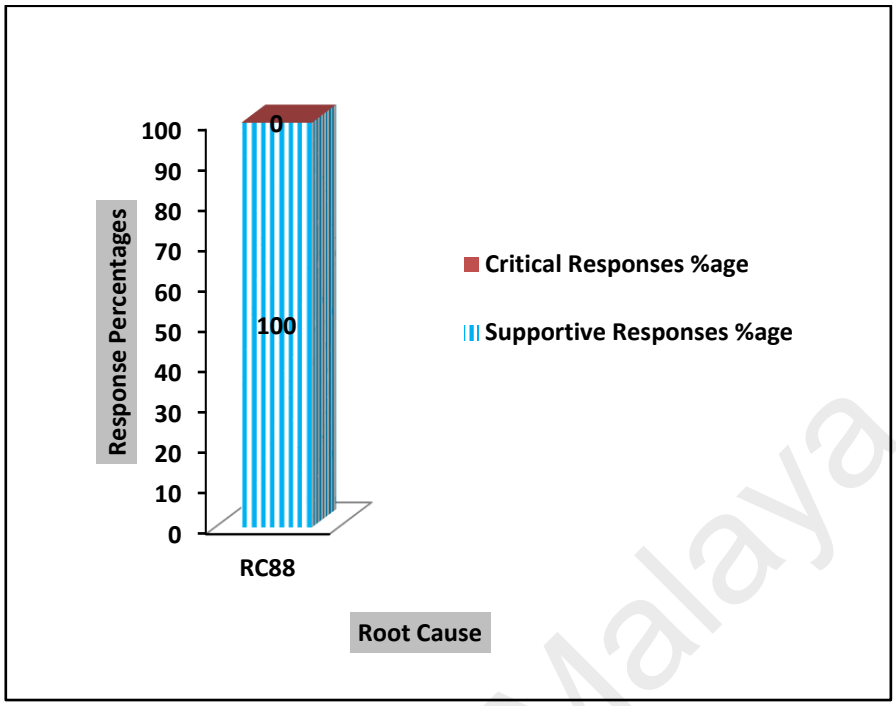

Figure 6. 52 : Percentages of critical and supportive responses for root causes of issue I_{42}

(f) Critical and supportive responses for issue I_{43}

Issue I_{43} is 'Vendor failure in meeting deadlines and fulfilling commitments about requirements'. In case of I_{43} there are three root causes RC_{61}, RC_{18} and RC_{89}. For all the three root causes, percentage of critical responses is 0 whereas for supportive responses percentage is 100 which is acceptable with respect to CI as LL for CI is 74% and UL is 100%. The [74, 100] with CI 95% means one can be 95% confident that in case of RC_{61} or RC_{18} or RC_{89} for issue I_{43}, proportion of supportive responses in case of whole population of experts will fall within the range of 74% to 100%. This shows that recommended set of RE practices in case of RC_{61} or RC_{18} or RC_{89}, is beneficial enough for addressing issue $\mathbf{I_{43.}}$ Figure 6.53 shows %ages of critical and supportive responses in case of all the three root causes for issue I_{43}.

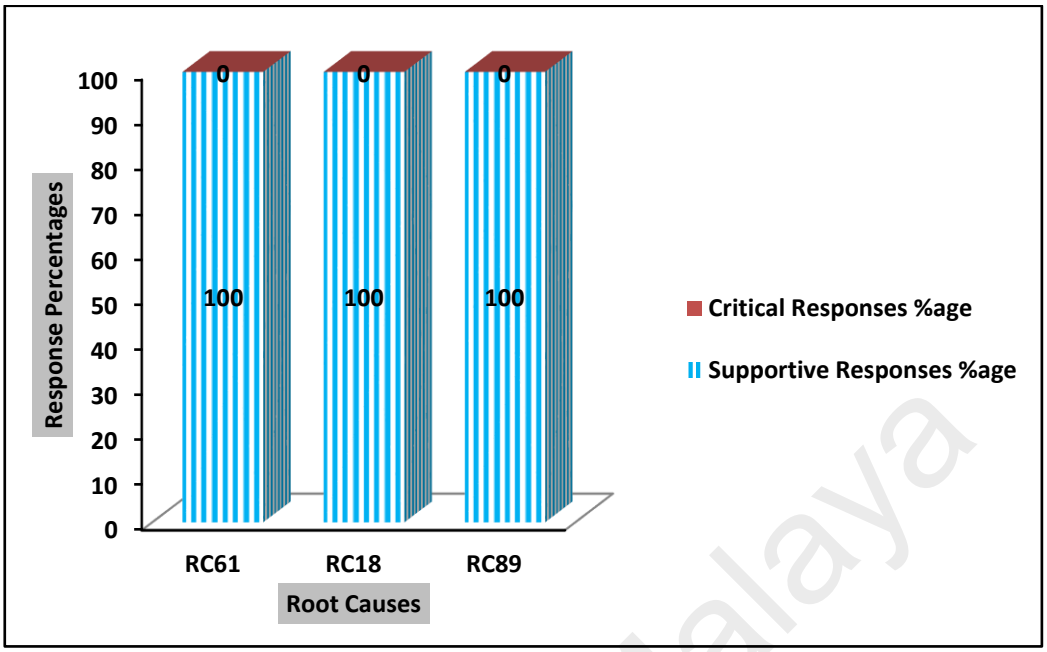

Figure 6. 53 : Percentages of critical and supportive responses for root causes of issue I_{43}

6.1.7 Recommendations from practitioners for improvement of the REP Model

Investigation of the industrial evaluation results by three different methods (applying the 50% rule, analysis of the Content Validity Index, and the Confidence Interval analysis), show that for four issues that are **I_{21}, I_{23}, I_{30} and I_{33}** (for case # 58, 62,100 and 108 respectively) the recommended RE practices have not been considered as beneficial enough to address the corresponding issues of RE process for SDO. Therefore, the four aforementioned cases require new RE practices to address corresponding issues. During the evaluation from the industrial perspective, SDO practitioners have been requested to suggest the RE practices if given RE practices are not ranked as having 'High Perceived Benefits' or 'Medium Perceived Benefits'. Therefore, practitioners have recommended RE practices for issues **I_{33}, I_{30}, I_{23}** and **I_{21}**.

(a) Recommendations for issues I_{33} (Case #108) and I_{30} (Case # 100)

In case of issue **I_{33}** that is selection of inappropriate RE tool(s), there are three root causes:

i) Unawareness from the features of tool(s) (RC_{79}).

ii) Not knowing and fulfilling expectations of other stakeholders (RC_{74}).

iii) Unawareness from the cognitive styles of stakeholders (RC_{80}).

For root cause RC_{74}, recommended RE practice is 'keeping common expectations (P_{63})'. For this case (I_{33}, RC_{74}, P_{63}) that is case no. 108, out of 11 practitioners 10 have ranked P_{63} as 'Low Perceived Benefits' RE practice and only one practitioner has considered it as having 'High Perceived Benefits'. The prominence level is 9.09 which is very low as compared to prominence criterion (50). Moreover, for supportive responses percentage is 9 and CVI is .09.

Similarly in case of issue **I_{30}** that is Lack of trust there are seven root causes:

i) Lack of socialization (RC_5).

ii) Lack of face to face meetings (RC_{71}).

iii) Communication is infrequent and constrained (RC_4).

iv) Unfamiliarity from cultural values (RC_{11}).

v) Poor conflict handling (RC_{72}).

vi) Lack of capability, reliability and expertise (RC_{73}).

vii) Not knowing and fulfilling expectations of other stakeholders (RC_{74}).

For root cause RC_{74}, recommended RE practice is 'keeping common expectations (P_{63})'. For this case (I_{30}, RC_{74}, P_{63}) that is case no. 100, out of 11 practitioners 10 have ranked P_{63} as 'Low Perceived Benefits' RE practice and only one practitioner has

considered it as having 'Medium Perceived Benefits'. The prominence level is 9.09 which is very low as compared to prominence criterion (50). Moreover, for supportive responses percentage is 9 and CVI is .09.

The possible reason for rating P_{63} as having 'Low Perceived Benefits' by a large percentage of practitioners may be that perhaps 'keeping common expectations' is not possible in SDO scenarios as stakeholders belong to different regions of world, have diverse cultural background, speak different languages, and have their own priorities and likings. That is why majority of the SDO practitioners (91%) have ranked P_{63} as having 'Low Perceived Benefits' for addressing corresponding issue(s). Therefore, instead of P_{63}, the practitioners have recommended these three RE practices to address $\mathbf{I_{33}}$ and $\mathbf{I_{30}}$ issues for case no. 108 and case no. 100 respectively.

i) Appointing cultural liaisons or Proxies (individuals who are familiar with the culture of client and vendor) (P_6).

ii) Arranging traveling to remote sites frequently in order to build trust (P_{13}).

iii) Encouraging team members to visit locations of other stakeholders (P_{59}).

(b) Recommendations for Issues I_{23} (Case # 62) and I_{21} (Case # 58)

In case of issue $\mathbf{I_{23}}$ **t**hat is incomplete requirements, there are nine root causes:

i) Unawareness from or not accessing all requirements sources (RC_{52}).

ii) Only selected stakeholders are consulted during the requirements elicitation that results in biased elicitation (RC_{53}).

iii) Key users are not identified or accessed (RC_{54}).

iv) Requirements are not based upon appropriate or sound business case (RC_{56}).

v) Requirements related information is not provided or intentionally ambiguous information is provided (RC_{57}).

vi) System users and people who interact with the requirements engineering team are different (RC_{58}).

vii) Stakeholders are not clear about their requirements (RC_{59}).

viii) Analysts do not have domain knowledge (RC_{60}).

ix) RE teams work with tight schedules to meet deadlines (RC_{61}).

For root cause RC_{54}, recommended RE practice is 'identifying and accessing the key users (P_{99})'. For this case (I_{23}, RC_{54}, P_{99}) that is case no. 62, out of 11 practitioners 9 have ranked P_{99} as 'Low Perceived Benefits' RE practice and two practitioners have considered it as having 'High Perceived Benefits'. The prominence level is 18.18 which is very low as compared to prominence criterion (50). Moreover, for supportive responses percentage is 18 and CVI is .18.

Similarly in case of issue **I_{21}** that is finalizing requirements for all stakeholders based on the requirements gathered or information obtained from the available stakeholders, there are three root causes:

i) Unawareness from or not accessing all requirements sources (RC_{52}).

ii) Only selected stakeholders are consulted during the requirements elicitation that results in biased elicitation (RC_{53}).

iii) Key users are not identified or accessed (RC_{54}).

For root cause RC_{54}, recommended RE practice is 'identifying and accessing the key users (P_{99})'. For this case (I_{21}, RC_{54}, P_{99}) that is case no. 58, out of 11 practitioners 9 have ranked P_{99} as 'Low Perceived Benefits' RE practice, one has considered it as having 'High Perceived Benefits' whereas one practitioner has rated it as having 'Medium Perceived Benefits'. The prominence level is 18.18 which is very low as compared to prominence criterion (50). Moreover, for supportive responses percentage is 18 and CVI is .18.

The possible reason for rating P_{99} as having 'Low Perceived Benefits' by a large percentage of practitioners may be that mostly identifying and accessing all the key users is not possible in SDO scenario as stakeholders are geographically distributed, they may be large in number and they may belong to the regions having large time zone differences. That is why majority of the SDO practitioners (82%) have ranked P_{99} as having 'Low Perceived Benefits' for addressing corresponding issue(s). Therefore, instead of P_{99}, the SDO practitioners have emphasized on improving communication among the stakeholders and have recommended the ten RE practices to address $\mathbf{I_{23}}$ and $\mathbf{I_{21}}$ issues for case no. 62 and case no. 58 respectively. The recommended RE practices are:

i) Establishing proper infrastructure to facilitate communication and ensuring that it works properly (P_1).

ii) Encouraging Synchronous communication in form of chatting, telephone calls, and videoconferencing (P_2).

iii) Adapting and understanding the culture of other stakeholders means knowing about the traditions, beliefs, ethos and native language (P_3).

iv) Deciding and using a standard language for communication (P_4).

v) Focusing on improving the communication language, for example, offering English language courses (P_5).

vi) Appointing cultural liaisons or Proxies (individuals who are familiar with the culture of client and vendor) (P_6).

vii) Establishing 'proximity development center' in the region having no or a little time zone difference from the region of client (P_7).

Viii) Trying to find natural overlapping of working hours (P_8).

ix) Assessing 'around-the-clock' capability of working (P_9).

x) Achieving time zone proximity through time-shifting (changing one‘s working hours in order to overlap with other’s working hours) for which different approaches are:

a) Flextime (working at flexible timings to overlap).

b) Overtime (working for extra time to overlap).

c) Telework (working with flexible schedules from residence to overlap).

d) Long working days (availing working time overlap either at start of day or at end of the day).

e) Unrestricted working hours (there are no restricted working hours and employees set their own working hours to overlap) (P_{10}).

The adoption of these recommendations leads to the revised REP Model.

This completes answer to RQ9.

6.2 The revised REP Model

Table 6.30 presents the revised REP Model after accommodating suggestions given by SDO industry practitioners.

Table 6. 30 : The revised REP Model to address frequently occurring issues of RE process for SDO

Communication Issues *(C1)*	CR_v	OR_u	Root Causes	RE Practices
I_1: Delayed responses.	**1**	**1**	**RC_1**: Lack of informal communication.	**P_1:** Establishing proper infrastructure to facilitate communication and ensuring that it works properly. **P_2:** Encouraging Synchronous communication in form of chatting, telephone calls, and videoconferencing. **P_3:** Adapting and understanding the culture of other stakeholders means knowing about the traditions, beliefs, ethos and native language. **P_4:** Deciding and using a standard language for communication. **P_5:** Focusing on improving the communication language, for example, offering English language courses. **P_6:** Appointing cultural liaisons or Proxies (individuals who are familiar with the culture of client and vendor). **P_7:** Establishing 'proximity development center' in the region having no or a little time zone difference from the region of client. **P_8:** Trying to find natural overlapping of working hours. **P_9:** Assessing 'around-the-clock' capability of working. **P_{10}:** Achieving time zone proximity through time-shifting (changing one's working hours in order to overlap with other's working hours) for which different approaches are: i) Flextime (working at flexible timings to overlap). ii) Overtime (working for extra time to overlap). iii) Telework (working with flexible schedules from residence to overlap). iv) Long working days (availing working time overlap either at start of day or at end of the day). v) Unrestricted working hours (there are no restricted working hours and employees set their own working hours to overlap). **P_{11}:** Equipping remote practitioners' rooms with electronic message "drop in", remote calling and artifacts sharing facilities. **P_{12}:** Facilitating socialization among the practitioners from the beginning of the project, like arranging face-to-face start-off meetings to establish personal relationships. **P_{13}:** Arranging traveling to remote sites frequently in order to build trust. **P_{14}:** Facilitating direct communication among the stakeholders. **P_{15}:** Ensuring that stakeholders introduce themselves to one another right from beginning of the project. **P_{16}:** Encouraging communication in the native language of client. **P_{17}:** Encouraging use of Facebook or Twitter as communication mechanism.
			RC_2: Time Zone differences	**P_7, P_8, P_9, P_{10}.**
			RC_3: Use of asynchronous tools.	**P_2,** **P_{18}:** Promoting the use of groupware tools. **P_{73}:** Appointing one team member that works after the normal working timings and responses to inquiries.
I_2: Lack of informal communication.	**2**	**2**	**RC_4:** Communication is infrequent and constrained.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}.**
			RC_5: Lack of socialization.	**P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}** **P_{17}**
I_3: Usually commitments made during videoconferencing or telephonic conversation cannot be referred if required.	**3**	**3**	**RC_6:** No recording of the conversation.	**P_{26}:** Recording the synchronous communication through telephone calls, Skype and videoconferencing. **P_{27}:** Using email as communication medium for verification as it keeps written record of communication.
			RC_7: Client and vendor rely on oral agreement.	**P_{28}:** Reaching written and properly documented agreements.

