IMPACT OF GEOGRAPHICAL DISTANCE ON REQUIREMENTS ELICITATION IN GLOBAL SOFTWARE DEVELOPMENT (GSD)


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In

the

Name

of

ALLAH

The Most Merciful

The Most Beneficent

International Islamic University, Islamabad
Faculty of Basic Applied Sciences
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Final Approval

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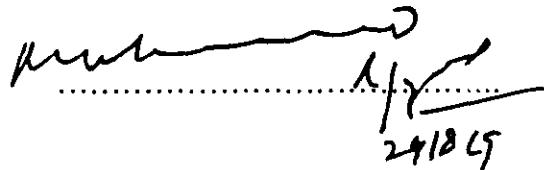
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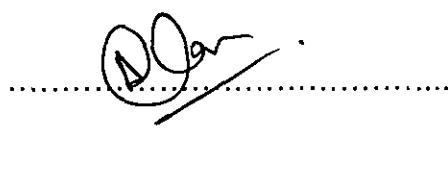
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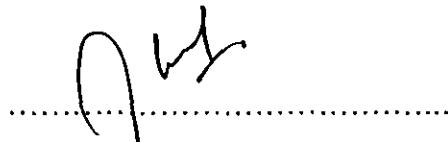
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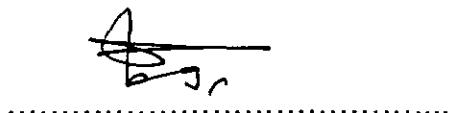
A Thesis Submitted to the Department of Computer Science,

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Requirements for the Award of the Degree of

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DECLARATION

I hereby declare and affirm that this thesis neither as a whole nor as part thereof has been copied out from any source. It is further declared that I have completed this thesis on the basis of my personal efforts, made under the sincere guidance of my supervisors. If any part of this report is proven to be copied out or found to be a reproduction of some other, I shall stand by the consequences. No portion of the work presented in this report has been submitted in support of an application for other degree or qualification of this or any other University or Institute of learning.

ZAFAR IQBAL KHAN
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DEDICATION

To **ALLAH** who has given us the brain to explore

&

My **Teachers** who always guide us

&

My **Family**, especially to my **Father**

&

His valuable suggestions that helped me a lot to achieve my goal..

ACKNOWLEDGMENT

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I pay my heartiest tributes to my supervisor **Mr. Aihab Khan**, Deputy Director, Department of Computer Science, FJU for Woman, Rawalpindi for his valuable suggestions, positive criticism and proper guidance. It was because of his constructive guidance, sympathic attitude and dynamic supervision that I have carried out this project in the best way as possible.

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ZAFAR IQBAL KHAN
December, 2008.

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PROJECT IN BRIEF

Project Title: Impact of Geographical Distance on Requirements Elicitation in Global Software Development

Organization: International Islamic University, Islamabad, Pakistan.

Objective: The objective of the research is to study the distance dimension's impact over requirements elicitation process by developing a framework to support human communication process in requirements elicitation in the form of communication Model during GSD w.r.t. geographical distance.

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Research Work Start: January 2007

Research Area: Requirement Engineering (Requirements Elicitation Process)

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ABSTRACT

Requirements elicitation is a coherent process which observes requirements for the development of software project. These observations occupy a complex communication between large groups of participants. The process of software development is complex, when team members are located widely in distributed geographical locations which possess many challenges for developers, particularly during the requirements elicitation phase. When participants are working together on a global software development project then it probably introduces problems in communication. Managing such geographically dispersed participants is one of the biggest challenges faced by organizations that operate for global software development. To have a possible solution to this problem, the current study is conducted to examine the impact of geographical distance i.e., groupware tools , RE techniques, RE methods and factors on requirements elicitation process in global software development. This study aims to explore and evaluates the communication model which represents all aspects of human communication in requirement elicitation process. A questionnaire was made and then survey by fourthy-one (41) project managers within twenty-six (26) multinational software houses in our local domain. A framework to support human communication in global requirements elicitation w.r.t geographical distance is developed on the basis of the findings of this empirical study.

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CHAPTER-1

INTODUCTION

1.1   Introduction

Software is critical in any of the engineering activity. Software is an attractive and a major part of global software market. Software importance is growing everyday due to the growth of technology [1]. The global software market needs to develop software with new features in short time. Software development is the critical activity mostly related with proceeding of technology and high level of information [2]. Every Software development project faces a considerable amount of risks. The success of software development is directly connected with the involved communication (i-e Communication should be effectively managed in order to end a software development project) [3]. By this situation, today's global software development organizations maintain the advanced software development project that is influenced by communication, which takes us project failure [4].

Today, many software development organizations wanting to develop software in a distributed environment, where team members are widely spread over several regions/ countries and they use group tool as communication [5]. In such virtual environments, these software development projects are affected by many factors that make communication more difficult, in this way new methodologies are needed to improve the requirements elicitation and development process [6].

The software development success or failure depends on the quality of requirements [7]. The quality of requirements is greatly influenced by techniques employed during requirements elicitation process [8]. The requirements elicitation is the process where analysts determine the problems and needs of customers within a particular organization [9] because elicitation is all about learning the needs of users, and communicates these needs to system builders. The effective requirements elicitation process will provide a set of requirements that can be used by the participants (software development teams) [10]. But the communication between participants within requirement elicitation is challenged by many factors (like technology, management activities, and participants) [11].

Global software development (GSD) is the development of software where participants are distributed across geographically distance sites [12]. The distribution of participant's increases day by day, those communicate through some kind of technology. This distribution introduces communication problems on global software development projects [13]. In GSD context,

traditional requirements elicitation process presents numerous problems [14]. Most of these problems are concerned with communication with participants [15].

The primary objective of this research work is to analyze the impact of the distance dimensions i.e., groupware tools, RE methods, RE techniques and RE communication factors on the success of RE process in global software development and to analyze the inter-relationship between various distance dimensions. For this we have proposed a framework to support human communication process in global requirements elicitation. We combine the analysis of existing communication models with the requirements elicitation process knowledge in literature to produce a human communication process in the form of a single communication model. This framework is based on communication concepts and factors. The framework expresses the communication process in requirements elicitation process in terms of the environment's in which they occur and also in terms of the outputs (outcomes) of those communication processes.

1.2   The Research Problem

Ongoing for many years, many authors defined interpersonal or human communication in a varity of ways [5,16,17]. Most of the authors believe that interpersonal communication is the interaction between two or more people. In the literature [18], there is a link between interpersonal communication and information sytems and also applied the interpersonal communication and group communication in the field of software development. Interpersonal communication is a highly complex process where many factors depend on the success of two or more participants interactions [19].

The requirements elicitation is a human-centered process, where communication is crucial [20]. Numerous authors have developed a variety of traditional requirements elicitation methods and tried to control their interactions, which are helping to make the human communication in their environments easy. Basically these methods are used to develop different types of organization needs which help in working within different environments. There is no individual method that is used in the requirements elicitation process but different methods are combined together throughout the requirements elicitation process. The analyst should take these methods with full confidence which help to develop a correct system and fulfill the user requirements needs.

Interpersonal or human communication is described by numerous authors (as discussed above), but nothing else has been done where the requirements elicitation process is represented in the form of a single communication model that describes all aspects of human communication. Previous models (in literature) underlying some basic concepts, which can be found in [21,22,23,24,25,26], where a sender (human/ machine) encodes and transmits a message (letters, number etc) and sends the message along a channel (tools, technology) to a receiver (human/machine).

1.2.1   The Research Problem Statement

The statement of this research problem is to focus on the impact of distance dimensions on the success of requirements elicitation process, represented through a single communication model, which describes all aspects of interpersonal or human communication during global software development (distributed environment).

1.1.2   The Research Question

The research 'question' that actually motivated this study was **"what is the impact of geographical distances on requirements elicitation in global software development"?**

The goal of our research question is to understand: -

- What is communication process with respect to requirements elicitation process?
- Can a single communication model describe all aspects of interpersonal (human) communication? If yes, than how?
- How RE process is conducting in geographically distributed environments?
- Can requirements elicitation process be representing in the form of communication model in distributed environment.
- By using communication technology, can RE process work successfully?
- How requirements elicitation process can be facilitated by using communication technology (today which is easily available)?