Table 6.30, Continued

Communication Issues *(C_1)*	CR_v	OR_u	Root Causes	RE Practices
I_4: Lack of synchronous communication.	**4**	**8**	**RC_8:** Lack of communication infrastructure.	**P_1, P_2.**
			RC_2: Time zone differences.	**P_7, P_8, P_9, P_{10}.**
			RC_9: Reluctance to share information or propensity for non-reporting of the problems because of the fear of negative consequences.	**P_{18}** **P_{19}:** Persuading the stakeholders that revealing the issues or providing information will not have negative fallouts instead will have positive consequences.
			RC_{10}: Shyness of the stakeholders.	**P_{12}, P_{14}, P_{15}, P_{17}.**
I_5: Infrequent and constrained communication among the stakeholders.	**5**	**9**	**RC_8:** Lack of communication infrastructure.	**P_1, P_2**
			RC_{11}: Unfamiliarity from cultural values.	**P_3, P_6**
			RC_{12}: Language diversities among stakeholders.	**P_4, P_5, P_6**
			RC_2: Time zone differences.	**P_7, P_8, P_9, P_{10}**
I_6: Meetings that are held to take decisions about the requirements are unproductive.	**6**	**12**	**RC_{13}:** Use of inappropriate communication medium. **RC_{14}:** Un-readiness or concealing of agenda. **RC_{15}:** Relevant stakeholders are not selected for meeting. **RC_{16}:** Key participants and decision makers are not consulted and/or informed about meeting schedule. **RC_{17}:** No access to the supporting documents that have information about the requirements.	**P_{21}:** Arranging requirements engineering meetings by: i) Engaging a human facilitator and using a rich communication media that supports integration of data, videos and audios. ii) Preparing agenda and following it. iii) Selecting relevant participant and informing them timely to take part in requirements meetings. iv) Timely exchanging supporting documents to give participants enough time to read the relevant material. v) Enabling participants of requirements meetings to access the resources (like emails, relevant documents, work artifacts etc.) that contain information about the requirements.
			RC_{18}: Expected participants do not honor commitments made for participation.	**P_{70}:** Developing stakeholders' consensus on operating terms and conditions for attending meetings and, honoring deadlines and commitments. **P_{20}:** Scheduling video conferences or teleconferences daily, weekly, bimonthly, monthly so that there are no or minimal inconvenient hours for all the stakeholders.
			RC_2: Time zone differences.	**P_7, P_8, P_9, P_{10}.**
Management and coordination Issues (C_2)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_7: Delay in clarifications about requirements and decision making.	**1**	**4**	**RC_1:** Lack of informal communication.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}.**
			RC_2: Time Zone differences.	**P_7, P_8, P_9, P_{10}.**
			RC_3: Use of asynchronous tools.	**P_2, P_{18}, P_{73}**
I_8: Nonperformance of a Requirements Engineering related task as everybody presumes that this is the responsibility of somebody else.	**2**	**7**	**RC_{19}:** Responsibilities are assigned without consent and/ or to inappropriate persons.	**P_{24}:** Having clearly defined and agreed responsibilities for each individual and group.
			RC_{20}: The responsibilities are poorly defined or undefined.	**P_{22}:** Establishing authoritative leadership at the level of project managers and team heads. **P_{23}:** Marinating explicit sequence of commands. **P_{24},** **P_{25}:** Having clearly delineated and comprehended requirements engineering processes.

				P_{34}: By using an awareness support system for requirements management, all the stakeholders should be able to access following information: i) Requirements' descriptions, rationale and priorities. ii) Dependencies among the requirements and with design, coding and testing. iii) Each team member's responsibilities with respect to particular requirement(s) and contact information like email, phone number. iv) Requirements' initiators. v) Issues related to requirements, issues' initiators, status of the resolution of those issues and decisions taken due to issues. vi) Meetings' date, time and location, stakeholders that are involved, discussed issues and decisions taken. vii) Change requests, initiators of change request, status of the decisions about those requests, people involved in taking decisions and decisions taken. **P_{77}:** Providing training potential team members for using appropriate processes, and supporting tools and technologies. **P_{78}:** There is no standard RE process but six common activities for RE process are: i. Requirements Elicitation, ii. Requirements Analysis and negotiations, iii. Describing requirements, iv. System Modeling, v. Requirements Validation and vi. Requirements Management.
			RC_{21}: Leaders do not use authority.	**P_{22}, P_{23}**

Table 6.30, Continued

Management and coordination Issues (C_2)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_9: Poorly defined or undefined responsibilities.	**3**	**10**	**RC_{22}:** Absence of central and trusted management.	**P_{22}, P_{23}, P_{24}, P_{34}.**
			RC_{23}: Unclear or undefined RE processes.	**P_{25}, P_{78}, P_{77}**
I_{10}: Difficulties in comprehending information, reasons and activities that are required for common Requirements Understanding (RU) among the dispersed stakeholders.	**4**	**14**	**RC_1:** Lack of informal communication.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}, P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}.**
			RC_{24}: Stakeholders belonging to diverse cultural backgrounds: i) Have different values regarding hierarchies, handling risks, following schedules and precision of work. ii) Speak different languages, use different communication styles and are at different proficiency level of communication language. iii) Deduce inexplicit meanings and explanations from the information about requirements.	**P_{59}:** Taking following measures to overcome cultural issues: i) (P_6) Appointing cultural liaisons or Proxies (individuals who are familiar with the culture of client and vendor). ii) Encouraging team members to visit locations of other stakeholders. iii) Arranging the cultural trainings. iv) Conducting orientation courses for cultural differences. v) Keeping in view cultural values of stakeholders while deciding females' roles. vi) Adopting 'Negotiated Culture', a compromised culture that is developed to honor the cultural norms of all the stakeholders. vii) Nominating the individuals, who are experienced and acquainted with the culture of the client, to assist for requirements negotiation and specification. viii) (P_4) Deciding and using a standard language for communication. ix) (P_5) Focusing on improving the communication language, for example, offering English language courses. x) Arrangement and monitoring of all the activities, which are performed to deal with cultural diversities, by project manager or senior team members.
			RC_{25}: Different terminologies and notations are used to express same meanings or same terminologies are used to convey different meanings.	**P_{68}:** Defining and using requirements specification glossary and notations.

			RC_{26}: Lack of coordination.	**P_{69}:** Taking following measures, by vendor mangers, for creating coordination: i) Defining roles and responsibilities of team members and creating Organizational Charts that display positions and responsibilities ii) Attaining the required human resources and managing them through Resource Calendar. iii) Allocating tasks appropriately. iv) (P_{30}) Establishing peer-to-peer links among distributed sites at the team, project and management level. v) (P_{31}) Partially synchronizing inter-organizational processes. vi) (P_{32}) Maintaining open communication lines among different well-defined roles of stakeholders. vii) (P_{33}) Regularly checking and notifying the progress about mutually agreed upon artifacts.
			RC_{27}: Interaction among stakeholders is difficult.	**P_{118}:** Using Wikis geographically distributed stakeholders are engaged to explore their needs or requirements, discuss related issues, ask about new features and create requirements.
			RC_{28}: Stakeholders' lack of motivation to participate in RE activities.	**P_{120}:** Enabling online collaboration using requirements visualization tools (like use case models, business process diagrams) and social visualization techniques to stimulate the involvement of stakeholders and provide better understanding of requirements.
			RC_2: Time zone differences	**P_7, P_8, P_9, P_{10}.**

Table 6.30, Continued

Management and coordination Issues (C_2)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{11}: Need for adjustment of actual requirements to interact with other software(s).	**5**	**19**	**RC_{29}:** Requirements belong to a software system that, being part of a large system, interacts with other software.	**P_{45}:** Identifying all the stakeholders and considering their needs. **P_{47}:** Defining operational processes. **P_{48}:** Defining system boundaries. **P_{49}:** Defining operating environment of system. **P_{50}:** Using business concerns of client to derive requirements elicitation. **P_{56}:** Developing the model of system's environment. **P_{74}:** Organizing the requirements inspections and involve multi-disciplinary teams for reviewing requirements. **P_{75}:** Defining the checklists for validation of requirements. **P_{41}:** Defining policies to manage changes in requirements.
Knowledge management and awareness Issues (C_3)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{12}: Poor requirements change management.	**1**	**4**	**RC_{30}:** Inability to identify and refer requirements.	**P_{46}:** Recording requirements originating sources. **P_{38}:** Identifying each requirement through a unique identifier.
			RC_{31}: Inability to trace requirements sources, rationale, dependencies among requirements, and dependencies between requirements and design, sub-systems and interface.	**P_{39}:** Defining requirements traceability policies. **P_{40}:** Maintaining the manual for traceability.
			RC_{32}: Not defining requirements change request process, and process for analysis of impacts and costs of changes.	**P_{41}** **P_{101}:** Establishing the Change Control Board (CCB) and including new requirements by following a proper requirements change management process (change evaluation and propagation mechanism). **P_{42}:**Using a Requirements Management System (to control and track changes) that provides following feature: i) Navigating given set of requirements, retrieving specific requirements and grouping requirements based on certain parameters.

				ii) Management of requirements change process, requirements traceability support and generation of various types of reports about requirements. iii) Interface to accept external documents. iv) Management of the various versions of requirements. v) Support for performing different types of analysis (like impact analysis, to know a requirement is orphan or not, for tracking of status). vi) Restricting rights to access and edit the given set of requirements.
			RC_{33}: Ineffective dissemination of the information about requirements changes.	**P_{34}.**
			RC_{34}: Analysts change requirements by ignoring the change management process.	**P_{41}, P_{101} , P_{42}, P_{22}**

Table 6.30, Continued

Knowledge management and awareness Issues (C_3)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{13}: Unawareness of the stakeholders from current or latest information about requirements.	**2**	**4**	**RC_1:** Lack of informal communication.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}.**
			RC_{35}: Distance among the stakeholders. **RC_{36}:** Inexperienced team members. **RC_{37}:** Decentralized communication	**P_{34}** **P_{35}:** Keeping experienced practitioners in team and those practitioners should bridge the awareness gap. **P_{36}:** Implementing centralized communication structure.
I_{14}: Unawareness from or not accessing all requirements sources.	**3**	**10**	**RC_{38}:** Not identifying all potential requirements sources.	**P_{45}** **P_{57}:** Identifying and accessing all requirements sources. The possible requirements sources are: i) End-users of the system, managers, directors, administrators, clients, developers and maintenance personnel. ii) Individuals who are involved in the activities of business processes. iii) Individuals who are concerned or affected as stated by client management. iv) Requirements specification provided by client or needs of various stakeholders. v) Problems or issues faced by stakeholders. vi) Domain experts. vii) Domain constraints, regulations and standards to be followed. viii) Similar existing systems. ix) Users of similar existing systems. x) Documents about the target system like record-keeping books, bills, receipts and reports. xi) Other software(s) or system(s) that interact with the system to be developed. **P_{100}:** Asking the known or identified stakeholders about other stakeholders, based on their suggestions building stakeholders' social network and then prioritizing stakeholders based on measures of social network.
			RC_{39}: High number of stakeholders as sources of requirements.	**P_{58}:** In case of high number of stakeholders: i) Appointing a person (communication channel) from each unit of organization or group of requirements information sources for gathering the requirements from respective unit or group. Then communication channels transfer requirements to an expert where these requirements can be bundled. ii) Using group elicitation techniques like group Brainstorming, JAD (Joint Application Development), Focus groups and requirements creativity workshops for getting consensus on requirements. iii) Preparing a combined requirements document containing all the requirements. **P_{118}**

Table 6.30, Continued

Knowledge management and awareness Issues (C_3)	CR_v	OR_u	Root Causes	RE Practices
I_{15}: Reopening of the already discussed and seemingly settled issues.	**4**	**13**	**RC_{40}:** Stakeholders are not aware of the current information about requirements.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}. P_{34}, P_{35}, P_{36}.**
			RC_{41}: Repetitive discussions among the stakeholders as: i) They forget about already taken decisions. ii) Any team member is allowed to communicate with any other stake holder.	**P_{37}:** Describing summary of proceedings after every meeting. A team member or facilitator should summarize that which issues have been raised during the meeting, what has been decided about each issue, which issues are pending, whose responsibility is to find out further information and whose advice should be sought in case of each issue. **P_{72}:** Regarding decisions maintaining continuous communication with customer by arranging : i) Face-to-face meetings ii) Videoconferences. **P_{71}:** Defining the role of every team member and indicating who should communicate with whom. **P_{36}**
I_{16}: Unawareness of requirements engineers from the effects of new system implementation on the client organization.	**5**	**14**	**RC_{42}:** No assessment of system feasibility.	**P_{44}:** Assessing system feasibility.
			RC_{43}: Lack of the awareness, about the environment in which system is to be deployed.	**P_{45}, P_{46}, P_{47}, P_{48}, P_{49}**
			RC_{44}: Unawareness from the context and importance of requirements.	**P_{50}** **P_{51}:** Looking for domain constraints. **P_{52}:** Recording requirements rationale. **P_{53}:** Planning for conflict identification and resolution. **P_{54}:** Prioritizing requirements by consulting stakeholders. **P_{55}:** Assessing requirements risks. **P_{56}**
I_{17}: Working on obsolete requirements.	**6**	**14**	**RC_{45}:** Delayed responses.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}, P_{18}, P_{73}.**
			RC_1: Lack of informal communication.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10} P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}**
			RC_{46}: Poor requirements change management.	**P_{46}, P_{38}, P_{39}, P_{40}, P_{41}, P_{101}, P_{42}, P_{34}, P_{22}.** **P_{43}:** Informing the relevant stakeholder about the requirements change: i) Through the telephone calls, emails and internet supported communication tools. ii) By generating automatic notifications through the system.
I_{18}: Hindrance in circulation of requirements knowledge from or to organizations.	**7**	**41**	**RC_{47}:** Diverse and undefined organizational structure.	**P_{29}:** Forming a well-defined organizational structure having clear communication responsibilities. **P_{30}:** Establishing peer-to-peer links among distributed sites at the team, project and management level. **P_{31}:** Partially synchronizing inter-organizational processes. **P_{32}:** Maintaining open communication lines among different well-defined roles of stakeholders. **P_{33}:** Regularly checking and notifying the progress about mutually agreed upon artifacts. **P_6.**
Requirements centric Issues (C_4)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{19}: Client's insistence on adding new requirements after settlement of cost and time.	**1**	**14**	**RC_{48}:** Change in operational processes. **RC_{49}:** Change in business concerns. **RC_{50}:** Change in laws. **RC_{51}:** Change in operating environment.	**P_{117}:** Relating extra requirements to additional budget and time. **P_{101}.**
			RC_7: Client and vendor rely on oral agreement.	**P_{28}**

Table 6.30, Continued

Requirements centric Issues (*C4*)	CR_v	OR_u	Root Causes	RE Practices
I_{20}: Not providing information or providing intentionally ambiguous information about requirements.	**2**	**14**	**RC_9:** Reluctance to share information or propensity for non-reporting of the problems because of the fear of negative consequences.	**P_{18}, P_{19}.**
I_{21}: Finalizing requirements for all stakeholders based on the requirements gathered or information obtained from the available stakeholders.	**3**	**20**	**RC_{52}:** Unawareness from or not accessing all requirements sources.	**P_{45},P_{57}, P_{100}, P_{58} , P_{118}**
			RC_{53}: Only selected stakeholders are consulted during the requirements elicitation that results in biased elicitation.	**P_{45},P_{46}, P_{57}, P_{100}, P_{58}**
			RC_{54}: Key users are not identified or accessed.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}.**
I_{22}: Pressure on Requirements Engineers to hide certain information about requirements, resulting in compromised requirements elicitation and specification.	**4**	**21**	**RC_{55}:** Sensitivity of data.	**P_{19} ,** **P_{116}:** Sharing requirements related information only with concerned people.
I_{23}: Incomplete requirements.	**5**	**21**	**RC_{52}:** Unawareness from or not accessing all requirements sources.	**P_{45}, P_{57}, P_{100}, P_{58},P_{118}**
			RC_{53}: Only selected stakeholders are consulted during the requirements elicitation that results in biased elicitation.	**P_{45},P_{46}, P_{57}, P_{100}, P_{58}**
			RC_{54}: Key users are not identified or accessed.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}.**
			RC_{56}: Requirements are not based upon appropriate or sound business case.	**P_{50},P_{47}**
			RC_{57}: Requirements related information is not provided or intentionally ambiguous information is provided.	**P_{18}, P_{19}**
			RC_{58}: System users and people who interact with the requirements engineering team are different.	**P_{102}:** Involving real system users in RE process.
			RC_{59}: Stakeholders are not clear about their requirements.	**P_{103}:** Prototyping the poorly understood requirements.. **P_{104}:** Using elicitation techniques like Brainstorming. **P_{52}** **P_{105}:** Reusing requirements from already developed similar systems.
			RC_{60}: Analysts do not have domain knowledge.	**P_{83}:** Appointing a professional as requirements engineer or analyst that has: i) Knowledge or should be able to learn about domain and advanced elicitation techniques. ii) Abilities for operating in international context that is with virtual teams and diverse cultures. iii) Abilities for resolving conflicts and working in uncertain and ambiguous situations. iv) Knowledge about case tools, system modeling and programming languages, requirements management tools and human-computer interaction. v) Skills for communication, social interaction, problem solving, working as team member as well as independently, innovation and being adaptable to changes. **P_{85}:** Consulting domain experts if possible.

			RC_{61}: RE teams work with tight schedules to meet deadlines.	**P_{91}:** Making plan for requirements engineering and out of the total project efforts, dedicating 15 to 30 % effort for Requirements Engineering. **P_{92}:** Assessing the time required for different activities by considering the fact that delays are most likely to occur as stakeholders are spread. **P_{93}:** Calculating and accommodating the Float or Slack Time in schedule if possible. **P_{94}:** Reusing requirements from already developed similar systems if possible. **P_{98}:** In case of slow progress: Spending more time and resources OR Decreasing RE work after consulting stakeholders OR Transferring some load to some other contractor.

Table 6.30, Continued

Requirements centric Issues (C_4)	CR_v	OR_u	Root Causes	RE Practices
I_{24}: Gold plating or extra requirements.	**6**	**24**	**RC_{62}:** Requirements are added for sake of goodwill or to make client happy.	**P_{45}, P_{50}, P_{47}** **P_{109}:** Defining boundaries of the system and eliminating out of scope requirements.
			RC_{63}: Users are fascinated by the features of other systems and want to have in their system but actually those features not required.	**P_{45}, P_{47}, P_{109}**
			RC_{64}: Requirements Engineers assume, based on their experience, that they know requirements of users.	**P_{45},** **P_{106}:** Identifying a set of minimum requirements to satisfy the needs of client. **P_{107}:** Using checklists (a list of question to asses each requirement) for requirements analysis. **P_{108}:** Writing an agreed upon Software Requirements Specification document. **P_{74}, P_{75}.**
			RC_{60}: Analysts do not have domain knowledge.	**P_{83}, P_{85}**
I_{25}: Applying suppositions for finalizing requirements.	**7**	**32**	**RC_{57}:** Requirements related information is not provided or intentionally ambiguous information is provided.	**P_{18}, P_{19}**
			RC_{12}: Language diversities among stakeholders	**P_4, P_5, P_6.**
			RC_{59}: Stakeholders are not clear about their requirements.	**P_{103}, P_{104}, P_{52}, P_{105}**
			RC_{64}: Requirements Engineers assume, based on their experience, that they know requirements of users.	**P_{45}, P_{106}, P_{107}, P_{108}, P_{74}, P_{75}**
I_{26}: Poor or ambiguous requirements specification.	**8**	**32**	**RC_{65}:** Specifying requirements without following any standard templates.	**P_{110}:** Defining and using standard templates for requirements specification. IEEE Standard 830-1998 For Requirements specification can be followed.
			RC_{66}: Complex terminology or inconsistent terminology is used to specify requirements.	**P_{68},** **P_{111}:** Using simple, consistent and concise language to describe requirements. IEEE Standard 830-1998 For Requirements Specification can be followed.
			RC_{25}: Different terminologies and notations are used to express same meanings or same terminologies are used to convey different meanings.	**P_{68}**

			RC_{67}: Essential details are not provided in requirements specification assuming that readers have domain knowledge.	**P_{112}:** Drawing diagrams wherever they are appropriate. **P_{113}:** Describing requirements, in addition to natural language, using formulas, notations, decision tables etc. wherever appropriate. **P_{114}:** Specifying requirements quantitatively where appropriate. **P_{115}:** Using Prototypes in order to animate requirements.
			RC_{43}: Lack of awareness about the environment in which system is to be deployed.	**P_{45}, P_{46}, P_{47}, P_{48}, P_{49}.**

Table 6.30, Continued

Requirements centric Issues (C_4)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{27}: Incorrect or false requirements.	**9**	**35**	**RC_{56}:** Requirements are not based upon appropriate or sound business case.	**P_{50}, P_{47}**
			RC_{57}: Requirements related information is not provided or intentionally ambiguous information is provided.	**P_{18}, P_{19}.**
			RC_{53}: Only selected stakeholders are consulted during the requirements elicitation that results in biased elicitation.	**P_{45},P_{46}, P_{57}, P_{100}, P_{58}**
			RC_{68}: Non-stakeholders are involved for requirements elicitation.	**P_{45},P_{46}, P_{57}, P_{100}, P_{58}**
			RC_{58}: System users and people who interact with the requirements engineering team are different.	**P_{102}**
			RC_{59}: Stakeholders are not clear about their requirements.	**P_{103} ,P_{104},P_{52}, P_{105}**
			RC_{64}: Requirements Engineers assume, based on their experience, that they know requirements of users.	**P_{45}, P_{106}, P_{107}, P_{108}, P_{74}, P_{75}**
			RC_{60}: Analysts do not have domain knowledge.	**P_{83}, P_{85}**
Cultural diversities' Issues (C_5)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{28}: Difficulties in setting realistic expectations about response time.	**1**	**24**	**RC_{69}:** No tracking of the time(s) taken for previous response(s) from an individual or team.	**P_{67}:** Using scales to measure the average time for fulfillment of expectations. For example, adding a feature in the email application that calculates the average time taken by an individual/team to respond email. If average response time is 3 days then sender can expect that email should be responded till 3 days.
I_{29}: Difficulties in achieving consensus on requirements.	**2**	**26**	**RC_{11}:** Unfamiliarity from cultural values.	**P_3, P_6.**
			RC_{70}: Stakeholders' interests are contradicting to one another	**P_{50}, P_{47}, P_{52},** **P_{89}:** Aligning the objectives of client and vendor through negotiation. **P_{90}:** Classifying the requirements through multi-dimensional approach. **P_{60}:** Introducing Equality Model (EM) for all the stakeholders according to which all stakeholders are equal and can talk about the interests, religion and cultural values of one and another. They can also share knowledge and recommend solutions by considering the perception and position of others. **P_{54}, P_{53}.**
			RC_{39}: High number of stakeholders as sources of requirements.	**P_{58}, P_{118}.**

Table 6.30, Continued

Cultural diversities' Issues (*C5*)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{30}: Lack of trust.	**3**	**26**	**RC_5:** Lack of socialization.	**P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}.**
			RC_{71}: Lack of face to face meetings.	**P_1,P_2** **P_{123}:** Employing requirements workshop.
			RC_4: Communication is infrequent and constrained.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}**
			RC_{11}: Unfamiliarity from cultural values.	**P_3, P_6.**
			RC_{72}: Poor conflict handling.	**P_{61}:** Delineating the processes, tools and policies to be followed. **P_{62}:** Sharing knowledge. **P_{53}**
			RC_{73}: Lack of capability, reliability and expertise.	**P_{62}** **P_{64}:** Having technical, managerial and staffing capabilities to meet quality standards and meeting schedule.
			RC_{74}: Not knowing and fulfilling expectations of other stakeholders.	**P_6, P_{13}, P_{59}**
I_{31}: Avoidance of the commitments from the stakeholders.	**4**	**30**	**RC_{75}:** Lack of trust.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}** **P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}** **P_{123}, P_{53}, P_{61}, P_{62}, P_{63}, P_{64}**
I_{32}: Nonparticipation or exclusion of stakeholders from RE activities.	**5**	**35**	**RC_{76}:** Ignoring limitations (availability, consent from relevant authorities, and participation with some conditions) of stakeholders.	**P_{70}, P_{20}.**
			RC_{28}: Stakeholders' lack of motivation to participate in RE activities.	**P_{120}**
			RC_{77}: Stakeholders are not fluent in one communication language.	**P_4, P_5, P_6.** **P_{65}:** Starting with the informal conversation to motivate non-fluent or less fluent stakeholders for participating in the conversation. **P_{66}:** Utilizing translation services: i) Use of human translator. ii) Using real-time machine translation services. **P_{119}:** Adopting asynchronous communication like email so that less competent stakeholder could have time to understand and answer the communicated messages. Features like checking spellings and grammar, and language translation should be integrated with email facility.
			RC_2: Time zone differences.	**P_7, P_8, P_9, P_{10}.**
			RC_{78}: Stakeholders are unfamiliar from the use of tools and technology being used.	**P_{76}:** Providing training about how to: i) Use the tools. ii) Collaborate effectively in the environment where stakeholders are at distant locations.
Processes and tools' Issues (*C6*)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{33}: Selection of inappropriate RE tool(s).	**1**	**21**	**RC_{79}:** Unawareness from the features of tool(s).	**P_{82}:** Having training and knowing about different features of RE tool(s) before selecting tools. **P_{81}:** Assessing capabilities of RE tools by using ISO/IEC TR 24766:2009 framework and relevant information.
			RC_{74}: Not knowing and fulfilling expectations of other stakeholders.	**P_6, P_{13}, P_{59}**
			RC_{80}: Unawareness from the cognitive styles of stakeholders.	**P_{121}:** Selecting suitable groupware tools and techniques for requirements elicitation keeping in view cognitive characteristics of stakeholders by using Felder-Silverman's Learning Style Model (LSM).

Table 6.30, Continued

Processes and tools' Issues (*C6*)	CR_v	OR_u	Root Causes	RE Practices
I_{34}: RE rework or data loss during transfer from one tool to other.	**2**	**26**	**RC_{81}:** Different RE processes are used, resulting in usage of different templates and methodologies, at the different locations of client.	**P_{25}, P_{78}, P_{77}, P_{22}, P_{23},** **P_{79}:** Following shared and agreed processes.
			RC_{82}: Use of tools that do not integrate.	**P_{122}:** Having a common set of tools. **P_{80}:** Using tools that can interact with other tools. **P_{77},P_{81}**
I_{35}: Use of different RE processes, resulting in usage of different templates and methodologies, at the different locations of client.	**3**	**30**	**RC_{23}:** Unclear or undefined RE processes.	**P_{25}, P_{78}, P_{77}**
			RC_{21}: Leaders do not use authority.	**P_{22}, P_{23}.**
			RC_{83}: Stakeholders at different locations are at different maturity levels of RE process.	**P_{79}, P_{77}.**
I_{36}: Use of unsuitable RE processes.	**4**	**39**	**RC_{23}:** Unclear or undefined RE processes.	**P_{25}, P_{78}, P_{77}.**
			RC_{84}: Use of standard processes without adjusting them to distributed context.	**P_{77}**
I_{37}: Use of unsuitable requirements elicitation technique.	**5**	**41**	**RC_{85}:** Absence of a firm, skilled and central analyst role like unfamiliarity with the elicitation techniques and not knowing when to use them.	**P_{83}** **P_{84}:** Using a proper procedure to select an adequate requirements elicitation technique. **P_{85}**
			RC_{80}: Unawareness from the cognitive styles of stakeholders.	**P_{121}**
Relationship among stakeholders' Issues (*C7*)	**CR_v**	**OR_u**	**Root Causes**	**RE Practices**
I_{38}: Issues in signing-off requirements engineering deliverables.	**1**	**26**	**RC_7:** Client and vendor rely on oral agreement.	**P_{28}**
I_{39}: Use of different requirements documentation standards by customer and vendor.	**2**	**32**	**RC_{83}:** Stakeholders at different locations are at the different maturity levels of RE processes.	**P_{79}, P_{77}**
			RC_{86}: Lack of documentation standardization.	**P_{86}:** Defining and following standard document structure. **P_{87}:** Using IEEE Standard 830-1998 For Requirements Specification to structure the requirements specification document. **P_{88}:** Defining minimum standards for requirements documentation. **P_{124}:** Checking to verify that the requirements document structure is consistent with defined standards.
I_{40}: Lack of firm relationship among stakeholders.	**3**	**35**	**RC_{75}:** Lack of trust.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}** **P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}** **P_{123}, P_{53}, P_{61}, P_{62}, P_{63}, P_{64}**
			RC_1: Lack of informal communication.	**P_1, P_2, P_3, P_4, P_5, P_6, P_7, P_8, P_9, P_{10}** **P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}**
			RC_5: Lack of socialization	**P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}**
			RC_{11}: Unfamiliarity from cultural values.	**P_3, P_6.**
			RC_{87}: Lack of onsite visits.	**P_{11}, P_{12}, P_{13}, P_{14}, P_{15}, P_{16}, P_{17}.**
			RC_{72}: Poor conflict handling.	**P_{61}, P_{62}, P_{53}**

Table 6.30, Continued

Relationship among stakeholders' Issues (C_7)	CR_v	OR_u	Root Causes	RE Practices
I_{41}: Misconceptions of the vendor teams about client's working practices.	**4**	**38**	**RC_{24}:** Stakeholders belonging to diverse cultural backgrounds: i) Have different values regarding hierarchies, handling risks, following schedules and precision of work. ii) Speak different languages, use different communication styles and are at different proficiency level of communication language. iii) Deduce inexplicit meanings and explanations from the information about requirements.	**P_{59}**
I_{42}: Different priorities of client and vendor for collecting and finalizing requirements.	**5**	**39**	**RC_{88}:** Client and vendor have undisclosed and dissimilar objectives.	**P_{50} ,P_{52}, P_{53}, P_{54}, P_{89}, P_{60}**
I_{43}: Vendor failure in meeting deadlines and fulfilling commitments about requirements.	**6**	**43**	**RC_{61}:** RE teams work with tight schedules to meet deadlines.	**P_{91},P_{92}, P_{93}, P_{94}, P_{98}**
			RC_{18}: Expected participants do not honor commitments made for participation.	**P_{70}, P_{20}.**
			RC_{89}: Absence of mechanisms for tracking progress.	**P_{95}:** Designing metrics to measure performance. **P_{96}:** Developing mechanisms for reporting about the progress. **P_{97}:** Enhancing the progress tracking/visibility by increasing the number of RE deliverables.