1.3   Objective of the Research

The main objective of my thesis is: -

- To evaluate the requirements elicitation process in the form of communication model.
- To evaluate a single communication model that describes all aspects of interpersonal (human) communication.
- To conduct the requirements elicitation process in geographically distributed environment (related with distance).
- To evaluate an analysis of requirement elicitation methods, tools, techniques and factors with respect to theory and practice in our local domain.
- To provide many opportunities to software development projects all over the world.
- To improve literacy levels through distance learning.
- To provide better decision making due to flow of information between organizations.
- To develop a framework to support human communication in requirements elicitation for geographically distributed environment.

1.4   Purpose & Scope of Research

The current research is manual and representing a lot of problems. The problems are given as follows:

- In global software development, changes cannot adopt easily due to poor communication between stakeholders (participants). So we can say that the communication reduces the working performance of software development and also flexibility during global software development process. If distance increases between participants, then global software development process becomes more problematic.
- The requirements elicitation process always involves face-to-face interactions. During global software development, participants (analyst and users) need travel (long journeys and overnight stays) from one organization to the other. This travel is costly (both by financial and psychological means).
- In global software development, the level of communication is reduced, so it creates difficulties in coordination between participants. It means that successful communication plays an important role in the success of SD during geographical distribution.

- During global software development, the requirements elicitation process is challenged by many factors (like technologies and techniques). When participants are distributed by multi-sides organization, it creates problems in communication. So remote side operations are too high and costly.

- The geographic distance creates problems in requirements elicitation when stakeholders are working on a global software development project. As both money and time are still spent on physically traveling between organizations.

1.5   Outputs of the Proposed Research

The outputs of proposed research are given below:

- This research analyzes and describes the accurate nature of the communication processes with in requirements elicitation process during global software development.

- To develop a framework to support human communication in globally requirements elicitation with respect to geographical distance and also examines the human factors relationship within the framework.

- This research bridges the gap between theory and practice in the local domain.

1.6   Significance of the Research

Our research will give a lot of benefits to research communities, which are given below.

1. Reduced overall project and portfolio communication challenges in GSD.
2. Better management of communication problems in global software development.
3. Saving of daily communication through thousands of workers all over the world.
4. Improved solution delivery efficiency and Increased success rate.
5. Prevention of materials and energy wastages.
6. Reduces the development and maintenance costs.
7. Better control over scope, budget, schedule and quality.
8. Increased predictability over delivery schedules.
9. Increased user satisfaction and better quality projects.
10. Organizational alignment through effective planning and estimation.

1.7   Thesis Overview

This research presents a detailed study, which is gone through a series of detailed sequential steps to shape it into the final form. These sequential steps are explained by the following chapters included in the study.

Chapter 1   Provides an introduction to the research problem, to specify the objectives and significance of the research, and also to explain the organization of the thesis.

Chapter 2   Show the background of research.

Chapter 3   Reviews the literature relating to our research.

Chapter 4   Describes Research Methodology and Data Collection of the research.

Chapter 5   Presents the Data Analysis and Results of the research.

Chapter 6   Presents two Frameworks development in Requirements Elicitation Process.

Chapter 7   Provides the conclusion of the research.

References   Contains references which are related to our research.

Appendix A   Contains the abbreviations of our research.

Appendix B   Contains the questionnaire used to collect data for the empirical study presented in Chapter 4.

1.8   Summary

This chapter describes the research problem and also the research question. The purpose and scope of research was also defined. On the other hand, the importance of research and the proposed output of the research were also explored.

CHAPTER - 2

BACKGROUND

2.1 Introduction

This chapter discusses the requirements elicitation relevant to the human and communication models and also discusses the global software development as with advantages and disadvantages. The requirements analysis is also elaborated. The requirements elicitation groupware tools, methods and techniques (which are most common in literature) were also discusses.

2.2 Requirement Elicitation and Communication

The requirement elicitation occurs at the early stage of software development process, as it is a critical but complex stage in the software development [3]. Requirement elicitation is a human-centered process, where communication is critical, complex and error born [20], which creates problems between stakeholders (participants) [3]. The distance creates communication problems between stakeholders during software development process [27]. The [28], briefly describes the classification of communication challenges that occurs during the requirements elicitation process during software development. Basically it determines information for a system by communication with the stakeholders in software development process [29]. If we improve communication in the requirements elicitation process, the requirements elicitation process is itself improve [30]. It shows that, requirements elicitation is determining the needs of stakeholders within an organization. It means that effective requirements elicitation process require good communication skills.

2.2.1 Interpersonal (Human) Communication

Communication is a process, in which a sender constructed and encoded a message, that is transmitted by some channel and a recievier received and decode them. Many authors defined that interpersonal communication is the interaction between two are more people[19]. In the literature [18], link the interpersonal communication and information sytems and also applied the interpersonal communication and group communication in the field of software development. Interpersonal communication is a highly complex process where many factors depend on the success of two or more participants interactions [16].

The requirements elicitation is a human-centered process, where communication is crucial [20]. By this way, numerous authors have developed a variety of traditional requirements elicitation methods [1,4,6,9,10,23,26,31] and tried to control interpersonal interactions which are taking to make easy communication in this environment. These methods help to develop different types of organizations needs that help in working within different environments. There is no single method that is used in the requirements elicitation process but many different methods are combined together throughout the requirements elicitation process [3]. The analyst should be taken these methods with full confidence which help to correct demonstration of the system that required by the user [32].

2.2.2 Communication Models

Model should be easy to change and understand also easy to communicate. Stakeholders' needs should be explore by using these models [3]. Models could be used to provide early feedback to the stakeholders [32], (such as action diagram, structure chart and system overview model). The models which are developed during requirements elicitation, then requirements models should be more clear, accurate and complete during late-phase of software development [3]. Models also clarify the structure of complex events.

There are some basic concepts as shown in **Figure 2.1**, which can be found underlying most models [17,22,33,34]. There is a sender (human/machine) constructed and encoded a message, which is transmitted by some channel (technologies, tools, techniques) and a recievier (human/machine) received and decode them. The communication process is a process which interacts two or more participants in a face-to-face setting (telephone), or in a computer-mediated setting (E-mail).
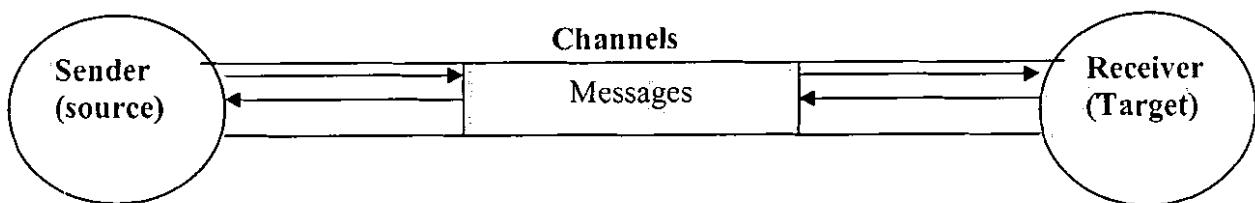
Figure 2.1 Communication Model

There are some important communication models which are discussed in the literature, are discussed below:

The Shannon-Weaver Communication Model [17], describes the communication process. The main factors of this model are source, message, signal, noise and signal are shown in **Figure 2.2.** The Shannon-Weaver Communication Model was produced in 1949 and his model was very technology-oriented at that time because his researching is based in the information theory field.
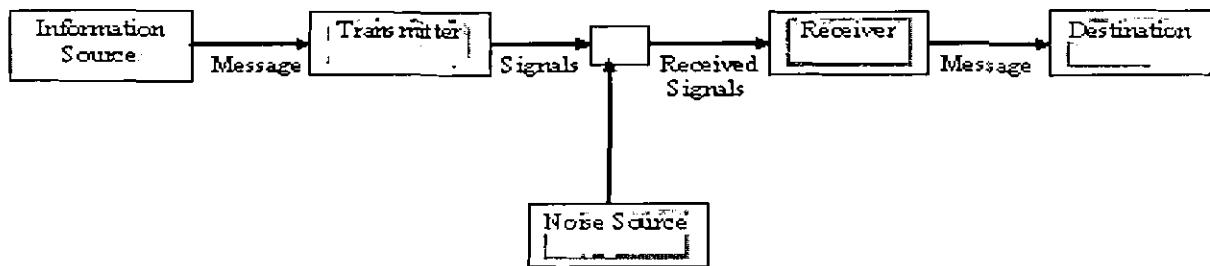
Figure 2.2. The Shannon-Weaver Communication Model [35]