6.3 Summary

This chapter evaluates the REP Model. The model is evaluated from: i) The academic perspective through the expert panel of 3 experienced researchers and academicians, ii) The industrial perspective through 11 skilled SDO industry practitioners. The criteria of 'Completeness', 'Practicality' and 'Usefulness' are defined for the evaluation from the academic perspective. The results are investigated through the Inter-Rater Reliability Analysis by calculating Cohen's kappa coefficient (k) and then through the Analysis of Means (ANOM). Both methods for the analysis of academic evaluation results indicate the fulfillment of the three defined criteria. For evaluation from the industrial perspective, the REP Model is evaluated for 'usefulness of the recommended RE practice(s) to address

the corresponding frequently occurring issue of the RE process for SDO in the case of respective root cause'. The industrial evaluation results are investigated through: i) 50% rule, ii) Content Validity Index analysis, and iii) Confidence Interval analysis. All the three methods for analysis prove that according to the perception of SDO industry practitioners, out of the total 132 cases, only for 4 cases (3.03%), which are case no. 58, 62,100 and 108, the recommended RE practices are not beneficial enough to address the corresponding issues of RE process for SDO. The practitioners recommend the beneficial or useful RE practices for those four cases during the industrial evaluation of the model. Incorporation of those RE practices in the REP Model leads to the formation of the revised REP Model.

CHAPTER 7: CONCLUSION

This chapter summarizes the research work, the strategy to achieve the research objectives, research contributions, limitations of the research and future work.

7.1 Summary of the research

This research aims at developing the REP Model for addressing the common or frequently occurring issues of the Requirements Engineering (RE) process for Software Development Outsourcing (SDO). The projects are outsourced for software development to attain benefits like cost reduction, utilizing better capabilities, mitigation of risks and optimal use of internal resources. However, the failure rate of the SDO projects is high (Gefen, et al., 2008; Iqbal, et al., 2013; Meyer, 2005; Niazi, et al., 2012). Studies show that RE problems are one of the basic reasons for the failure of the SDO projects as most of the factors contributing to such failures are related to the requirements (Lopes, et al., 2005; Niazi, et al., 2012; Šmite, 2006). This is not surprising as RE is the most critical phase of the software development life cycle (Bhat, et al., 2006; Edwards & Sridhar, 2005). This phase affects the other software development activities significantly (Sommerville & Ransom, 2005). RE is also complex process for co-located software development projects (D. E. Damian & Zowghi, 2003b). For the outsourced software development projects, the RE problems become more complex because the stakeholders are geographically distributed (Bhat, et al., 2006; D. E. Damian & Zowghi, 2003b; Lopes, et al., 2005). Communication lapses, inappropriate knowledge management, cultural diversities, differences in the usage of technologies, lack of coordination and rare face-to-face meetings are some of the reasons that cause and augment the issues of the RE process in case of SDO (D. E. Damian & Zowghi, 2003b; Iqbal, et al., 2013; Lopes, et

al., 2005). The delayed responses, unawareness from the effects of the new system implementation, difficulties in achieving a consensus on requirements, lack of participation in the RE process, use of dissimilar processes and incomplete requirements are some of the SDO RE process issues.

The REP Model intends to address SDO RE process issues for acquiring the anticipated benefits of SDO. The model encompasses 43 frequently occurring issues of the RE process for SDO, the root causes for the occurrence of each issue and the relevant RE practices for addressing the corresponding issue. The issues are further categorized and belong to the 7 categories which are: i) Communication, ii) Knowledge management and awareness, iii) Cultural diversities, iv) Management and coordination, v) Processes and tools, vi) Relationship among stakeholders, and vii) Requirements centric. Based on the frequency of occurrence, the 43 frequently occurring issues are first ranked within their respective categories followed by their ranking with respect to all the 7 categories. Thus, each frequently occurring issue has two ranks; within the respective category called Category-wise rank, and with respect to the frequently occurring issues of all the 7 categories called Overall rank. Similarly, the categories of the issues are also ranked based on the 'frequency of occurrence' of the issues in those categories. The frequently occurring issues are represented by $\boldsymbol{I_1, I_2, I_3 \ldots I_{43}}$. Through Root Cause Analysis, 89 root causes are discovered for the occurrence of 43 common or frequently occurring issues. $\boldsymbol{RC_1, RC_2, RC_3 \ldots RC_{89}}$ represent 89 root causes. For addressing 89 root causes and hence 43 frequently occurring issues of RE process for SDO, 124 RE practices are recommended. $\boldsymbol{P_1, P_2, P_3 \ldots P_{124}}$ represent 124 RE practices.

The REP Model is evaluated from: i) The academic perspective through the expert panel consisting of 3 experts with research and academics background, ii) The industrial

perspective through 11 skilled practitioners from the SDO industry. For the development of the REP Model, 3 research objectives are defined and fulfilled.

7.2 Responses to research objectives

This research intends to address the frequently occurring issues of RE process for SDO, therefore, the first objective of this research is to explore existing literature for finding: i) Issues of RE process for SDO which are already reported in the existing literature,

ii) Relevant RE practices that are used to address such issues.

Thus, the first objective of this research work is:

Objective 1: To identify the literature-based issues of the RE process for SDO and to identify the relevant literature-based RE practices to address those issues.

Three research questions are designed to achieve the first objective:

RQ1: Which are the literature-based issues of the RE process for SDO?

RQ1.1: Which are the categories of the issues of RE process for SDO?

RQ2: Which are the literature-based RE practices to address the literature-based issues of the RE process for SDO?

RQ3: Which of the RE practices recommended by Sommerville and Sawyer (1997) are significant to address the issues of RE process for SDO?

To achieve the first objective, as a first step, a Systematic Literature Review (SLR) is conducted (Section 4.1). The SLR is carried out by using guidelines as given in (Keele, 2007; B. Kitchenham, 2004). To conduct the SLR, five electronic databases: i) IEEE Xplore, ii) ACM, iii) Science Direct, iv) Springer Link, and v) Web of Science, are targeted. Studies are selected by applying inclusion, exclusion and quality assessment criteria. After analyzing the 117 studies, 129 issues of the RE process for SDO are identified (answer to RQ1). Along with the literature review, a questionnaire survey (1st

survey, questionnaire used is provided as questionnaire 1 in Appendix A) is conducted with the SDO practitioners to find the categories of the issues of RE process for SDO. Based on the data obtained from the 115 responses, the 7 categories of issues are finalized (given in Table 4.5) which are: i) Communication, ii) Knowledge management and awareness, iii) Cultural diversities, iv) Management and coordination, v) Processes and tools, vi) Relationship among stakeholders, and vii) Requirements centric (answer to RQ1.1). A category-wise listing of 129 issues identified through the SLR is shown in Table 4.6. Through the SLR, 90 literature-based RE practices are also identified to address the issues of the RE process for SDO (answer to RQ2). The 90 literature-based RE practices are given in Table 4.7.

While exploring the literature for finding the RE practices to address the issues of the RE process for SDO, the RE practices recommended by Sommerville and Sawyer (1997) cannot be ignored. Sommerville and Sawyer endorse the RE practices for conventional RE process. To utilize the RE practices for addressing the RE process issues in case of SDO, there is a need to empirically investigate which of the RE practices recommended by Sommerville and Sawyer are significant to address SDO RE process issues. For this purpose, a questionnaire survey (2^{nd} survey, questionnaire used is provided as questionnaire 2 in Appendix A) is conducted with SDO practitioners and 108 responses are selected for data analysis. Out of the 49 RE practices recommended by Sommerville and Sawyer, 43 RE practices are found significant to address the RE process issues in case of SDO (answer to RQ3). The 43 RE practices are given in Table 4.16. Thus objective 1 is fulfilled:

A) Through the SLR and the two questionnaire surveys,

B) By identifying:

i) 129 literature-based issues of the RE process for SDO (Table 4.6),

ii) Seven categories of the SDO RE process issues (Table 4.5),

iii) 90 literature-based RE practices for addressing the SDO RE process issues (Table 4.7),

iv) 43 conventional RE practices, recommended by Sommerville and Sawyer, which are significant to address the SDO RE process issues (Table 4.16).

In Chapter 4, Sections 4.1, 4.2, 4.3, 4.4 and 4.5 deal with the objective 1 of this research work.

For developing an effective and comprehensive model, the inclusion of the industry perspective is essential. Therefore, the second objective of this research is to identify the RE process issues faced by SDO practitioners and the RE practices followed by the practitioners to address those issues. Thus the second research objective is:

Objective 2: To identify additional issues, other than those reported in the literature, of the RE process for SDO and identify the relevant RE practices to address those identified issues.

To achieve objective 2, two research questions are defined:

RQ4: Which are the SDO RE process issues, other than those reported in the literature, faced by SDO practitioners?

RQ5: Which are the RE practices adopted by SDO practitioners to address the RE process issues they face?

Keeping in view objective 2 of the research, another questionnaire survey (3rd survey, questionnaire used is provided as questionnaire 3 in Appendix A) is conducted with the SDO practitioners. After analyzing the 106 responses, 21 additional issues are discovered (answer to RQ4) for the SDO RE process. Table 4.6 provides those additional issues. Thus, Table 4.6 presents a list of 150 issues (129 from literature and 21 from SDO industry). Through the 3rd questionnaire survey, 14 additional RE practices are also

identified to address the issues of the RE process for SDO (answer to RQ5). The 14 additional RE practices are shown in Table 4.18. Thus, objective 2 is achieved:

A) Through the questionnaire survey with the SDO practitioners,

B) By identifying the 21 additional issues of the RE process for SDO (Table 4.6) and the 14 additional RE practices to address those issues (Table 4.18).

In Chapter 4, Section 4.6 deals with the objective 2 of this research work.

After exploring the existing relevant literature and SDO industry to identify the issues of RE process for SDO and the relevant RE practices to address those issues, the next step is the formation of the REP Model and then evaluation. This leads to the third objective of this research work:

Objective 3: To propose and evaluate the REP Model for addressing the issues of RE process for SDO.

Four research questions (RQ6, RQ7, RQ8, and RQ9) are defined to realize the objective 3 of the research.

RQ6: Which are the frequently occurring issues of the RE process for SDO?

RQ7: What is the ranking of the each:

i) Frequently occurring issue of the RE process for SDO within the respective category of the issue (Category-wise ranking) and with respect to all the categories (Overall ranking)?

ii) Category of the issues of the RE process for SDO?

RQ8: Which are the root causes for the frequently occurring issues of the RE process for SDO, and which are the relevant RE practices to address those issues?

RQ9: How to evaluate the proposed REP Model?

Through the SLR (Section 4.1) and by conducting 3rd questionnaire survey with the SDO practitioners, the 150 issues of the RE process for SDO are identified (Table 4.6). To

develop a workable model, the frequently occurring issues are needed to be extracted out of the 150 issues. Similarly, the ranking of the frequently occurring issues and the ranking of the categories of those issues are also required for developing an effective model. For the extraction of the frequently occurring issues and for the ranking purpose, the Delphi method is employed and three rounds are conducted as recommended in (Nakatsu & Iacovou, 2009; R. Schmidt, et al., 2001; R. C. Schmidt, 1997). A list of the 150 issues of the RE process for SDO is consolidated (Sections 4.6.1 and 4.6.1.1) and presented in Table 4.6. This is the first round of the Delphi method. For the 2nd and 3rd rounds of the Delphi method, two rounds of a questionnaire survey (4th survey, questionnaire used is provided as questionnaire 4 in Appendix A) are conducted with the SDO practitioners. The respondents are requested to choose the 'frequency of occurrence' of each issue against a 5-point Likert Scale. After the 3rd round, 103 responses are considered for the analysis. Based on the means of response values and by applying the Cut-off value method, 43 issues are extracted as the frequently occurring issues of the RE process for SDO (answer to RQ6). The 43 issues are given in Table 5.6. Afterwards, based on the means of response values:

i) The 43 frequently occurring issues are assigned ranks with respect to their respective categories which are called the Category-wise ranks (Tables 5.8 to 5.14),

ii) Categories of the issues are ranked (Tables 5.15 and 5.16),

iii) The 43 frequently occurring issues are assigned ranks with respect to the frequently occurring issues of all the 7 categories which are called the Overall ranks (Table 5.17).

The 43 frequently occurring issues along with the Category-wise ranks, the Overall ranks and the categories' ranks are presented in Table 5.18 (answer to RQ7). The Top 10 frequently occurring issues of the RE process for SDO are also identified and presented in Table 5.19.

To recommend RE practices for addressing the 43 frequently occurring issues, first respective root causes for occurrences of the issues must be known so that the relevant RE practices could be identified and mapped by using the root causes. To find the root cause(s) for each frequently occurring issue, the Root Cause Analysis is performed. Root Cause Analysis comprises of the three steps which are: i) Detecting the problem(s), ii) Detecting the root causes, and iii) Recommending the actions to address problem(s) (Lehtinen, et al., 2011). For performing the Root Cause Analysis, in this research work, the five workshops are held. Each workshop is attended by three participants, one researcher and two experienced SDO practitioners. Each workshop is conducted approximately for 4 hours. The already identified 43 frequently occurring issues (Table 5.18) are presented during the workshops. To detect the root causes for occurrences of the issues, the 5 Whys technique is employed (Sandeep Dalal, 2013; Vorley, 2008). To recommend the relevant RE practices, the Brainstorming technique is applied (Sandeep Dalal, 2013; Vorley, 2008). Through the Root Cause Analysis, 89 root causes are discovered for the 43 frequently occurring issues. For the 89 root causes, 124 relevant RE practices are recommended to address the respective root causes and hence the respective issues (answer to RQ8).

The frequently occurring ranked issues of the RE process for SDO, the root causes for occurrences of such issues and the relevant RE practices to address the corresponding issues are shown according to the descending ranks (1 is the highest and 7 is the lowest) of the issues' categories in Table 5.20. The ranks of the issues' categories (R_w) are: Communication=1, Management and coordination=2, Knowledge management and awareness=3, Requirements centric=4, Cultural diversities=5, Processes and tools=6, and Relationship among stakeholders=7. $\boldsymbol{I_1, I_2, I_3 \ldots I_{43}}$ represent the 43 frequently occurring issues of the RE process for SDO, $\boldsymbol{CR_v}$ stands for the Category-wise ranks of the issues

and OR_u stands for the Overall ranks of the issues. $RC_1, RC_2, RC_3 \ldots RC_{89}$ represent 89 root causes for occurrences of the issues. $P_1, P_2, P_3 \ldots P_{124}$ represent 124 RE practices that are used to address respective root causes and the frequently occurring issues. This accomplishes the development of the REP Model (Table 5.20). Thus the model is formulated by:

A) Conducting the three rounds of the Delphi method, applying the Cut-off value method and performing the Root Cause Analysis,

B) Identifying the 43 frequently occurring issues of the RE process for SDO, discovering 89 root causes for occurrences of the issues, and recommending 124 RE practices for addressing corresponding issues (Table 5.20).

Chapter 5 deals with the RQ6, RQ7 and RQ8 to partially attain the objective 3 of this research work.

After development, the REP model is evaluated from:

i) The academic point of view through the expert panel of academicians and researchers.

ii) The industry perspective through the SDO industry practitioners.

The 'Completeness', 'Practicality' and 'Usefulness' are the three criteria for the evaluation from the academic perspective. For the REP Model evaluation from the academic perspective, the expert panel of three experts is involved. All the three experts have academic and research experience. Two experts have more than 10 years' experience whereas one expert has more than 15 years' experience. The three criteria are evaluated through an online questionnaire survey (5^{th} survey, questionnaire used is provided as questionnaire 5 in Appendix A) by using a 7-point Likert Scale. Suggestions for improvement, given by one expert, are accommodated and the expert is requested for performing the evaluation again. The expert panel evaluation results are shown in Table 6.2. To measure the degree of consensus among the three experts, Cohen's kappa

coefficient (k) is calculated for each pair of experts. Table 6.9 shows the values of Kappa coefficient for different pairs of experts. The value of Kappa coefficient for AcademicianandResearcher1 and AcademicianandResearcher2 is .71, for AcademicianandResearcher1 and AcademicianandResearcher3 is 1.00, and for AcademicianandResearcher2 and AcademicianandResearcher3 is .71. The values of the Kappa coefficient for different pairs of the experts prove that there is a substantial agreement among the three experts about 'Completeness', 'Practicality' and 'Usefulness' of the model as Kappa coefficient's value greater than or equal to .60 indicates an acceptable degree of agreement between the experts (Landis & Koch, 1977). After that the Analysis of Means (ANOM) is also performed to analyze the experts' responses, which indicates that all the three experts have an inclination towards the 'Completeness', 'Practicality' and 'Usefulness' of the REP Model (Figures 6.5, 6.6, 6.7 and 6.8).

For the model evaluation from the industrial standpoint, criterion is 'usefulness of recommended RE practices for addressing the corresponding issue in the case of respective root cause'. For this purpose, 11 experienced SDO practitioners are involved. Out of the 11 practitioners, 6 have SDO industry experience and also have research background whereas remaining 5 practitioners have only industrial experience. Two practitioners have more than 15 years' experience whereas remaining 9 practitioners possess more than 10 years' experience (Table 6.10). The industrial evaluation is conducted through a questionnaire survey (6^{th} survey, questionnaire used is provided as questionnaire 6 in Appendix A) by using a 4-point Likert Scale. The evaluation results are shown in Table 6.11. The results are analyzed through three different methods:

i) By applying the 50% rule (Table 6.13),

ii) By analysis of responses through the Content Validity Index (CVI) (Section 6.1.5, Tables 6.14 to 6.21),

iii) By analysis of responses through the Confidence Interval (CI) (Section 6.1.6, Tables 6.23 to 6.29).

Generally an issue, a root cause for the issue and the recommended set of RE practices is called a case. For example in Table 6.11, Case #1 is: I_1, RC_1 and P_1, $P_2 \ldots P_{17}$. Similarly Case# 2 is: I_1, RC_2 and P_7, $P_8 \ldots P_{10}$.

All the three methods for analysis (Tables 6.13, 6.14 to 6.21 and 6.23 to 6.29) prove that according to the perception of the SDO practitioners, out of all the 132 cases, only for 4 cases (case nos.58, 62, 100 and 108) the recommended RE practices are not considered as beneficial enough to address the corresponding frequently occurring issues of RE process for SDO. During the evaluation from the industrial perspective, the SDO practitioners are requested to suggest the RE practices if the given RE practices are not ranked as having 'High Perceived Benefits' or 'Medium Perceived Benefits'. Therefore, the practitioners suggest the RE practices for case nos. 58, 62, 100 and 108. The recommended RE practices are accommodated and the revised REP Model is presented in Table 6.30. This completes the answer for RQ9.

Thus the REP Model is evaluated:

A) From the academic point of view through the expert panel of 3 academicians and researchers, and from the industrial perspective through the 11 experienced SDO industry practitioners,

B) By analyzing the evaluation results through:

i) The Inter-Rater Reliability Analysis by calculating Cohen's kappa coefficient (k) (Table 6.9),

ii) The Analysis of Means (ANOM) (Figures 6.5, 6.6, 6.7 and 6.8),

iii) The 50% rule (Table 6.13),

iv) The Content Validity Index analysis (Section 6.1.5, Tables 6.14 to 6.21), and

v) The Confidence Interval analysis (Section 6.1.6, Tables 6.23 to 6.29).

Chapter 6 deals with the RQ9 to partially fulfill the research objective 3 of this research work.

7.3 Research contributions

The aim of this research work is to support the SDO RE process for achieving the anticipated benefits of SDO (like cost reduction, process improvement, optimal resource usage and dealing with a lack of required skills), and to avoid adoption of random and ad-hoc RE practices for dealing with the common or frequently occurring issues of the RE process for SDO. Therefore, the REP Model is developed that presents the 43 common issues of the SDO RE process, ranks the issues and the categories of the issues, discovers the root causes for the issues and recommends the RE practices to address the issues. Thus, the contributions of this research work are:

A) The 43 common or frequently occurring issues of the RE process for SDO are extracted from 150 issues collected from the literature and the SDO industry. The list of 43 frequently occurring issues helps SDO practitioners and researchers to find out the common issues of the SDO RE process. This assists in devising the proactive strategy for project management planning.

B) This research work provides ranking of:

   i) The frequently occurring issues of the RE process for SDO within the respective categories (Category-wise ranking) and with respect to all the categories (Overall ranking).

   ii) The categories of the frequently occurring SDO RE process issues. The

The ranking of the issues and the categories, with respect to frequency of occurrence of issues, helps SDO practitioners for project planning and risk management.

C) Root causes for the frequently occurring or common issues of the RE process for SDO are also discovered. Anticipating the root causes for the SDO RE process issues helps in avoiding the issues and significantly contributes to the successful completion of SDO projects in terms of cost and time.

D) Suitable RE practices to address the frequently occurring issues of the RE process for SDO are recommended. The recommended RE practices are followed to successfully address the corresponding issues and hence help to achieve the benefits of SDO.

7.4 Limitations of research

Despite the list of contributions, this research work has numerous limitations which are:

1. The REP Model has been formulated to address the issues that come up frequently during the RE process for different scenarios of SDO that are:

A) Vendor provides services at client's location,

B) Onshoring or Domestic Outsourcing,

C) Vendor provides services from another country:

i) Nearshoring, ii) Offshoring,

D) When multiple vendors are involved:

i) Distributed Software Development, ii) Global Software Development.

However, while identifying the issues of the RE process for SDO or recommending the RE practices to address the corresponding issues, the different scenarios have not been dealt with separately as it is beyond the scope of this research work. For example, judging

whether there are cultural differences among the stakeholders or not is a topic of social science and not of computer science. Sometimes stakeholders living in the same country (case of On Shoring or Domestic Outsourcing) may have cultural diversities. On the other hand, the stakeholders living in different countries (case of Near Shoring or offshoring) may have same cultures.

For the sake of understanding, consider the example of Malaysia, in Malaysia there are three main communities or ethnic groups: Malays, Chinese and Tamils. All the three live in same country but have different cultures. This means that there would be cultural differences among the stakeholders in case of On Shoring or Domestic Outsourcing in Malaysia. On the other hand, Tamils living in Malaysia have culture similar to that of Tamils living in India. This means that cultures of the stakeholders would be same in the case of Offshoring from the Malaysian Tamils to Tamils living in India or in other words Offshoring from Malaysia to India. But generally in the case of Offshoring, the stakeholders' cultures are different as they belong to different countries or regions. Therefore, the question now is how to decide whether there are cultural differences among the stakeholders or not if issues are considered with respect to the different categories of the outsourcing. Similarly, consider the scenario of the three communities living in Malaysia. As stated earlier, there would be cultural differences among the stakeholders in the case of On Shoring or Domestics Outsourcing. But generally the stakeholders' cultures are same in the case of On Shoring or Domestics Outsourcing as the stakeholders belong to the same country. Again, the question is how to decide whether there are cultural differences among the stakeholders or not if issues are considered with respect to the different categories of the outsourcing.

Thus, in the case of Offshoring sometimes there are no cultural differences among the stakeholders and sometimes there are cultural differences among the stakeholders.

Similarly, in the case of Domestic Outsourcing sometimes there are no cultural differences among the stakeholders and sometimes there are cultural differences among the stakeholders. How this differentiation can be done using computer science knowledge? Therefore, dealing with such aspects is not within the scope of computer science but of social science.

2. This research work involves a number of questionnaire surveys which mainly contain closed-ended questions. The closed ended questions limit the innovation and the thinking of respondents that may affect the findings. This problem has been tackled through open-ended questions.

3. Also the REP Model has not been developed:

i) For a particular domain, or

ii) Keeping in view the project size (small, medium or large project), or

iii) For size of companies (small, medium or large software companies)

as most of the relevant literature is not specific to a domain or project size or company size.

7.5 Threats to validity

This section explains the threats to the validity of the research work done.

(a) Construct validity

This study is based on the issues of RE process for SDO and practices to address those issues. It was anticipated that participants might have problems with precisely understanding the issues and the practices. To conduct effective surveys, two rounds of pilot study have been conducted in case of each survey. The recommendations given during the first round have been accommodated during the second round. Therefore, SDO RE process issues and practices under study were fairly known to the respondents.

(b) Internal validity

The respondents have relevant experience of 5- 15 years and have been selected from the SDO companies where practitioners deal with the issues of the RE process for SDO and employ the RE practices to address the issues. Therefore, the issues and the practices belong to the workspace of the respondents. To investigate the practices four ranks or categories of perceived benefits have been used:

i). High Perceived Benefits (H, 4), ii). Medium Perceived Benefits (M, 3), iii). Low Perceived Benefits (L, 2), iv). Zero Perceived Benefits (Z, 1). To filter out the frequently occurring issues of the RE process for SDO, five categories of the 'frequency of occurrence' have been utilized: *i). Almost always (5), ii). Frequently (4), iii). About half of the time (3), iv). Occasionally (2), V). Rarely (1).* A seven-point Likert Scale has been used to rank the three given evaluation criteria from research and academic perspective: *i). Agree Strongly (1), ii). Agree Moderately (2), iii). Agree Slightly (3), iv). Neither Agree nor Disagree (4), v). Disagree Slightly (5), vi). Disagree Moderately (6), vii). Disagree Strongly (7).* The 50% rule has also been employed for analyzing the results. All the used scales and 50% criterion have already been applied in the previous studies. The capabilities of the method employed are limited, since this method is based on only one form of objective evidence, which is gathered through questionnaires. Additionally, the method relies on the opinions, experiences, and observations of only a few staff members per company. This limitation has been handled by consulting with management to select the most relevant available professionals in the companies. To ensure the reliability and accuracy of the results, the facts provided in the questionnaires have been cross-checked.

(c) External validity

External validity has been addressed by selecting a sufficient number of practitioners from SDO companies originating in two different countries, Malaysia and Pakistan. For example, number of respondents approached for the first questionnaire survey is 200. Similarly, numbers of respondents approached during 2nd , 3rd and 4th questionnaire surveys are 130, 200 and 200 respectively. All the relevant professionals from the two countries may not completely agree with the results, but one can believe that these samples are true representatives of the population. As only the reputed SDO companies have been targeted for data collection and in case of all the surveys only those questionnaires have been selected for data analysis which fulfil the criteria of experience, job relevancy and reliability of data. The percentages of the responses selected for data analysis are 52.50%, 83.08%, 55.79% and 51.50% for 1st, 2nd, 3rd and 4th survey respectively. This indicates that only quality responses have been utilized for data gathering, data analysis and for generation of final results.

7.6 Future work

There are several suggestions that can be followed to enhance this research work. Future work of this research includes:

- Development of a software system to facilitate the implementation of the REP Model.
- Refinement or development of the REP Model with respect to:
    i) Size of the projects (small, medium or large),
    ii) Product domain,
    iii) Product portfolio,
    iv) Architectural design issues

to ensure the proper use of the recommended RE practices and to enhance the usefulness of the REP Model.

- Although the REP Model has been evaluated: i) Through the expert panel having academic and research background, and ii) From the industrial perspective through the experienced SDO practitioners, however, to make the model more effective for SDO industry, the evaluation should also be performed through the case studies. By extending the case study evaluation, the model can be evaluated:
    i) For projects from a particular domain, or
    ii) For projects of various sizes (small, medium, large), or
    iii) For companies of various sizes (small, medium, large).

  The case studies' findings can be utilized to enrich the model.
- Experts and practitoners can be employed to evalaute the model with the point of view of gaing some 'added value'.

REFERENCES

Abbott, P., & Jones, M. (2003). The importance of being nearest: nearshore software outsourcing and globalization discourse *Global and Organizational Discourse about Information Technology* (pp. 375-397): Springer.

Abdullah, L. M., & Verner, J. M. (2012). Analysis and application of an outsourcing risk framework. *Journal of Systems and Software, 85*(8), 1930-1952.

Abramson, E. L., Kern, L. M., Brenner, S., Hufstader, M., Patel, V., & Kaushal, R. (2014). Expert panel evaluation of health information technology effects on adverse events. *Journal of evaluation in clinical practice, 20*(4), 375-382.

Agresti, A., & Coull, B. A. (1998). Approximate is better than "exact" for interval estimation of binomial proportions. *The American Statistician, 52*(2), 119-126.

Ahmad, A., Goransson, M., Kolla, S. J., Shahzad, A., ul Arfeen, Q., & Arshad, Z. (2011, April). Requirements Development Life Cycle with Respect to Geographically Distributed Stakeholders: The" V" Model. In Information Technology: New Generations (ITNG), 2011 Eighth International Conference on (pp. 1076-1077). IEEE.

Ahmad, A., Shahzad, A., Padmanabhuni, V. K., Mansoor, A., Joseph, S., & Arshad, Z. (2011, June). Requirements prioritization with respect to Geographically Distributed Stakeholders. In Computer Science and Automation Engineering (CSAE), 2011 IEEE International Conference on (Vol. 4, pp. 290-294). IEEE.

Ahmed, F. (2012). Software Requirements Engineer: An Empirical Study about Non-Technical Skills. *Journal of Software, 7*(2), 389-397.

Al-Ani, B., Bietz, M. J., Wang, Y., Trainer, E., Koehne, B., Marczak, S., . . . Prikladnicki, R. (2013). *Globally distributed system developers: their trust expectations and processes.* Paper presented at the Proceedings of the 2013 conference on Computer supported cooperative work.

Allred, S. B., & Ross-Davis, A. (2011). The drop-off and pick-up method: An approach to reduce nonresponse bias in natural resource surveys. *Small-Scale Forestry, 10*(3), 305-318.

Alnuem, M. A., Ahmad, A., & Khan, H. (2012, July). Requirements Understanding: A Challenge in Global Software Development, Industrial Surveys in Kingdom of Saudi Arabia. In 2012 IEEE 36th Annual Computer Software and Applications Conference (pp. 297-306). IEEE.

Alam, K. A., Ahmad, R. B., & Akhtar, M. (2014, September). Change Impact analysis and propagation in service based business process management systems preliminary results from a systematic review. In Software Engineering Conference (MySEC), 2014 8th Malaysian (pp. 7-12). IEEE.

Anie, K. A., Jones, P. W., Hilton, S. R., & Anderson, H. R. (1996). A computer-assisted telephone interview technique for assessment of asthma morbidity and drug use in adult asthma. *Journal of clinical epidemiology, 49*(6), 653-656.

Aranda, G. N., Vizcaino, A., Cechich, A., & Piattini, M. (2006, October). Technology selection to improve global collaboration. In 2006 IEEE International Conference on Global Software Engineering (ICGSE'06) (pp. 223-232). IEEE.

Aranda, G. N., Vizcaíno, A., & Piattini, M. (2010). A framework to improve communication during the requirements elicitation process in GSD projects. *Requirements engineering, 15*(4), 397-417.

Tomoyuki, A., Eiji, G., & Tomoko, N. (2005). Business process oriented requirements engineering process. In Proceedings of 13th IEEE International Conference on Requirements Engineering.

Arnuphaptrairong, T. (2011, March). Top ten lists of software project risks: Evidence from the literature survey. In Proceedings of the International MultiConference of Engineers and Computer Scientists (Vol. 1, pp. 1-6).