The authors of [35], discussed the transaction communication model and it is the interaction of two or more people in the process to achieve a common goal. There is a sender which sends a message (written or nonverbal communication) that the sender transmit to the receiver [35]. The channel is that medium through which both sender and receiver interact [35]. This is done by two ways: writing messages and spooking messages. The writing messages are transmitting (in letter, report etc) and spoken messages are transmitting (in telephone or face-to-face setting). The feedback contains messages; the receiver sends back to the receiver in decode form [35]. The context is that situation in which communication takes place [30].
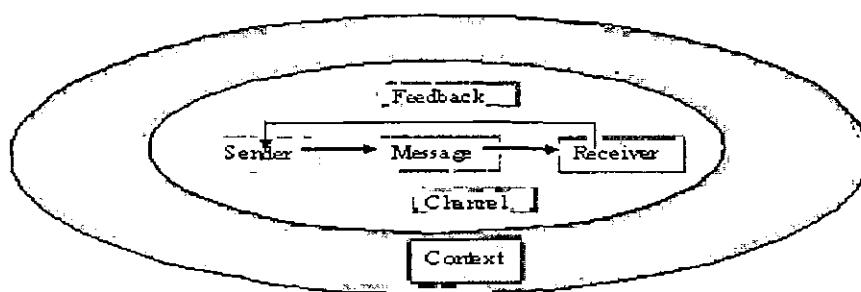
Figure 2.3   Transactional Model of Communication [35]

The Berlos SMCR communication model [33] describes human factors of the communication process and also focus on interpersonal communication. The four main factors are source (i.e., communication skills, attitudes, etc), message (i.e., structure, code, content, etc), receiver (i.e., communication skills, attitudes, etc.) and channel (i.e., tasting, seeing, etc).
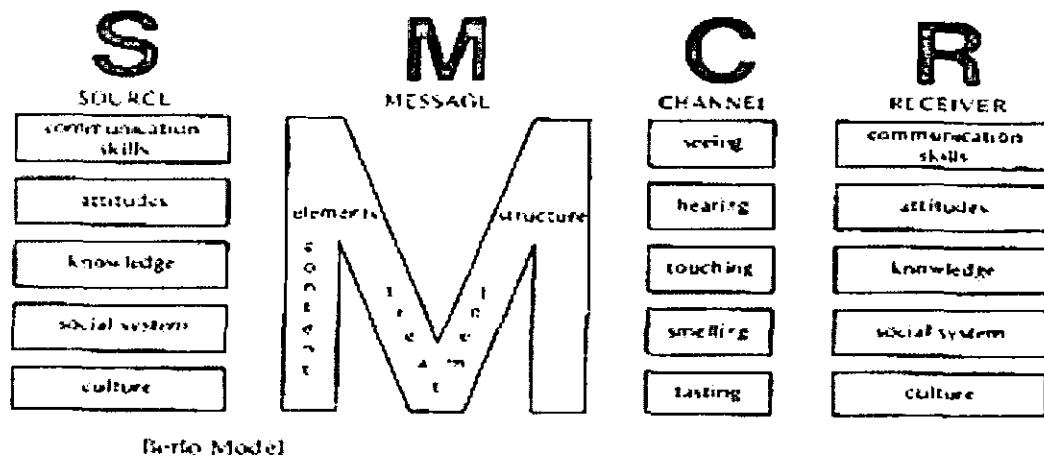
Figure 2.4   The Berlos SMCR communication model [33]

2.2.3   Communication Networks

When we see that two-persons are communicated within work groups or within organization, we concerned them with communication networks because communication networks are the systems of communication lines interact different senders and receivers (participants). But the main purpose of communication network is that to explore the communication model. The [36] proposed numerous communication networks (i.e. five persons Communication networks) as shown in **Figure 2.5**.

Here, the dots show participants and lines show two ways communication (interaction) between participants [36]. The communication between participants and other participants.
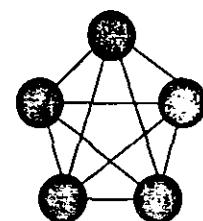
Figure 2. 5 Communication Network [36]