Avritzer, A., Ostrand, T., & Weyuker, E. (2006, October). Experience developing software using a globally distributed workforce. In 2006 IEEE International Conference on Global Software Engineering (ICGSE'06).

Azadegan, A., Cheng, X., Niederman, F., & Yin, G. (2013, January). Collaborative requirements elicitation in facilitated collaboration: report from a case study. In System Sciences (HICSS), 2013 46th Hawaii International Conference on (pp. 569-578). IEEE.

Babar, M. A., Verner, J. M., & Nguyen, P. T. (2007). Establishing and maintaining trust in software outsourcing relationships: An empirical investigation. *Journal of Systems and Software, 80*(9), 1438-1449.

Babar, M. A., & Zahedi, M. (2013, August). Understanding structures and affordances of extended teams in global software development. In 2013 IEEE 8th International Conference on Global Software Engineering (pp. 226-235). IEEE.

Barak, M., & Rafaeli, S. (2004). On-line question-posing and peer-assessment as means for web-based knowledge sharing in learning. *International Journal of Human-Computer Studies, 61*(1), 84-103.

Beecham, S., Hall, T., Britton, C., Cottee, M., & Rainer, A. (2005). Using an expert panel to validate a requirements process improvement model. *Journal of Systems and Software, 76*(3), 251-275.

Begel, A., & Nagappan, N. (2008, August). Global software development: who does it?. In 2008 IEEE International Conference on Global Software Engineering (pp. 195-199). IEEE.

Belsis, P., Koutoumanos, A., & Sgouropoulou, C. (2014). PBURC: a patterns-based, unsupervised requirements clustering framework for distributed agile software development. *Requirements engineering, 19*(2), 213-225.

Berenbach, B. (2006, May). Impact of organizational structure on distributed requirements engineering processes: lessons learned. In Proceedings of the 2006 international workshop on Global software development for the practitioner (pp. 15-19). ACM.

Bertolino, A., De Angelis, G., Di Sandro, A., & Sabetta, A. (2011). Is my model right? Let me ask the expert. *Journal of Systems and Software, 84*(7), 1089-1099.

Bhat, J. M., Gupta, M., & Murthy, S. N. (2006). Overcoming requirements engineering challenges: Lessons from offshore outsourcing. *Software, IEEE, 23*(5), 38-44.

Boden, A., Avram, G., Bannon, L., & Wulf, V. (2009, July). Knowledge Management in Distributed Software Development Teams-Does Culture Matter?. In 2009 Fourth IEEE International Conference on Global Software Engineering (pp. 18-27). IEEE.

Boehm, B. W. (1988). A spiral model of software development and enhancement. *Computer, 21*(5), 61-72.

Boehm, B. W. (1991). Software risk management: principles and practices. *Software, IEEE, 8*(1), 32-41.

Bohner, S. A. (1996, November). Impact analysis in the software change process: A year 2000 perspective. In Software Maintenance 1996, Proceedings., International Conference on (pp. 42-51). IEEE.

Braun, A. (2007, August). A framework to enable offshore outsourcing. In International Conference on Global Software Engineering (ICGSE 2007) (pp. 125-129). IEEE.

Brockmann, P. S., & Thaumuller, T. (2009, July). Cultural aspects of global requirements engineering: An empirical Chinese-German case study. In 2009 Fourth IEEE International Conference on Global Software Engineering.

Bush, A. A., Tiwana, A., & Tsuji, H. (2008). An empirical investigation of the drivers of software outsourcing decisions in Japanese organizations. *Information and Software Technology, 50*(6), 499-510.

Calefato, F., Damian, D., & Lanubile, F. (2012). Computer-mediated communication to support distributed requirements elicitations and negotiations tasks. *Empirical Software Engineering, 17*(6), 640-674.

Calefato, F., & Lanubile, F. (2005). Using the Econference tool for synchronous distributed requirements workshops.

Calefato, F., Lanubile, F., & Prikladnicki, R. (2011, August). A controlled experiment on the effects of machine translation in multilingual requirements meetings. In 2011

IEEE Sixth International Conference on Global Software Engineering (pp. 94-102). IEEE.

Cambridge (2015) Retrieved 15 November 2015, from http://dictionary.cambridge.org/dictionary/english/issue

Cambridge. (2015), 15 November 2015, from http://dictionary.cambridge.org/dictionary/english/rank

Carmel, E., & Agarwal, R. (2001). Tactical approaches for alleviating distance in global software development. *Software, IEEE, 18*(2), 22-29.

Carpio, M., Martín-Morales, M., & Zamorano, M. (2015). Comparative study by an expert panel of documents recognized for energy efficiency certification of buildings in Spain. *Energy and Buildings, 99*, 98-103.

Carrizo, D., Dieste, O., & Juristo, N. (2014). Systematizing requirements elicitation technique selection. *Information and Software Technology, 56*(6), 644-669.

Casey, V., & Richardson, I. (2008, August). The impact of fear on the operation of virtual teams. In 2008 IEEE International Conference on Global Software Engineering (pp. 163-172). IEEE.

Catledge, L. D., & Potts, C. (1996, April). Collaboration during conceptual design. In Requirements Engineering, 1996., Proceedings of the Second International Conference on (pp. 182-189). IEEE.

Chisan, J., & Damian, D. (2004, May). Towards a model of awareness support of software development in gsd. In IEE Seminar Digests (Vol. 912, pp. 28-33).

Choi, B. C. (2004). Computer assisted telephone interviewing (CATI) for health surveys in public health surveillance: methodological issues and challenges ahead. *Chronic Diseases and Injuries in Canada, 25*(2), 21.

Christiansen, H. M. (2007). Meeting the challenge of communication in offshore software development *Software Engineering Approaches for Offshore and Outsourced Development* (pp. 19-26): Springer.

Confidence Intervals, Statistical glossary. (2015) Retrieved 06 July 2015, from http://www.stats.gla.ac.uk/steps/glossary/confidence_intervals.html

Cox, K., Niazi, M., & Verner, J. (2009). Empirical study of Sommerville and Sawyer's requirements engineering practices. *Software, IET, 3*(5), 339-355.

Creswell, J. W. (2002). Educational research: Planning, conducting, and evaluating quantitative. *New Jersey: Upper Saddle River*.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches*: Sage publications.

Crnkovic, G. D. (2010). Constructive research and info-computational knowledge generation *Model-Based Reasoning in Science and Technology* (pp. 359-380): Springer.

Cusick, J., & Prasad, A. (2006). A practical management and engineering approach to offshore collaboration. *Software, IEEE, 23*(5), 20-29.

D'agostino, R. B., Belanger, A., & D'Agostino Jr, R. B. (1990). A suggestion for using powerful and informative tests of normality. *The American Statistician, 44*(4), 316-321.

Damian, D. (2001, December). An empirical study of requirements engineering in distributed software projects: is distance negotiation more effective?. In Software Engineering Conference, 2001. APSEC 2001. Eighth Asia-Pacific (pp. 149-152). IEEE.

Damian, D. (2002, May). The study of requirements engineering in global software development: as challenging as important. In Proceedings of Global Software Development, Workshop (Vol. 9).

Damian, D. (2007). Stakeholders in global requirements engineering: Lessons learned from practice. *Software, IEEE, 24*(2), 21-27.

Damian, D., Chisan, J., Allen, P., & Corrie, B. (2003, May). Awareness meets requirements management: awareness needs in global software development. In Proc. of the International Workshop on Global Software Development, International Conference on Software Engineering (pp. 7-11).

Damian, D., Helms, R., Kwan, I., Marczak, S., & Koelewijn, B. (2013, May). The role of domain knowledge and cross-functional communication in socio-technical coordination. In 2013 35th International Conference on Software Engineering (ICSE) (pp. 442-451). IEEE.

Damian, D., Lanubile, F., & Mallardo, T. (2008). On the need for mixed media in distributed requirements negotiations. *Software Engineering, IEEE Transactions on, 34*(1), 116-132.

Damian, D. E., Eberlein, A., Shaw, M. L., & Gaines, B. R. (2003). An exploratory study of facilitation in distributed requirements engineering. *Requirements engineering, 8*(1), 23-41.

Damian, D. E., & Zowghi, D. (2002, September). The impact of stakeholders' geographical distribution on managing requirements in a multi-site organization. In Requirements Engineering, 2002. Proceedings. IEEE Joint International Conference on (pp. 319-328). IEEE.

Damian, D. E., & Zowghi, D. (2003, January). An insight into the interplay between culture, conflict and distance in globally distributed requirements negotiations. In System Sciences, 2003. Proceedings of the 36th Annual Hawaii International Conference on (pp. 10-pp). IEEE.

Damian, D. E., & Zowghi, D. (2003b). RE challenges in multi-site software development organisations. *Requirements engineering, 8*(3), 149-160.

Daneva, M., Van Der Veen, E., Amrit, C., Ghaisas, S., Sikkel, K., Kumar, R., . . . Wieringa, R. (2013). Agile requirements prioritization in large-scale outsourced system projects: An empirical study. *Journal of Systems and Software, 86*(5), 1333-1353.

Davis, L. L. (1992). Instrument review: Getting the most from a panel of experts. *Applied nursing research, 5*(4), 194-197.

de Farias Junior, I. H., de Azevedo, R. R., de Moura, H. P., & da Silva, D. S. M. (2012, August). Elicitation of communication inherent risks in distributed software development. In 2012 IEEE Seventh International Conference on Global Software Engineering Workshops (pp. 37-42). IEEE.

De Gea, J. M. C., Nicolás, J., Alemán, J. L. F., Toval, A., Ebert, C., & Vizcaíno, A. (2012). Requirements engineering tools: Capabilities, survey and assessment. *Information and Software Technology, 54*(10), 1142-1157.

de Gea, J. M. C., Nicolás, J., Alemán, J. L. F., Toval, A., Vizcaíno, A., & Ebert, C. (2013). Reusing requirements in global software engineering *Managing requirements knowledge* (pp. 171-197): Springer.

Decker, B., Ras, E., Rech, J., Jaubert, P., & Rieth, M. (2007). Wiki-based stakeholder participation in requirements engineering. *Software, IEEE, 24*(2), 28-35.

Deshpande, S., Beecham, S., & Richardson, I. (2011). Global Software Development Coordination Strategies-A Vendor Perspective *New Studies in Global IT and Business Service Outsourcing* (pp. 153-174): Springer.

Deshpande, S., Richardson, I., Casey, V., & Beecham, S. (2010, August). Culture in global software development-a weakness or strength?. In 2010 5th IEEE International Conference on Global Software Engineering (pp. 67-76). IEEE.

Desouza, K. C., Awazu, Y., & Baloh, P. (2006). Managing knowledge in global software development efforts: Issues and practices. *IEEE software, 23*(5), 30.

Dhar, S., & Balakrishnan, B. (2006). Risks, benefits, and challenges in global IT outsourcing: Perspectives and practices. *Journal of Global Information Management (JGIM), 14*(3), 59-89.

Dictionary. (2015) Retrieved 15 November 2015, from http://dictionary.reference.com/browse/practice

Driscoll, D. L., Appiah-Yeboah, A., Salib, P., & Rupert, D. J. (2007). Merging qualitative and quantitative data in mixed methods research: How to and why not. Ecological and Environmental Anthropology (University of Georgia), 18.

Duarte, D., Farinha, C., da Silva, M. M., & da Silva, A. R. (2012, June). Collaborative requirements elicitation with visualization techniques. In Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE), 2012 IEEE 21st International Workshop on (pp. 343-348). IEEE.

Dubé, L., & Paré, G. (2001). Global Virtual Teams. *Communications of the ACM*, *44*(12), 71.

Dyba, T. (2000). An instrument for measuring the key factors of success in software process improvement. *Empirical Software Engineering*, *5*(4), 357-390.

Ebert, C., & De Neve, P. (2001). Surviving global software development. *Software, IEEE*, *18*(2), 62-69.

Edwards, H. K., & Sridhar, V. (2005). Analysis of software requirements engineering exercises in a global virtual team setup. *Journal of Global Information Management (JGIM)*, *13*(2), 21-41.

El Emam, K., & Jung, H.-W. (2001). An empirical evaluation of the ISO/IEC 15504 assessment model. *Journal of Systems and Software*, *59*(1), 23-41.

Fan, C. K., & Cheng, C. L. (2006). A study to identify the training needs of life insurance sales representatives in Taiwan using the Delphi approach. *International Journal of Training and Development*, *10*(3), 212-226.

Fleiss, J. L. (1971). Measuring nominal scale agreement among many raters. *Psychological bulletin*, *76*(5), 378.

Gefen, D., Wyss, S., & Lichtenstein, Y. (2008). Business familiarity as risk mitigation in software development outsourcing contracts. *MIS quarterly*, 531-551.

Gerrish, K., & Clayton, J. (2004). Promoting evidence-based practice: an organizational approach. *Journal of nursing management*, *12*(2), 114-123.

Gibbs, R. D. (2006). *Project Management with the IBM Rational Unified Process: lessons from the trenches*: Prentice Hall Professional.

Gliem, R. R., & Gliem, J. A. (2003). Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales. Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education.

Goguen, J. A. (1993, January). Social issues in requirements engineering. In RE (pp. 194-195).

Guideline, D. (1992). Root Cause Analysis Guidance Document: US Department of Energy: Washington.

Gumm, D. C. (2007). A Model of Requirements Engineering at Organizational Interfaces: An Empirical Study on Distributed Requirements Engineering. In WORKSHOP P.

Habibi, A., Sarafrazi, A., & Izadyar, S. (2014). Delphi technique theoretical framework in qualitative research. *The International Journal of Engineering and Science, 3*(4), 8-13.

Hafeez, Y., Riaz, M., Asghar, S., Naz, H., Gilani, S. M. M., Batool, A., ... & Hassan, M. S. (2012, December). A requirement change management framework for distributed software environment. In Computing and Convergence Technology (ICCCT), 2012 7th International Conference on (pp. 944-948). IEEE.

Hakim, C. (1988). Research Design: Strategies and Choices in the Design of Social Research: JSTOR.

Han, W.-M., & Huang, S.-J. (2007). An empirical analysis of risk components and performance on software projects. *Journal of Systems and Software, 80*(1), 42-50.

Hanisch, J., & Corbitt, B. (2007). Impediments to requirements engineering during global software development. *European Journal of Information Systems, 16*(6), 793-805.

Hanisch, J., Corbitt, B., & Thanasankit, T. (2005). Differentiating local and global systems requirements gathering processes in IS software development projects. *PACIS 2005 Proceedings*, 17.

Hanisch, J., & Corbitt, B. J. (2004). Requirements Engineering During Global Software Development: Some Impediments to the Requirements Engineering Process-A Case Study. *ECIS 2004 Proceedings*, 68.

Hashmi, S. I., Ishikawa, F., & Richardson, I. (2013, May). A communication process for global requirements engineering. In Proceedings of the 2013 International Conference on Software and System Process (pp. 136-140). ACM.

He, X. (2009). Confidence intervals for the binomial proportion with zero frequency.

Heeks, R., Krishna, S., Nicholsen, B., & Sahay, S. (2001). Synching or sinking: global software outsourcing relationships. *Software, IEEE, 18*(2), 54-60.

Heindl, M., & Biffl, S. (2006, May). Risk management with enhanced tracing of requirements rationale in highly distributed projects. In Proceedings of the 2006 international workshop on Global software development for the practitioner (pp. 20-26). ACM.

Heindl, M., Reinisch, F., & Biffl, S. (2007). " Requirements Management Infrastructures in Global Software Development-Towards Application Lifecycle Management with Role-based In-time Notification"; Vortrag: International Conference of Global Software Engineering (ICGSE), Munich; 27.08. 2007-30.08. 2007; in:" International Conference on Global Software Engineering (ICGSE), Workshop on Tool-Supported Requirements Management in Distributed Projects (REMIDI)", REMIDI, ICGSE, Munich (2007).