2.3 Requirement Analysis Communication

Requirement analysis is a process of modeling and specification and understanding the organizational context within which a software system will evenly function [38]. During the requirements analysis process, both the developers and customers take an active role. It focuses on "what" instead of "how". The inputs of requirements analysis process are software project plan and system specification (if one exists). The outputs of requirements analysis process software requirements specification document (SRS) [31], as shown in **Figure 2.9**. In requirement analysis the customer and developer can check the quality of the software and provides useful feedback.

```
┌──────────────┐          ┌─────────────────────────┐          ┌──────────────┐
│ Project Plan │          │                         │          │   Software   │
│     And      │─────────▶│  Requirement Analysis   │─────────▶│ Requirements │
│   Sign-off-  │          │                         │          │Specification │
│documentation │          └─────────────────────────┘          │   Document   │
└──────────────┘                                                └──────────────┘
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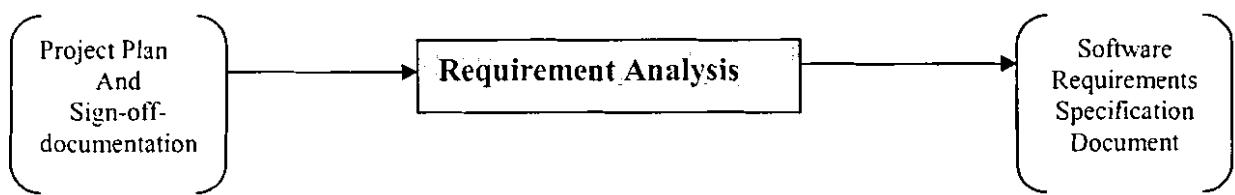
Figure 2.9 The inputs and outputs of requirements Analysis

2.4 Globally Software Development (GSD)

Global software development (GSD) is rapidly growing, day by day in the software development industry, due to the technology improvements [39]. Many organizations wanting to share software development efforts over several globally distributed environments but GSD is technologically and organizationally complex and presents a variety of communication challenges among the software development teams [40] because software development teams are often geographically distributed from their participants. This creates significant communication and coordination challenges that effect requirements elicitation process effectiveness [3]. The global software development challenges, effects and advantages are shown in **Figure 2.10**.

2.4.1 Benefits of and disadvantages of GSD

The benefits of global software development [41,42] are:

- It reduces cost.
- It reduces time-to-market.
- GSD access to leading-edge technology (video conferencing).

- GSD increased productivity.

- 24-hour working on day during opposite direction.

The disadvantages of global software development [43,44] are:

- The distance between user and developer during software development.

- The differences in culture (i.e., language, norms etc).

- Time-zone differences which lead to participants problems (like, coordination).
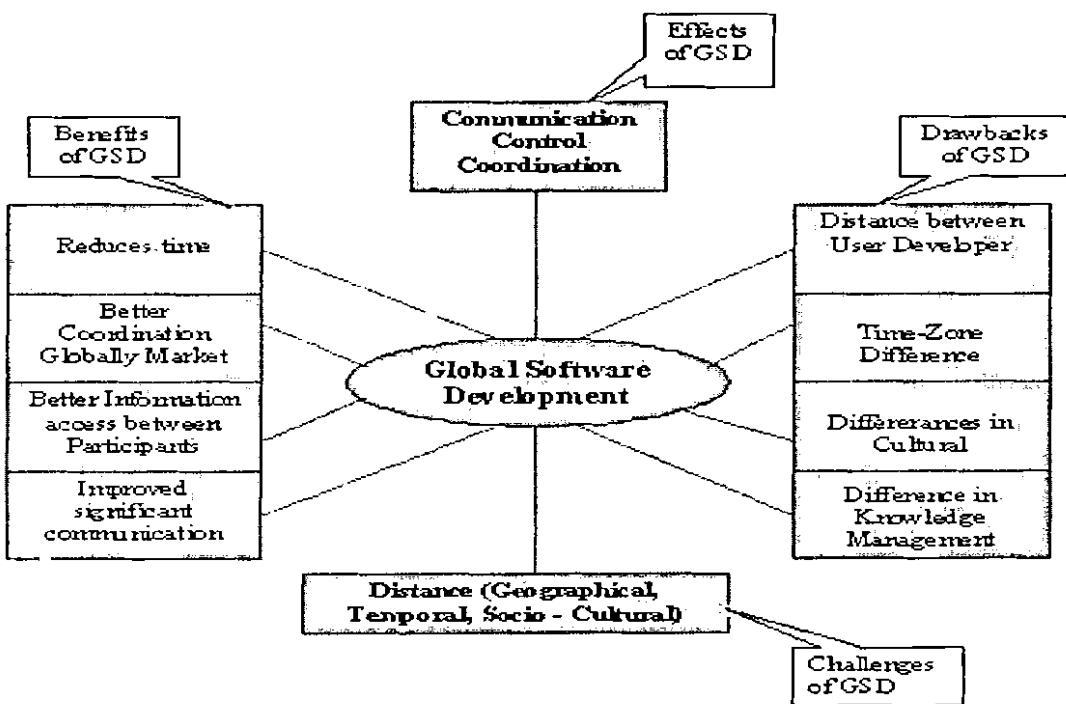
Figure 2.10   Global Software Development (GSD)

2.4.2   Geographical Distance

When participants are not located at the same location and they are geographically distributed, then distance between participants introduces both formal and informal communication problems [43]. But this participants communication is highly dependent on the quality of communication technology (i.e., email) [45]. The geographical distance is an effort measure which is important for visit one participants to another participant [7]. During geographical distribution, software development teams are distributed from their customer and end users which effects the effectiveness of requirements engineering [31].

2.5 Groupware Tools

Nowadays, geographically distributed teams must require a lot of groupware tools to support activities (factors) which is directly related with the people interaction [46]. Groupware is software which is used to enable communication between participants and who working on a common task [5]. According to [4], "We also collect information about groupware technology, as this has a direct influence upon the communication process, and about the requirement elicitation techniques since this choice is also very important for the quality of requirement specifications". Furthermore, if communication improve it is necessary to choosing in an appropriate set of groupware tools and according to the performance of stakeholders , we propose going a step further and using knowledge about stakeholders' cognitive characteristics to choose the groupware tools and requirements elicitation techniques that are closer to the way in which they learn [31]. During GSD, geographical distributed projects use many different groupware tools. There are some groupware tools which are common during multi-side development projects are shown in **Table 2.1**.

Groupware Tools	Description	References
E – mail	It is used for elicitating user requirements and also discussing them.	[12,15,31,47]
Telephone	It provides verbal communication between people and improves communication between two people. It has low system effort.	[12,31,43]
Video-Conference	It communicates two persons with two or more locations and interact both with audio and video transmissions.	[31,43,47,48]
Audio- Conference	It communicates two persons with two or more locations. It moderate cost and effort.	[15,31,44,48]
Discussion Forums	It is used for better information access and also improves communication.	[30,47]
Instant Messaging	It is used to facilitate the quick exchange of information between two or more people.	[15,47]

Table 2.1   List of Groupware Tools

2.6   Requirements Elicitation Techniques

The requirements elicitation techniques provides a useful means of facilitating communication [24] and always help the participants analysts to collect information from participants [i.e., customers and end-users] [67]. In the literature, there are numerous requirements elicitation techniques which are used by the analyst regularly for requirements collection during geographical distributed environment. The most commonly techniques for requirement are shown in **Table 2.2**.

Groupware Techniques	Description	References
Team building	It helps to build communication. It shared common idea between stakeholder and aiding communication. It is used by analyst to influence the interactions between participants.	[9,30,43]
Brainstorming	It is used to generate ideas and also prioritize them. It is mostly used in requirements development. It also allows rapidly develop an idea.	[25,31,44,50]
Protocol Analysis	It is used for collecting tacit (clear) requirements. During existing systems it interacts with problems.	[9,34,49]
Repertory Grids	Provide numerous ways to elicit attributes which are not easily clear by expert.	[34,49]
Card Sorting	It is used for knowledge acquisition which is necessary in requirements elicitation.	[34,49]
Storyboards	It is used to provide stakeholders with a real model.	[25,31,24,34]

Table 2.2   List of Requirements Elicitation Techniques

2.7   Requirements Elicitation Methods

Requirements elicitation process should be done successfully when we using the requirements elicitation methodology [3]. Many of such elicitation methodologies should be exist and helps the analysts to understanding the needs of participants with a common aim [1]. Similarly, some analysts should think that just one methodology is suitable for all conditions but some think that it is not [51] because such methodology is not sufficient for all situations. In those way requirements elicitation methods should be grown rapidly with the needs of various software development methodologies [3].

The author of [34], describes the difference between four categories of requirements elicitation methods (i.e., observational, synthetic, analytic and conversional) across as a means of

communication and suggests that each type of requirements elicitation methods show a specific interaction model across analyst and stakeholders. The requirements elicitation methods are mostly used in the design process of the requirements elicitation phase which make communication easy [3]. A lot of requirements elicitation methods were developed in the literature to take information for the purpose of requirements elicitation process as shown in **Table 2.3**.

RE Methods	Description	References
Interviews	Make an exchange of ideas between analyst and user to elicit user requirements. They are used to verify and simplify facts and also used to get the user involved.	[24,25,51,52,53]
Prototyping	It provides a powerful vehicle of communication and simplifies the detailed requirements. It is used to elicit user requirements. It is used to innovate new ideas.	[4,51,52]
Joint Application Development (JAD)	It is used to improve the relationship between user and analyst and also helps to bring together the needs of different parts of organization. It generated plans. It enhances the quality of the development process.	[4,21,51,54,55]
Requirement Reuse	It provides participants rich information in relation to the product. It provides various ways to explore the existing documentation.	[24,34]
Observation	It provides highly reliable data that can be gathered and is used for observing human activities. It facilitates the communication between the participants within the organization.	[34,49,51,52]
Participatory Design (PD)	It generates plans and also accurate models of activities in order to gather the relevant raw data.	[25,51,53]
Questionnaires	It is useful for gathering variety of data and helps in the quick and feasible analysis of the data.	[25,31,51,52,55]
Rapid Application Development (RAD)	User involvement is high and provides a systems development plan. It is useful RE method. It helps the participants to involvement in the process. It is also a strategy of developing software systems.	[10,26,51,54,55]
Laddering	Technical terms explanation are elicited by laddering (i.e. tree diagram). Laddering assists in the domain knowledge creation and then edition and reviewing of that knowledge.	[34]