Helén, M. (2004). Challenges in Multi-Site and Multi-Cultural Globally Distributed Software Development: Information System Science Bachelor Thesis. University of Jyväskylä.

Herbsleb, J. D., Mockus, A., Finholt, T. A., & Grinter, R. E. (2000, December). Distance, dependencies, and delay in a global collaboration. In Proceedings of the 2000 ACM conference on Computer supported cooperative work (pp. 319-328). ACM.

Herbsleb, J. D., Paulish, D. J., & Bass, M. (2005, May). Global software development at siemens: experience from nine projects. In Proceedings. 27th International Conference on Software Engineering, 2005. ICSE 2005. (pp. 524-533). IEEE.

Hofmann, H. F., & Lehner, F. (2001). Requirements engineering as a success factor in software projects. *IEEE software*, *18*(4), 58.

Hofstede, G., Hofstede, G. J., & Minkov, M. (1991). *Cultures and organizations: Software of the mind* (Vol. 2): Citeseer.

Holmström, H., Ågerfalk, P. J., & Fitzgerald, B. (2006, October). Exploring the assumed benefits of global software development. In 2006 IEEE International Conference on Global Software Engineering (ICGSE'06) (pp. 159-168). IEEE.

Holmstrom, H., Conchúir, E. Ó., Agerfalk, J., & Fitzgerald, B. (2006, October). Global software development challenges: A case study on temporal, geographical and socio-cultural distance. In 2006 IEEE International Conference on Global Software Engineering (ICGSE'06) (pp. 3-11). IEEE.

Hussain, W., Buchan, J., & Clear, T. (2014, August). Managing Requirements in Globally Distributed COTS Customization. In 2014 IEEE International Conference on Global Software Engineeering Workshops (pp. 33-38). IEEE.

Hyrkäs, K., Appelqvist-Schmidlechner, K., & Oksa, L. (2003). Validating an instrument for clinical supervision using an expert panel. *International Journal of nursing studies*, *40*(6), 619-625.

Illes-Seifert, T., Herrmann, A., Geisser, M., & Hildenbrand, T. (2007). *The Challenges of Distributed Software Engineering and Requirements Engineering: Results of an Online Survey.* Paper presented at the WORKSHOP P.

Iqbal, J., Ahmad, R., Nizam, M. H., Nasir, M., & Noor, M. A. (2013, June). Significant requirements engineering practices for software development outsourcing. In 2013 22nd Australian Software Engineering Conference (pp. 137-144). IEEE.

Ishenko, O. (2005). Outsourcing of Software development. *Humbold University Berlin, Wirtschaftwissenschaftliche Fakultaet, study*.

Islam, S. (2009). *Offshore-outsourced software development risk management model*. Paper presented at the Computers and Information Technology, 2009, ICCIT'09, IEEE.

Islam, S., Joarder, M. M. A., & Houmb, S. H. (2009, July). Goal and risk factors in offshore outsourced software development from vendor's viewpoint. In 2009 Fourth IEEE International Conference on Global Software Engineering (pp. 347-352). IEEE.

Jalali, S., Gencel, C., & Šmite, D. (2010, September). Trust dynamics in global software engineering. In Proceedings of the 2010 ACM-IEEE International Symposium on Empirical Software Engineering and Measurement (p. 23). ACM.

Javed, B., & Minhas, S. S. (2010, December). Process Support for Requirements Engineering Activities in Global Software Development: A Literature Based Evaluation. In Computational Intelligence and Software Engineering (CiSE), 2010 International Conference on (pp. 1-6). IEEE.

Kannabiran, G., & Sankaran, K. (2011). Determinants of software quality in offshore development–An empirical study of an Indian vendor. *Information and Software Technology*, *53*(11), 1199-1208.

Keele, S. (2007). Guidelines for performing systematic literature reviews in software engineering *Technical report, Ver. 2.3 EBSE Technical Report. EBSE*.

Kehal, H. (2006). *Outsourcing and Offshoring in the 21st Century: A Socio-Economic Perspective: A Socio-Economic Perspective*: Igi Global.

Kelly, K. P., & Porock, D. (2005). A survey of pediatric oncology nurses' perceptions of parent educational needs. *Journal of pediatric oncology nursing*, *22*(1), 58-66.

Khalid, M., ul Haq, S., & Khan, M. N. A. (2013). An Assessment of Extreme Programming Based Requirement Engineering Process. *International Journal of Modern Education and Computer Science*, *5*(2), 41.

Khan, A. A., Basri, S., & Dominic, P. D. D. (2012, June). A propose framework for requirement Change Management in Global Software Development. In Computer & Information Science (ICCIS), 2012 International Conference on (Vol. 2, pp. 944-947). IEEE.

Khan, H. H., Naz'ri bin Mahrin, M., & bt Chuprat, S. (2014, September). Situational requirement engineering framework for global software development. In Computer, Communications, and Control Technology (I4CT), 2014 International Conference on (pp. 224-229). IEEE.

Khan, H. H., Naz'ri bin Mahrin, M., & bt Chuprat, S. (2014). Factors generating risks during requirement engineering process in global software development environment. *International Journal of Digital Information and Wireless Communications (IJDIWC)*, *4*(1), 63-78.

Khan, S. U., Niazi, M., & Ahmad, R. (2009, December). Critical barriers for offshore software development outsourcing vendors: a systematic literature review. In 2009 16th Asia-Pacific Software Engineering Conference (pp. 79-86). IEEE.

Khan, S. U., Niazi, M., & Ahmad, R. (2011). Barriers in the selection of offshore software development outsourcing vendors: An exploratory study using a systematic literature review. *Information and Software Technology, 53*(7), 693-706.

Kitchenham, B. (2004). Procedures for performing systematic reviews. *Keele, UK, Keele University, 33*(2004), 1-26.

Kitchenham, B., Pfleeger, S. L., McColl, B., & Eagan, S. (2002). An empirical study of maintenance and development estimation accuracy. *Journal of Systems and Software, 64*(1), 57-77.

Kitchenham, B. A., & Pfleeger, S. L. (2008). Personal opinion surveys *Guide to Advanced Empirical Software Engineering* (pp. 63-92): Springer.

Kitchenham, B. A., Pfleeger, S. L., Pickard, L. M., Jones, P. W., Hoaglin, D. C., El Emam, K., & Rosenberg, J. (2002). Preliminary guidelines for empirical research in software engineering. IEEE Transactions on software engineering, 28(8), 721-734.

Knauss, E., & Damian, D. (2013, May). V: issue: lizer: exploring requirements clarification in online communication over time. In Proceedings of the 2013 International Conference on Software Engineering (pp. 1327-1330). IEEE Press.

Krishna, S., Sahay, S., & Walsham, G. (2004). Managing cross-cultural issues in global software outsourcing. *Communications of the ACM, 47*(4), 62-66.

Kwan, I., Damian, D., & Marczak, S. (2007, August). The effects of distance, experience, and communication structure on requirements awareness in two distributed industrial software projects. In Global Requirements Engineering Workshop (GREW'07), in Proc. of International Conference on Global Software Engineering (ICGSE 2007), Munich, Germany.

Lam, S. S., Petri, K. L., & Smith, A. E. (2000). Prediction and optimization of a ceramic casting process using a hierarchical hybrid system of neural networks and fuzzy logic. *Iie Transactions, 32*(1), 83-91.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *biometrics*, 159-174.

Lanubile, F. (2003, May). A P2P toolset for distributed requirements elicitation. In Proc. 2nd Int'l Workshop Global Software Development (GSD 2003) (pp. 12-15).

Lauesen, S., & Vinter, O. (2001). Preventing requirement defects: An experiment in process improvement. *Requirements engineering, 6*(1), 37-50.

Laurent, P., & Cleland-Huang, J. (2009). Lessons learned from open source projects for facilitating online requirements processes *Requirements Engineering: Foundation for Software Quality* (pp. 240-255): Springer.

Layman, L., Williams, L., Damian, D., & Bures, H. (2006). Essential communication practices for Extreme Programming in a global software development team. *Information and Software Technology, 48*(9), 781-794.

Lehtinen, T. O., Mäntylä, M. V., & Vanhanen, J. (2011). Development and evaluation of a lightweight root cause analysis method (ARCA method)–field studies at four software companies. *Information and Software Technology, 53*(10), 1045-1061.

Lehtinen, T. O., Mäntylä, M. V., Vanhanen, J., Itkonen, J., & Lassenius, C. (2014). Perceived causes of software project failures–An analysis of their relationships. *Information and Software Technology, 56*(6), 623-643.

Lethbridge, T. C., Sim, S. E., & Singer, J. (2005). Studying software engineers: Data collection techniques for software field studies. *Empirical Software Engineering, 10*(3), 311-341.

Levina, N., & Vaast, E. (2008). Innovating or doing as told? Status differences and overlapping boundaries in offshore collaboration. *MIS quarterly*, 307-332.

Li, B., Sun, X., Leung, H., & Zhang, S. (2013). A survey of code-based change impact analysis techniques. *Software Testing, Verification and Reliability, 23*(8), 613-646.

Lim, S. L., Damian, D., & Finkelstein, A. (2011, May). StakeSource2. 0: using social networks of stakeholders to identify and prioritise requirements. In Proceedings of the 33rd international conference on Software engineering (pp. 1022-1024). ACM.

Lloyd, W. J., Rosson, M. B., & Arthur, J. D. (2002). Effectiveness of elicitation techniques in distributed requirements engineering. In Requirements Engineering, 2002. Proceedings. IEEE Joint International Conference on (pp. 311-318). IEEE.

Lohmann, S., Ziegler, J., & Heim, P. (2008). Involving end users in distributed requirements engineering *Engineering Interactive Systems* (pp. 221-228): Springer.

Lopes, L., Prikladnicki, R., Audy, J., & Majdenbaum, A. (2005). Requirements specification in distributed software development a process proposal. *Requirements Specification in Distributed Software Development a Process Proposal. Porto Alegre, RS, Brazil*.

Lopes, L., Prikladnicki, R., Audy, J. L. N., & Majdenbaum, A. (2004). Distributed Requirements Specification: Minimizing the Effect of Geographic Dispersion. In ICEIS (3) (pp. 531-534).

Lopez, A., Nicolas, J., & Toval, A. (2009, July). Risks and safeguards for the requirements engineering process in global software development. In 2009 Fourth IEEE International Conference on Global Software Engineering (pp. 394-399). IEEE.

Lormans, M., Van Dijk, H., Van Deursen, A., Nocker, E., & de Zeeuw, A. (2004, September). Managing evolving requirements in an outsourcing context: an industrial experience report. In Software Evolution, 2004. Proceedings. 7th International Workshop on Principles of (pp. 149-158). IEEE.

Lynn, M. R. (1986). Determination and quantification of content validity. *Nursing research, 35*(6), 382-386.

Macaulay, L. A. (2012). *Requirements engineering*: Springer Science & Business Media.

Mallardo, T., Calefato, F., Lanubile, F., & Damian, D. (2007). *The effects of communication mode on distributed requirements negotiations.* Paper presented at the WORKSHOP P.

Market share analysis: IT outsourcing services, worldwide. (2014) Retrieved 18 November 2014, from http://www.gartner.com/newsroom/id/2643919

Market share analysis: IT outsourcing services, worldwide, 2011. (2012) Retrieved October 08, 2012, from http://www.gartner.com/it/page.jsp?id=2021215

Market share analysis: IT outsourcing services, worldwide, 2013. (2013) Retrieved 10 December 2013, from http://www.gartner.com/newsroom/id/2550615

Mathew, S., Field, W., & French, B. (2011). Content Validation Using an Expert Panel: Assessment Process for Assistive Technology Adopted by Farmers with Disabilities. *Journal of agricultural safety and health, 17*(3), 227-241.

Mathrani, A., Parsons, D., & Mathrani, S. (2012). Knowledge Management Initiatives in Offshore Software Development: Vendors' Perspectives. *J. UCS, 18*(19), 2706-2730.

Meadows, A. B., Maine, L. L., Keyes, E. K., Pearson, K., & Finstuen, K. (2005). Pharmacy Executive Leadership Issues and Associated Skills Knowledge and Abilities. *Journal of the American Pharmacists Association, 45*(1), 55-62.

Merriam Webster (2015) Retrieved 15 November 2015, from http://www.merriam-webster.com/dictionary/issue

Meyer, B. (2005). The unspoken revolution in software engineering. *New York Times*.

Mikulovic, V., & Heiss, M. (2006, May). How do I know what I have to do?: the role of the inquiry culture in requirements communication for distributed software development projects. In Proceedings of the 28th international conference on Software engineering (pp. 921-925). ACM.

Mikulovic, V., Heiss, M., & Herbsleb, J. D. (2006, October). Practices and Supporting Structures for Mature Inquiry Culture in Distributed Software Development Projects. In 2006 IEEE International Conference on Global Software Engineering (ICGSE'06) (pp. 245-246). IEEE.

Minhas, N. M., & Zulfiqar, A. (2014). An improved framework for requirement change management in global software development. *Journal of Software Engineering and Applications, 7*(9), 779.

Moe, N. B., & Šmite, D. (2007). Understanding lacking trust in global software teams: A multi-case study *Product-Focused Software Process Improvement* (pp. 20-34): Springer.

Nakatsu, R. T., & Iacovou, C. L. (2009). A comparative study of important risk factors involved in offshore and domestic outsourcing of software development projects: A two-panel Delphi study. *Information & management, 46*(1), 57-68.

Neetu Kumari, S., & Pillai, A. S. (2013). *A survey on global requirements elicitation issues and proposed research framework. In Software Engineering and Service Science (ICSESS), 2013 4th IEEE International Conference on (pp. 554-557). IEEE.*

Nevo, D., & Chan, Y. E. (2007). A Delphi study of knowledge management systems: Scope and requirements. *Information & management, 44*(6), 583-597.

Niazi, M., Babar, M. A., & Verner, J. M. (2010). Software Process Improvement barriers: A cross-cultural comparison. *Information and Software Technology, 52*(11), 1204-1216.

Niazi, M., El-Attar, M., Usman, M., & Ikram, N. (2012, May). GlobReq: A framework for improving requirements engineering in global software development projects: Preliminary results. In Evaluation & Assessment in Software Engineering (EASE 2012), 16th International Conference on (pp. 166-170). IET.

Niazi, M., Ikram, N., Bano, M., Imtiaz, S., & Khan, S. U. (2013). Establishing trust in offshore software outsourcing relationships: an exploratory study using a systematic literature review. *Software, IET, 7*(5), 283-293.

Niazi, M., Wilson, D., & Zowghi, D. (2005). A maturity model for the implementation of software process improvement: an empirical study. *Journal of Systems and Software, 74*(2), 155-172.

Nidhra, S., Yanamadala, M., Afzal, W., & Torkar, R. (2013). Knowledge transfer challenges and mitigation strategies in global software development—A systematic literature review and industrial validation. *International journal of information management, 33*(2), 333-355.

Noll, J., Beecham, S., & Richardson, I. (2010). Global software development and collaboration: barriers and solutions. *ACM Inroads, 1*(3), 66-78.

Nuseibeh, B., & Easterbrook, S. (2000, May). Requirements engineering: a roadmap. In Proceedings of the Conference on the Future of Software Engineering (pp. 35-46). ACM.

Okoli, C., & Pawlowski, S. D. (2004). The Delphi method as a research tool: an example, design considerations and applications. *Information & management*, *42*(1), 15-29.

Oshri, I., Kotlarsky, J., & Willcocks, L. P. (2007). Global software development: Exploring socialization and face-to-face meetings in distributed strategic projects. *The Journal of Strategic Information Systems*, *16*(1), 25-49.

Oshri, I., Kotlarsky, J., & Willcocks, L. P. (2015). *The Handbook of Global Outsourcing and Offshoring 3rd Edition*: Palgrave Macmillan.

Oxford Dictionary. (2012) Retrieved September 04, 2012, from http://oxforddictionaries.com

Oxford Learners' Dictionary (2012) Retrieved September 04, 2012, from http://oald8.oxfordlearnersdictionaries.com/dictionary

oxforddictionary. (2015) Retrieved 15 November 2015, from http://www.oxforddictionaries.com/definition/learner/practice

Oyegoke, A. (2011). The constructive research approach in project management research. *International Journal of Managing Projects in Business*, *4*(4), 573-595.

Oza, N. V., Hall, T., Rainer, A., & Grey, S. (2006). Trust in software outsourcing relationships: An empirical investigation of Indian software companies. *Information and Software Technology*, *48*(5), 345-354.

Paetsch, F., Eberlein, A., & Maurer, F. (2003, June). Requirements Engineering and Agile Software Development. In WETICE (Vol. 3, p. 308).

Paré, G., & Dubé, L. (1999, January). Virtual teams: an exploratory study of key challenges and strategies. In Proceedings of the 20th international conference on Information Systems (pp. 479-483). Association for Information Systems.

Pelly, F., Meyer, N. L., Pearce, J., Burkhart, S. J., & Burke, L. M. (2014). Evaluation of food provision and nutrition support at the London 2012 Olympic Games: the opinion of sports nutrition experts. *International Journal of Sport Nutrition & Exercise Metabolism*, *24*(6).

Perera, I. (2011). Impact of poor requirement engineering in software outsourcing: a study on software developers' experience. *International Journal of Computers Communications & Control*, *6*(2), 337-348.

Pfleeger, S. L., & Kitchenham, B. A. (2001). Principles of survey research: part 1: turning lemons into lemonade. *ACM SIGSOFT Software Engineering Notes*, *26*(6), 16-18.

Pitangueira, A. M., Maciel, R. S. P., de Oliveira Barros, M., & Andrade, A. S. (2013, August). A systematic review of software requirements selection and prioritization using SBSE approaches. In International Symposium on Search Based Software Engineering (pp. 188-208). Springer Berlin Heidelberg.

Polit, D. F., & Beck, C. T. (2004). *Nursing research: Principles and methods*: Lippincott Williams & Wilkins.

Polit, D. F., & Beck, C. T. (2006). The content validity index: are you sure you know what's being reported? Critique and recommendations. *Research in nursing & health, 29*(5), 489-497.

Polit, D. F., Beck, C. T., & Owen, S. V. (2007). Is the CVI an acceptable indicator of content validity? Appraisal and recommendations. *Research in nursing & health, 30*(4), 459-467.

Portillo-Rodríguez, J., Vizcaíno, A., Piattini, M., & Beecham, S. (2012). Tools used in Global Software Engineering: A systematic mapping review. *Information and Software Technology, 54*(7), 663-685.

Pressman, R. S. (2005). *Software engineering: a practitioner's approach*: Palgrave Macmillan.

Prikladnicki, R., Audy, J., & Evaristo, R. (2003, May). Requirements management in global software development: Preliminary findings from a case study in a sw-cmm context. In The International Workshop on Global Software Development (pp. 53-58).

Prikladnicki, R., Audy, J. L. N., Damian, D., & de Oliveira, T. C. (2007, August). Distributed Software Development: Practices and challenges in different business strategies of offshoring and onshoring. In International Conference on Global Software Engineering (ICGSE 2007) (pp. 262-274). IEEE.

Prikladnicki, R., Boden, A., Avram, G., de Souza, C. R., & Wulf, V. (2014). Data collection in global software engineering research: learning from past experience. *Empirical Software Engineering, 19*(4), 822-856.

Prikladnicki, R., & Carmel, E. (2013, May). Is time-zone proximity an advantage for software development? The case of the Brazilian IT industry. In Proceedings of the 2013 International Conference on Software Engineering (pp. 973-981). IEEE Press.

Prikladnicki, R., Evaristo, R., Gallagher, K., Lopes, L. T., & Audy, J. L. N. (2005). The Role of Culture in Interpreting Qualitative Data: Methodological Issues in an Exploratory Study of Cross-Cultural Distributed Software Development. *the 13th Special Interest Group on Cross-Cultural Research in Information Systems (SIGCCRIS) at ICIS, Las Vegas*.

Radatz, J., Geraci, A., & Katki, F. (1990). IEEE standard glossary of software engineering terminology. *IEEE Std, 610121990*(121990), 3.

Rainer, A., & Hall, T. (2002). Key success factors for implementing software process improvement: a maturity-based analysis. *Journal of Systems and Software, 62*(2), 71-84.

Ramasubbu, N., Krishnan, M. S., & Kompalli, P. (2005). Leveraging global resources: A process maturity framework for managing distributed development. *Software, IEEE, 22*(3), 80-86.

Ramzan, M., Batool, A., Minhas, N., Qayyum, Z. U., & Jaffar, M. A. (2011, December). Automated Requirements Elicitation for Global Software Development (GSD) Environment. In International Conference on Advanced Software Engineering and Its Applications (pp. 180-189). Springer Berlin Heidelberg.

Romero, M., Vizcaíno, A., & Piattini, M. (2008). Competencies Desirable for a Requirements Elicitation Specialist in a Global Software Development. In ICSOFT (SE/MUSE/GSDCA) (pp. 347-354).

Rong, X., Mu, L., & Liu, P. (2009, August). Project evaluation with time, cost, and quality considerations. In Fuzzy Systems and Knowledge Discovery, 2009. FSKD'09. Sixth International Conference on (Vol. 3, pp. 316-319). IEEE.

Rooney, J. J., & Heuvel, L. N. V. (2004). Root cause analysis for beginners. *Quality progress, 37*(7), 45-56.

Rosqvist, T., Koskela, M., & Harju, H. (2003). Software quality evaluation based on expert judgement. *Software Quality Journal, 11*(1), 39-55.

Ross, T. D. (2003). Accurate confidence intervals for binomial proportion and Poisson rate estimation. *Computers in biology and medicine, 33*(6), 509-531.

Ruiz, J. L., Segura, J. V., & Sirvent, I. (2015). Benchmarking and target setting with expert preferences: An application to the evaluation of educational performance of Spanish universities. *European Journal of Operational Research, 242*(2), 594-605.

Rusman, E., Van Bruggen, J., Cörvers, R., Sloep, P., & Koper, R. (2009). From pattern to practice: Evaluation of a design pattern fostering trust in virtual teams. *Computers in Human Behavior, 25*(5), 1010-1019.

Sabahat, N., Iqbal, F., Azam, F., & Javed, M. Y. (2010, August). An iterative approach for global requirements elicitation: A case study analysis. In Electronics and Information Engineering (ICEIE), 2010 International Conference On (Vol. 1, pp. V1-361). IEEE.

Sadraei, E., Aurum, A., Beydoun, G., & Paech, B. (2007). A field study of the requirements engineering practice in Australian software industry. *Requirements engineering, 12*(3), 145-162.

Sale, J. E., Lohfeld, L. H., & Brazil, K. (2002). Revisiting the quantitative-qualitative debate: Implications for mixed-methods research. *Quality and quantity, 36*(1), 43-53.

Sandeep Dalal, R. S. C. (2013). Empirical study of root cause analysis of software failure. *ACM SIGSOFT Software Engineering Notes, 38*(4), 1-7.

Santos, J. R. A. (1999). Cronbach's alpha: A tool for assessing the reliability of scales. *Journal of extension, 37*(2), 1-5.

Sayão, M., Haendchen Filho, A., & do Prado, H. A. (2008). Requirements Engineering for Distributed Development Using Software Agents *Advances in Conceptual Modeling–Challenges and Opportunities* (pp. 272-281): Springer.

Schmid, K. (2014). Challenges and solutions in global requirements engineering–A literature survey *Software Quality. Model-Based Approaches for Advanced Software and Systems Engineering* (pp. 85-99): Springer.

Schmidt, R., Lyytinen, K., & Mark Keil, P. C. (2001). Identifying software project risks: An international Delphi study. *Journal of management information systems, 17*(4), 5-36.

Schmidt, R. C. (1997). Managing Delphi surveys using nonparametric statistical techniques*. *decision Sciences, 28*(3), 763-774.

Schopf, J. M., & Nitzberg, B. (2002). Grids: The top ten questions. *Scientific programming, 10*(2), 103-111.

Sekaran, U. (2006). *Research methods for business: A skill building approach*: John Wiley & Sons.

Shao, B., & David, J. S. (2007). The impact of offshore outsourcing on IT workers in developed countries. *Communications of the ACM, 50*(2), 89-94.

Shi, L., Wang, Q., & Li, M. (2013, July). Learning from evolution history to predict future requirement changes. In 2013 21st IEEE International Requirements Engineering Conference (RE) (pp. 135-144). IEEE.

Sinha, V., Sengupta, B., & Chandra, S. (2006). Enabling collaboration in distributed requirements management. *Software, IEEE, 23*(5), 52-61.

Skulmoski, G. J., Hartman, F. T., & Krahn, J. (2007). The Delphi method for graduate research. *Journal of information technology education, 6*, 1.

Šmite, D. (2006). Requirements management in distributed projects. *Journal of Universal Knowledge Management, 1*(2), 69-76.

Šmite, D., & Galviņa, Z. (2012). Socio-technical congruence sabotaged by a hidden onshore outsourcing relationship: lessons learned from an empirical study *Product-Focused Software Process Improvement* (pp. 190-202): Springer.

Šmite, D., Moe, N. B., & Torkar, R. (2008). Pitfalls in remote team coordination: Lessons learned from a case study *Product-Focused Software Process Improvement* (pp. 345-359): Springer.

Sommerville, I. (2007). *Software engineering* (8th Edition ed.): , Addison Wesley.

Sommerville, I., & Kotonya, G. (1998). *Requirements engineering: processes and techniques*: John Wiley & Sons, Inc.

Sommerville, I., & Ransom, J. (2005). An empirical study of industrial requirements engineering process assessment and improvement. *ACM Transactions on Software Engineering and Methodology (TOSEM), 14*(1), 85-117.

Sommerville, I., & Sawyer, P. (1997). *Requirements engineering: a good practice guide*: John Wiley & Sons, Inc.

Steele, J., Bourke, L., Luloff, A., Liao, P.-S., Theodori, G. L., & Krannich, R. S. (2001). The drop-off/pick-up method for household survey research. *Community Development, 32*(2), 238-250.

T. Hall, S. B., Austen Rainer. (2002). Requirements problems in twelve software companies: An empirical analysis. *IEE PROCEEDINGS - SOFTWARE, 149*(5), 153 - 160.

Tam, M. C., & Tummala, V. R. (2001). An application of the AHP in vendor selection of a telecommunications system. *Omega, 29*(2), 171-182.

Vagias, W. M. (2006). Likert-type scale response anchors. *Clemson International Institute for Tourism & Research Development, Department of Parks, Recreation and Tourism Management. Clemson University*.

Verner, J. M., & Abdullah, L. M. (2012). Exploratory case study research: Outsourced project failure. *Information and Software Technology, 54*(8), 866-886.

Vicinanza, S. S., Mukhopadhyay, T., & Prietula, M. J. (1991). Software-effort estimation: an exploratory study of expert performance. *Information systems research, 2*(4), 243-262.

Viera, A. J., & Garrett, J. M. (2005). Understanding interobserver agreement: the kappa statistic. *Fam Med, 37*(5), 360-363.

Vizcaíno, A., García, F., Villar, J. C., Piattini, M., & Portillo, J. (2013). Applying Q-methodology to analyse the success factors in GSD. *Information and Software Technology, 55*(7), 1200-1211.

Vorley, G. (2008). Mini Guide to Root Cause Analysis. Published by Quality Management & training.

Walia, G. S., & Carver, J. C. (2009). A systematic literature review to identify and classify software requirement errors. *Information and Software Technology, 51*(7), 1087-1109.

Wallin, P., Larsson, S., Fröberg, J., & Axelsson, J. (2012). Problems and their mitigation in system and software architecting. *Information and Software Technology, 54*(7), 686-700.

Waltz, C. F., & Bausell, B. R. (1981). *Nursing research: design statistics and computer analysis*: Davis FA.

Williams, B., Onsman, A., & Brown, T. (2010). Is the Australian paramedic discipline a full profession? *Australasian Journal of Paramedicine, 8*(1).

Wilson, E. B. (1927). Probable inference, the law of succession, and statistical inference. *Journal of the American Statistical Association, 22*(158), 209-212.

Wohlin, C., & Aurum, A. (2006). Criteria for selecting software requirements to create product value: An industrial empirical study *Value-based software engineering* (pp. 179-200): Springer.

Wu, X., & Kumar, V. (2009). *The top ten algorithms in data mining*: CRC Press.

Xiong, W., & Wu, Z. (2009, December). Research on DQFD and Cross-Cultural Communication in Outsourcing Software Requirement Change Control. In Computational Intelligence and Software Engineering, 2009. CiSE 2009. International Conference on (pp. 1-4). IEEE.

Zhang, H., Li, J., Zhu, L., Jeffery, R., Liu, Y., Wang, Q., & Li, M. (2014). Investigating dependencies in software requirements for change propagation analysis. *Information and Software Technology, 56*(1), 40-53.

Zimmermann, T., Zeller, A., Weissgerber, P., & Diehl, S. (2005). Mining version histories to guide software changes. *Software Engineering, IEEE Transactions on, 31*(6), 429-445.

Zowghi, D. (2002). Does global software development need a different requirements engineering process. *In Proceedings of International Workshop on Global Software Development* (Vol. 2002).

LIST OF PUBLICATIONS

Journal Papers

[1] J. Iqbal, R. B. Ahmad, M. H. N. M. Nasir, M. Niazi, S. Shamshirband, and M. A. Noor, "Software SMEs' unofficial readiness for CMMI®-based software process improvement," *Software Quality Journal*, pp. 1-27, May 2015.

[2] J. Iqbal, R. B. Ahmad, M. H. N. M. Nasir and M. A. Noor, "A Framework to Address Communication Issues of Requirements Engineering Process for Software Development Outsourcing," *Journal of Internet Technology.*

Conference Papers

[1] J. Iqbal, R. B. Ahmad, and M. A. Noor, "Frequently occurring risks for IT outsourcing projects," in *IEEE International Conference on Computer and Communication Engineering (ICCCE),*Kuala Lumpur, Malaysia, 2012, pp. 957-960.

[2] J. Iqbal, R. B. Ahmad, H. N. M. Nasir, and M. A. Noor, "Significant requirements engineering practices for software development outsourcing," in *22nd Australian Software Engineering Conference (ASWEC),*Melbourne, Australia, 2013, pp. 137-144.

[3] J. Iqbal, R. B. Ahmed, and S. Marczak, "A framework to resolve requirements engineering issues in software development outsourcing," in *IEEE Fourth International Workshop on Empirical Requirements Engineering, EmpiRE, (22nd IEEE International Requirements Engineering Conference,RE'14),* Karlskrona, Sweden, 2014, pp. 72-75.

Book Chapter

[1] Javed Iqbal and Rodina Binti Ahmad, "Requirements Engineering process for Software Development Outsourcing," in *Requirements Engineering and Management: Principles and Research*, Kuala Lumpur, Malaysia, University of Malaya Press, 2016.