workshop	It is used to revised requirements and also used for problem solving and training. They establish group tasks.	[23,50]

Table 2.3   List of Requirements Elicitation Methods

2.8   Requirements Elicitation Communication Factor

There are numerous human communication factors, which are used in the user requirements elicitation process as a role. These factors influence communication in the success of user requirements elicitation process. Some factors (i.e., mind set factors) are used to influence human interactions in the user RE process. All of the factors listed in **Table 2.4,** are requirements elicitation communication factors, which may be performed by any of the participants in the requirements elicitation process.

Communication Factors	Description
Technology	The technology factors have quite importance in RE process success. Like email, used to eliciting and describing the user requirements.
System Modeling	It is generic in nature and used for RE process success.
Standards	Standards are quietly used in the communication process to improve RE process.
Project Management	The nature of project management factors has highly impact on communication between participants.
Participation	The RE process success is due to the involved people i.e., user and analyst. More people are involved in the success of RE process.
Mind set	The mind set factors of participants have highly influence on the RE communication process success.
Personal Appearance	The personal appearances are the natural communication tools that plays important role in the requirements elicitation process success.
Body Language	It is natural communication tools important in the RE process success.
Speech	Speech is an influence on RE communication process success. It is natural communication tool.
Interpersonal Communication	It shows the human communication on RE process success.
Ergonomics	The ergonomics factors are uses to facilities an effective communication in RE process.
Decision-making	The decision-making techniques have highly impact on RE communication process.
Documentation	Tools are used for the creation of documentation will influence the communication process in RE.

Table 2.4   List of Requirements Elicitation Communication Factors

2.9   Human Aspects Relevant to Requirements Elicitation Process

There are some basic human aspects which are found most of the communication models [22,33,35,56,57], like sender, receiver, message, channel, context, noise, environment etc. These human aspects are use in the software development because they are more relevant to requirements elicitation and may be used as a part of requirements elicitation process. The definitions of these human aspects are taken from the literature [16,58], when it is related to the requirements elicitation process. Each human aspect allows importance influence in the success of entire requirements elicitation process and communication environment but also influence in the success of requirements elicitation methods. When these human aspects are combine, it produce a better communication process during software development in requirements elicitation process, otherwise a single factor have no meaning. In the **Table 2.5**, we only mention human aspects and human activities, which are relevant to the requirements elicitation process.

Human Aspects	Human Activities
Sender	- Interpersonal communication tools - Interpersonal skill - Mind set activities - Human information
Receiver	- Interpersonal communication tools - Interpersonal skill - Mind set activities - Human information
Channel	- Medium - Mode
Communication Context	- Participants (group) information - Purpose of RE - System analyst role
Environment	Organization information
Message	
Human communication process	- Network - Management

Table 2.5   Human aspects and human factors relevant to the requirements elicitation process.

2.10 Summary

This chapter describes requirements elicitation is an important part of software development. This chapter also explains the groupware tools, RE techniques and RE methods. The concept of communication models, communication networks and human communication is also explored. GSD and the benefits and disadvantages of GSD are also explained.

CHAPTER - 3

LITERATURE SURVEY

3.1   General Review of Literature

During software development, when team members are located in geographic distributed environment poses many challenges for participants, mostly during the requirements elicitation phase. Requirements elicitation is a complex and critical phase of software development, presents numerous new challenges in global software development environment [56]. In this case, the requirements engineering seems to be an even more critical phase.

The authors [4] revealed the strategies to minimize the problems in requirement elicitation while managing GSD. For this they proposed a methodology that focused on the detection and analysis of possible problems in advance, and as an outcome a set of strategies were presented to diminish them. They resulted that most of the challenges in GSD are due to lack of in person communication and the participants need to sense comfortable with the technology, they are using.

However, [5], have elaborated some fundamental concepts about groupware tools and learning style models and on the basis of these concepts they developed a model to support personal preferences in geographically distributed processes. The model supports more requirements elicitation technologies and group tools according to the stakeholders learning characteristics. They described that the quality of requirements depends on the selection of technology. The authors also suggested that if the communication is improved in requirements elicitation process then the requirements elicitation process will itself improved.

The authors of [6] investigated the impact of organizational structure on distributed requirements engineering processes in global software development. Analysis, design, implementation and testing of the communication problems were done at several locations. They described various organizational structures and the accompanying problems launched into requirements engineering processes and also the techniques that were efficient in justifying some of the negative effects of global software development. They resulted that a huge percent of the problems were requirements associated and these problems appeared due to organizational missteps and a missing layer of leadership.

Normally, [12], described the development of an information system and also implemented them in the distributed environment in the form of a case study (Sapphire). This paper shows numerous communication issues that may arise during the requirements engineering phase in global software development. But it is problematic for the solution of communication issues.

According to [15], proposed a technically feasible methodology for reducing problems in global requirements elicitation during global software development (GSD). The authors thoroughly described the problems in distributed requirements elicitation process. They identified that successful communications play important role to control the problems among stakeholders. Their research methodology was based on pervious generic models which helped in minimizing or eliminating the problems during global software development.

The [31] investigated the efficacy of requirements elicitation techniques and groupware tools in the distributed requirements elicitation era of global software development process. The study involved engineers to develop software requirements specification document and the effectiveness of requirements elicitation techniques which were used in a distributed setting for requirements gathering.

The [40] executed a case study on the challenges of temporal, geographical and socio-cultural distances associated with managing GSD. Their study was based on workshop negotiations and qualitative interviews at the three US based GSD companies. The authors described that even if the challenges echoed all over the three organizations, the ways of trouncing them are remarkably diverse. They proposed a variety of solutions to deal with these challenges, faced by the companies.

For instance of [43] evaluated the effect of stakeholders' geographical distribution on organizing requirements in a multi-site organization. The authors reported that requirements elicitation is an intricate task when it is done locally, but it is even more intricate one when globally distributed stakeholder groups specify requirements across communication, knowledge management, and time sector limits. They resulted that distribution of participants has a significant effect on the relationship between geographical distributed groups.

The authors [44] planed a model of challenges and the requirements elicitation affected due to the problems of cultural diversity, inadequate communication, knowledge management and time differences in global software development It has provided as important insight into the interplay between culture and conflict as well as the impact of distance on the ability to reconcile different viewpoints related to requirements elicitation process. This study briefly explains the impact of global software development teams in the requirement elicitation process and disputes that there is a need to examines, develops and investigates requirements elicitation process to support GSD.

The [51] conducted a study to demonstrate the mistakes and complexities linked with the communication between participants that is a necessary part of requirements elicitation (RE) process. They selected the requirements elicitation technique of interviewing, literature survey and also implemented the A. Davis and Dieste elicitation model for their study. They observed that the personal construct, cognitive and the education theories are the three basic knowledge domains that recommended the methods to improve conversations in the global software development (GSD).

The authors of [57], conducted the study for the possible improvement of requirements elicitation process in distributed environment on the basis of cognitive approach. They exercised psychological theories and proposed a stackholder's preferences model to identify requirements elicitation techniques and elicitation groupware tools. As a result they were able to evaluate the interaction of stackholder's preferences to the most appropriate requirement's elicitation techniques thus the improvement of RE process.

According [47], in a case study revealed the common communication tools which would be used in software documentation and creation. According to them, these tools would be used by software and data management teams in distributed software developments. They observed that, although there is a long range of communication tools or techniques, their zonal allocation, time instant etc., there is a greater communication among the workgroups in global software development.

3.2   Research Concept Relevant Review of Literature

3.2.1   Problems related to Geographical Distance in GSD

Global software development (GSD) is rapidly growing, day by day in the software development industry, due to the technology improvements [39]. Global software development is the development of software where participants are distributed across geographically distance sites [27]. This geographical distance creates a number of problems between participants in global software development includes inadequate communication [11,15,39,43,79], cultural diversity [4,15,43,44,78], time difference [12,44], knowledge management [11,44,61,59] and technical connectivity issues [59], as shown in **Figure 3.1**.
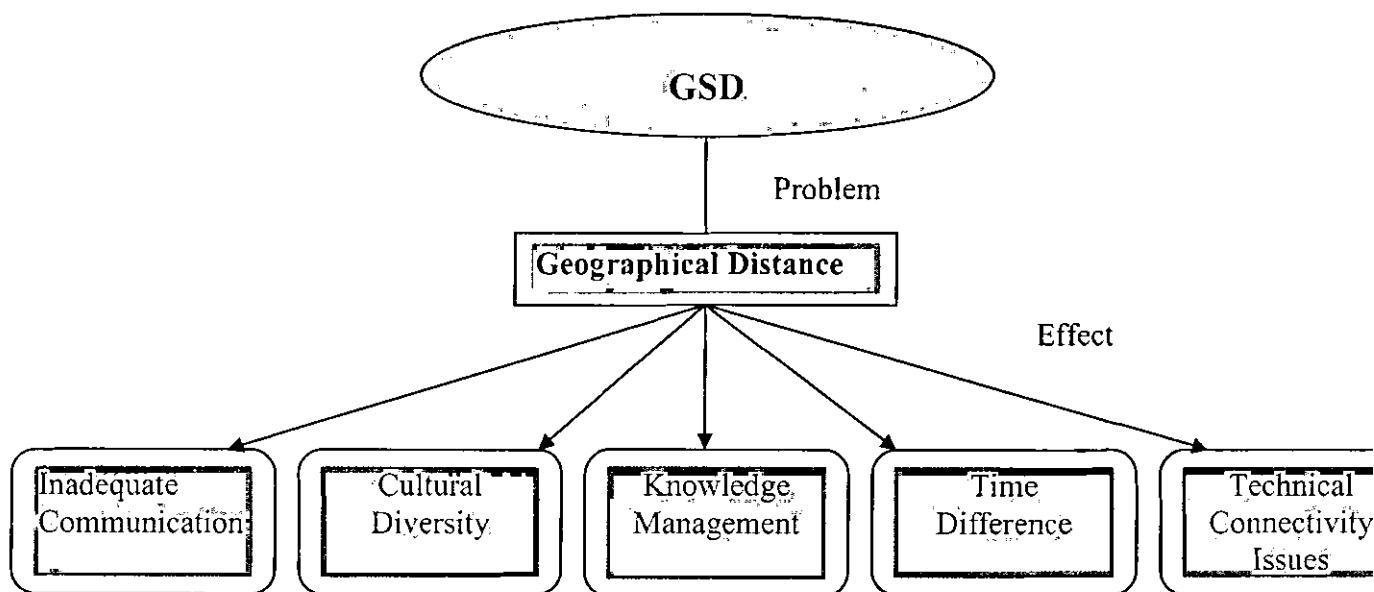
Figure 3.1   Problems related to Geographical Distance in GSD

The above **Figure 3.1**, describes the problems related to geographical distances between participants in (GSD). Each of these problems has several factors involved and the relationship between them is close to one another and what issue makes these factors difficult to define the limits of each one as shown in **Table 3.1**.

GSD Problems	Geographical Distance	Factors	Refrances
Inadequate Communication	The geographical distance depends largely on communication between participants and this distribution makes communication more difficult. It is caused by the fact that geographical distribution of the participants increases the cost of formal communication among participants.	• Language • Time zone • Speech • Interpersonal communication • Technology	[15] [20] [44] [57] [60]
Cultural Diversity	The geographical distance introduces differences in participant's culture and languages which highly affect the global software development. Cultural diversity happens when participants come from different cultural background.	• Context • Attitude • Values • Participation • Project management • Mind set	[12] [15] [43] [45] [87]
Knowledge Management	The geographical distance introduces difficulties between participants (i.e., analyst and user), as information sharing may be occur in a non uniform manner and always slow.	• Expectations • Management • Awareness	[45] [55] [59] [61] [62]
Time Difference	The geographical distribution of stakeholders across participants introduced large time zone differences and allowed little available overlap for synchronous collaboration.	• Technology • Communication • Time zone	[3] [12] [43] [63]
Technical Connectivity Issues	Numerous technical aspects affect in geographically distributed environments during GSD.	• Communication Connectivity • Process	[5] [64]

Table 3.1   Problems related to Geographical Distance in GSD

The main problems which are related to geographical distance in GSD are culture diversity, inadequate communication, knowledge management, technical connectivity issues and time difference are discussed below.

Inadequate Communication

The geographical distance introduces difficulties to face-to-face communication [44], the participants are distributed through various countries [27,39] and where the participant's communication is mostly dependent on the quality of using synchronous or asynchronous electronic communication tools [15]. The core factors related to communication found in literature are language, time zone, body language, interpersonal communication and speech.

Culture

The geographical distance introduces differences in participant's culture and languages effect global software development [43,79]. Cultural diversity is inherent in GSD environment [45], which given that the team members on geographical distance have diverse professional, national and organizational background [44]. The main factors related to culture are context, attitude, values, participation, project management, mind set, personal appearance, body language, ergonomics, and technology.

Knowledge Management

The sheering of requirements information introduces difficulties between participants [45] (i.e., analyst and user), then distance is exploited to strengthen certain positions of power in the distributed organization environment [60]. The main common factors identified related to knowledge management are expectations, management and awareness of cultural information

Time Difference

When time-zone difference between multiple sites is considerable across participants, it is high depends that timetables do not overlap or just overlap for a short period of time, then some delays in the project can happens because synchronous collaboration is not possible [43]. This timetables means time separation, which can not just because of time difference but also as a result of cultural diversity issues, e.g., different holidays, weekend time, working hours and

lunch breaks etc [63]. The time-zone is highly impact on geographical distance during GSD [45].

Technical Connectivity Issues

Technical aspects have an impact on the network communication which linking the various sites [65]. It hinders communication and also focuses on communication tools used by geographically distributed participants [64]. Since those participants are dependent on electronic communication and any down time could effectively separate participants [63]. The main factors found are process and communication connectivity.

The distribution of participant's increases day by day, those communicate through some kind of technology [19]. This distribution introduces communication problems on global software development projects [43,66]. Many organizations wanting to share software development efforts over several globally distributed environments [42] but GSD is technologically and organizationally complex and presents a variety of communication challenges among the software development teams [29,40] because software development teams are often geographically distributed from their participants. This creates significant communication and coordination challenges [27].

3.2.2 Requirements Engineering Activities in GSD

Requirements engineering is the most critical and complex process within the software development [38], presents several new challenges in global software development [29]. In this case, the requirements engineering seems to be an even more critical phase [26]. Normally, requirements engineering is an important aspect of any software development project [10], because it documents and maintenances software requirements throughout the software development life cycle [24]. Software requirements engineering compose of two main major processes: requirements development and requirements management [18]. Requirements development encompasses of all activities involved in eliciting, specifying, negotiating, analyzing and validating the requirements [18,45] as shown in **Figure 3.2**.
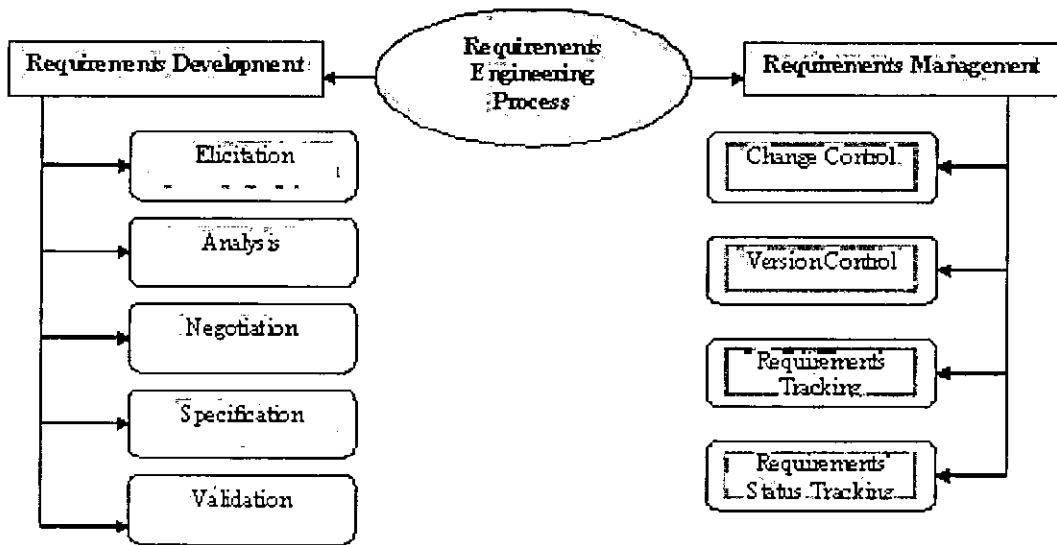
Figure 3.2   Requirement Engineering Process

The literature states that the problems related with requirements engineering are one of the main reasons for software projects failures. This means that the final product does not have all the requirements gathering from users and customers. The requirements engineering activities in GSD that stated in the literature as shown in **Table 3.2**.

RE Activities / GSD Problems	Requirements Development Activities				
	Requirements Elicitation	Requirements Analysis	Requirements Negotiation	Requirements Specification	Requirements Validation
Inadequate Communication	[3,4,15,28,43]	[43,56]	[12,43,66]	[45,59,60]	[45,59]
Cultural Diversity	[13,27]	[13,66]	[13,67]	[13]	[13,48]
Knowledge Management	[12,45,66]	[45,50]	[12,45]	[45,60]	[12,68,45]
Time Difference	[43,52,63]	[43]	[12,43]	[43,60]	[43,48]
Technical Connectivity Issues	[15,28]	[56,60]	[67]	[59]	[50]

Table 3.2   Requirements Engineering Activities in GSD

3.2.2.1 Requirements Elicitation in GSD

GSD has a number of problems that comes in the literature [39,43,63,64], such as inadequate communication, cultural diversity, time difference, knowledge management and technical connectivity issues. These problems are mostly relating to requirements elicitation process during GSD, as shown in **Table 3.2**. Each of these problems has several factors involved [4,15, 39,43,45,69] and the relationship between them is close to one another and what issue makes these factors difficult to define the limits of each one as shown in **Table 3.1**. These factors contribute to GSD facing a fundamental problem in requirements elicitation [4,15,45,57,58].

The requirements elicitation process depends largely on communication between participants [15] and this distribution makes communication more difficult [4]. In addition, global software development is becoming more common day by day [27] and the distribution of participants makes communication more difficult. The geographic distance introduces communication problems between stakeholders that increase the difficulty in developing the requirements elicitation process [71]. However, communication is mainly less effective because of the different time zone [70] and insufficient knowledge transfers [45,64] makes difficult formal communication and distance which makes face-to-face meeting more difficult. Communication is also made difficult by technical connectivity issues [59,64] and cultural difference [44] which may cause misunderstandings.

Culture of the team's members (i.e. participants) influence the requirements elicitation process & communication is also made difficult by differences in cultural. Normally, it arises when staff members come from different cultural background. The requirements elicitation process deals with large volume of information. (i.e., Collect process, store and make available the knowledge related to the requirements elicitation process). The large distribution of stakeholders across five continents introduced large time zone differences and allowed little available overlap for synchronous collaboration. Several technical connectivity issues affect the requirements elicitation in distributed environments [59]. The requirements elicitation process depends on control and coordination mechanisms, i.e., which are help to reduce the impact caused by participants [60].

3.2.2.2 Requirements Elicitation Challenges in GSD

GSD has a number of problems that comes in the literature [43,45], such as inadequate communication, cultural diversity, time difference and knowledge management. These "generic" problems of global software development had created specific difficulties during requirements engineering activities and they are described in the literature [43,45,46,61,62,68]. These problems are mostly relating to requirements elicitation process during global software development. These requirements elicitation challenges and their effect in global software development with references are shown in **Table 3.4.**

During software development the global software development effects the process of communication [12], particularly in the requirements elicitation process that is critically depends on the communication between participants [32,72]. Because requirements elicitation process is a human – centric process, where communication is critical, complex and error born [8], which creates communication problems between participants [13,22]. But cultural diversity, time difference and knowledge management also introduces many issues that effect communication and that are worth of consideration [30].The achieving of effective communication in the requirements elicitation process is a well-known challenge during GSD [45]. When requirements elicitation is undertaken as a part of global software development these problems (i.e., GSD problems) may be make worse in the requirements elicitation process with dynamic nature as well as groupware tools [15,72], RE techniques [5,15,72], RE methods [3,34] and factors [4] associated with managing and gathering requirements.

GSD Problems	RE Challenges Effects in GSD			
	RE challenges	Effects	Effects are due to	References
Inadequate Communication	• Lack of interaction between participants (analyst and user) • Difficulty in conflict during managing • Increased complexity of spreading awareness • Increased complexity of spreading knowledge • Reduces accurate level of trusting working relationship • Lack of effective decision-making meetings • Difficulty in achieving common understanding of requirements	GSD	Communication	[2] [4] [13] [15] [28] [45] [61] [69] [71] [92]
Cultural Diversity	• Poor culture fit • Reduces accurate level of trusting working relationship • Difficulty in achieving common understanding of requirements	GSD	Communication	[2] [11] [28] [44] [75]
Knowledge Management	• Difficulty in conflict during managing • Lack of effective decision-making meetings	GSD	Communication	[6] [29] [44]
Time Difference	• Increased complexity of spreading awareness • Increased complexity of spreading knowledge • Lack of effective decision-making meetings • Lack of interaction between participants (analyst and user)	GSD	Communication	[44] [63] [74] [91]
Technical Connectivity Issues	• Lack of interaction between participants (analyst and user) • Increased complexity of spreading knowledge	GSD	Communication	[59] [60] [64]

Table 3.3.   Requirements Elicitation Challenges in GSD

This research has described the impact of geographical distance on the success of requirements elicitation process in global software development. The research is of importance because it expands our understanding and knowledge of the ways in which participants (i.e., software development teams) work in the global software development environment. This research mostly highlights some communication issues that may occur during the requirements elicitation phase, and the impact to requirements elicitation during global software development. This research most supports the work of [12,5,15,43,45,73] and adds to information in the area of global software development during geographical distribution, by demonstrating that communication involves a complex human interactions and there are many ways to influences requirements elicitation processes during global software development, so that find out the impact, but solutions to communication issues, is problematic.

This research explores the requirements elicitation process during global software development with highlighting on communication issues that occurs during software development. The research question is formed for this research is: *"what is the impact of geographical distances on requirements elicitation in global software development"?* The goal of our research question is to *explore communication issues associated with the requirements elicitation phase of the software development process as it occurs in the global software development.*

CHAPTER – 4

RESEARCH METHODLOGY AND DATA COLLECTION

4.1   Introduction

This chapter describes the research methodology and data collection of our research problem. The research methodology examines the research approach, method, design and methodology model. The data collection describes structure and explanation of questionnaires. The purpose of this chapter is to understand how we will conduct our research and what the best method for our research is and why the selected method is suitable for our research than others.

4.2   Research Methodology

This section deals with the selection of research approach and research method for our research problem. The purpose of this section is to understand how we will conduct our research and why the selected research methods are suitable for our research.

4.2.1   Research Approach

In the Literature, there are two research approaches: deductive and inductive. In deductive approach some theories, suggestions and hypothesis are created from a theoretical framework and then these theories, suggestions and hypothesis are tested by some experiments. While in inductive method researcher starts to know the reality and identify the observable fact. For this purpose he uses analytical tools such as theories, questionnaires, and interviews and so on. This analysis provides a new theoretical framework with understanding of the phenomenon. We will use inductive approach for research problem.

4.2.2   Research Method

There are five main research methods in the literature:-
1. Experiment
2. Survey
3. History
4. Archival analysis
5. Case study.

Each method has its own functionality and follows its own way (logic). They collect data from different way. Each method controlling is different from another and also time focus. Every method can solve problems by its own logic. For example, a case study mostly focuses on "how" and "why" types of questions are being asked in research problem and a survey mostly focus on "what" and "which" types of questions are being asked in research problem. Our research problem deals with the "what" and "which" type of questions, so we will use survey as our research strategy to solve our problem.

4.2.3   Research Design

The design of our research will be questionnaire based. Because the questionnaire is a best approach in a survey to collect the data. Questionnaires are very easy to analyze and are familiar to most of the people. Our questionnaire was completed with in three months. The questions (and their answers) were written by respondents in the questiontionaire, which represent their best judgment to the question.

4.2.4   Research Methodology Model

We will use survey methodology for our research. A sample of questionnaire was made and then Fourthy-One (41) respondents were selected from Twenty-Six (26) multinational software houses in several major cities Pakistan.

To conduct our survey, organization were required to:

- Be multinational and based in Pakistan.
- Should be affiliated with Pakistan Software Export Board (PSEB).
- Should have an experience of at least one year at the development of GSD projects.

To conduct our survey, respondents were required to:

- Must have an experience in GSD projects.
- Be based in Pakistan.
- Should have requirements elicitation experience.
- Be currently involved in the development of software projects.

- Must have experience in software development.
- Be a member of any multinational software house in Pakistan.
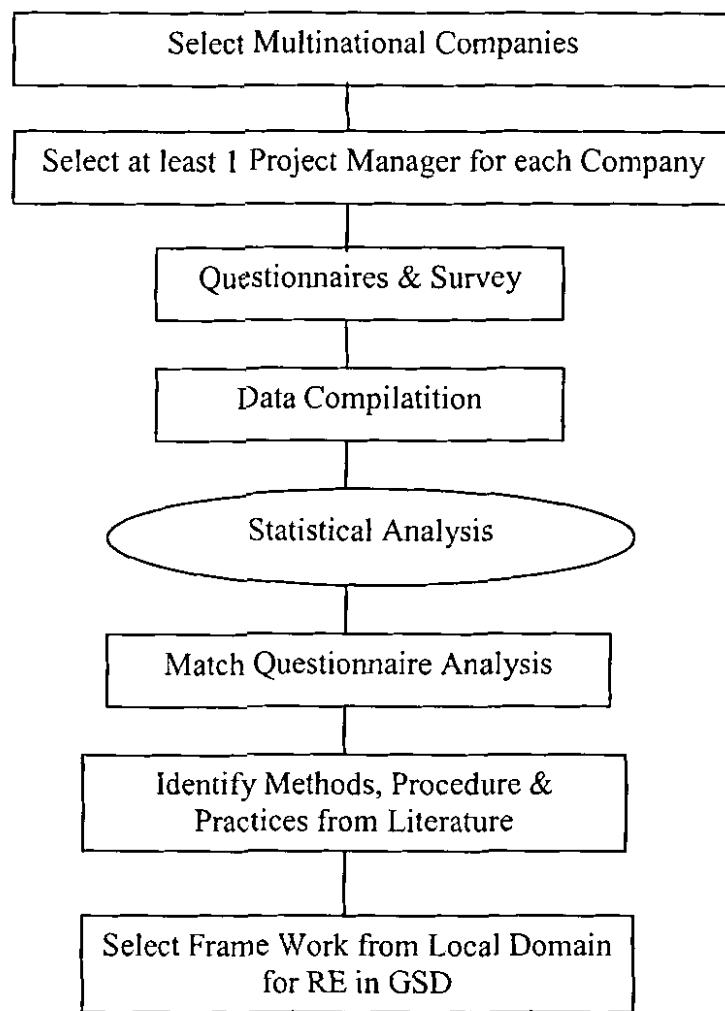
Figure 4.1   The Adopted Research Pathway

Organization should be Multinational (working on GSD projects evaluations) and should be affiliated with Pakistan Software Export Board (PSEB). The project managers should have an experience with requirements elicitation and software development (mean GSD context).

4.3   Data Collection

According to [76], the questionnaire is the most important data collection tool. The questionnaires design was done with the guidance of [4,47,95]. In the literature, data collection can be divided into two main categories, primary and secondary data collection. The primary data is collected by the researcher for the specific purpose of addressing the problem at hand. Secondary data concerns data that has already been collected and is available in periodicals, academic literature, journals, etc. Our data collection source is the local software industry. We have listed twenty-six (26) multinational software houses in our local domain. For primary data collection we targeted twenty-six (26) multinational software houses for local software industry. The secondary data that we used, consisted of articles from research papers, Internet sources, surveys conducted by others, books, and journals.

4.3.1   Research Questionnaire Structure

Respondents were required to place a mark "√" in the appropriate block which represents their best judgments to the question is positive, as shown in **Table 4.1**. A lack of a mark"√" in the appropriate block does not considered as a nil response but is considered as a negative response.

2-4 years
5-7 years √
Above 7

Table 4.1   Appropriate Block

Respondents were required to place a mark "√" in the check block which represents their best judgments to the question is positive, as shown in **Table 4.2**.

Method	Response
PD	
JAD	√
RAD	

Table 4.2   Check Block

We have used 5-point Lickert scale for to match the value of response. The lower boundary of scale is 5 and an upper boundary of scale is 1. It means that low numbers indicated a high rating while high numbers indicated a low rating. That is same for the mean. We have used computer software program "Statistical Package for Social Science" (SPSS, version 17.00). The mean is a widely used statistical technique for analyzed 5 point Lickert scales. In this study, the mean shows the individual impact on, groupware tools, RE methods, RE techniques and RE communication factors on RE process. Percentage has been used for making comparison of various respondents' responses. Percentage is worked out by formula, P=F/N*100, where P is percentage, F is absolute frequency and N is the total number ranking rates. We summarized demographic details by pie charts and histograms. But our research data analyses are mostly based on means.

We used two types of scales in our questionnaire, one of them was rate to agreement (mean importance), and the other one is rate to influence, as shown in **Table 4.3**. After all, on the basis of available results, Pearson's Correlation Coefficient indicates the mutual impact between the various distance dimensions. Respondents were asked to rate the circle, which represent their best judgment to question according to their own experience.

Very Agreement	1
Agreement	2
Undecided	3
Unagreement	4
Totally Unagreement	5

Very Influence	1
Influence	2
Undecided	3
Barely Influence	4
No Influence	5

Table 4.3   Two types of scale, one is to rate Agreement and other is to rate Influence

4.3.2   Questionnaire Explanation

Our research questionnaire was divided into five sections:

i)   Demographics section

ii)   Groupware Tools section

iii)   RE Methods section

iv)   RE Techniques section

v)   Factors section

4.3.2.1 Demographics Section

In order to obtain information about the respondents, involved in the survey, we have proposed the data to identify about the respondents (name, company and position), and also captured their experience and training.

4.3.2.2 Groupware Tools Section

In this section, we listed communication technologies that are presently available. Those communication technologies describe which type of communication process should be adopted in local multinational software houses in context of Pakistan. It shows the nature of the technology wanted to support the requirements elicitation process in global software development. In the questionnaire, the respondents introduced chat, discussion forums and teleconference. Because in the questionnaire, we were given the opportunities to respondents to add new groupware tools, **Table 4.4,** shows groupware technologies examined (from literature) and introduced by respondents in this research.

Groupware Tools	Questionnaire	Introduced by Respondents in Questionnaire
E – mail	√	
Telephone	√	
Discussion Forums		√
Chat		√
Teleconference		√
Audio conference	√	
Instant messing	√	
Video conference	√	

Table 4.4   Groupware Tools examined and introduced by this Research

4.3.2.3 Requirements Elicitation Methods Section

In our local multinationals software development houses, respondents may have experience in some of the requirements elicitation methods, but may not use some other requirements elicitation methods in their daily works, as there are differences in using these methods. Simply it means that one method is more important than other method in their human communication characteristics. In the questionnaire, we have given the opportunities to respondents to add new methods. In this way, some respondents introduce data model, Brainstorming, formal methods

and human interface methods in the questionnaire. Requirement elicitation Methods examined and introduced by this research are shown in **Table 4.5**.

RE Methods	Questionnaire	Introduced by Respondents in Questionnaire
Interview	√	
Prototyping	√	
JAD (Joint Application Design)	√	
Requirements Reuse	√	
Questionnaire	√	
RAD (Rapid Application Develop.)	√	
Workshops	√	
Participatory Design (PD)	√	
Observation	√	
Laddering	√	
Formal Models		√
Brainstorming		√
Human Interface		√
Data Model		√
Scenario Analysis		√

Table 4.5   Requirement Elicitation Methods examined and introduced by this Research

3.3.2.4 RE Techniques Section

The techniques which are chosen from this survey were different in terms of the tools used for the implementation of these techniques and also needed some technology to hold them (support) during implementation. The RE techniques examined and introduced by this research is shown in **Table 4.6**.

RE Techniques	Questionnaire	Introduced by Respondents in Questionnaire
Team building	√	
Brainstorming	√	
Protocol Analysis	√	
Repertory Grids	√	
Card Sorting	√	
Storyboards	√	
User Training		√
Use cases		√
Documentation		√

Table 4.6   Requirements Elicitation Methods examined and introduced by this Research

In the questionnaire, we have also given the opportunities to respondents to add methods. In this way, some respondents introduced uses cases and user training.

4.3.2.5 Requirements Elicitation Communication Factors Section

There are numerous human communication factors, which are used in the user requirements elicitation as a role. These factors have been grouped into thirteen (13) categories and each one representing a different group of factors. There were different measures within those sections aimed at exploring different aspects of the study area. All of the factors listed are requirements elicitation communication factors, which may be performed by any of the participants in the requirements elicitation process. These factors are listed below:

- Technology
- System Modeling
- Standards
- Project Management
- Participation
- Mind set (user and developer)
- Personal Appearance
- Body Language
- Speech
- Interpersonal Communication
- Ergonomics
- Decision-making
- Documentation

4.4 Summary

This chapter briefly explores the research methodology and data collection of our research problem. The design of our research will be questionnaire based, because the questionnaire is a best approach in a survey to collect the data. We will use survey methodology for our research. A questionnaire was made and then a sample of Fourthy-one (41) respondents was selected from twenty-six (26) multinational software houses in Pakistan.

CHAPTER - 5

DATA ANALYSIS AND RESULTS

5.1   Introduction

This chapter describes the data analysis and results of our research, which are used for the development of a framework to support human communication process in requirements elicitation process during global software development w.r.t. geographical distance.

5.2   Data Analysis

This study is based on data collected by means of a questionnaire survey because, this data collection tool generates a large amount of qualitative data. For analysis of data, we use computer software program "Statistical Package for Social Science" (SPSS, version 17.00). The mean is a widely used statistical technique for analysis at 5 point Lickert scale. The mean shows the impact of groupware tools, RE techniques, RE methods and factors on the user requirements elicitation process in GSD. While, the correlation is used to find the bi-variant impact of various groupware tools, RE techniques, RE methods and factors. Percentage has been used for making comparison of various respondents' responses. Percentage is worked out by formula, P=F/N*100, where P is percentage, F is absolute frequency and N is total number of ranking rates. We summarized demographic details by pie charts and histograms. But our research data analysis is mainly based on means.

5.3   Results

5.3.1   Demographics

We analyzed the collected data, taken from fourthly-one (41) respondents (project managers), which were selected from sixteen (26) multinational software houses in Pakistan as shown in (Appendix C). Most of the respondents had 2-3 year experience in the global software development (GSD) field (40%), as shown in **Figure 5.1**.
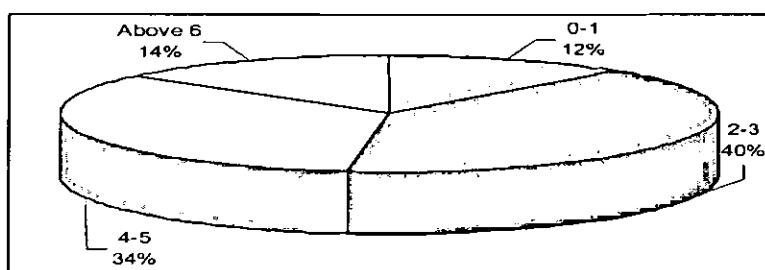
Figure 5.1   Respondents experience in GSD

Most of the respondents (56%) had 4-5 years experience in the user requirements elicitation process, as shown in **Figure 5.2**.
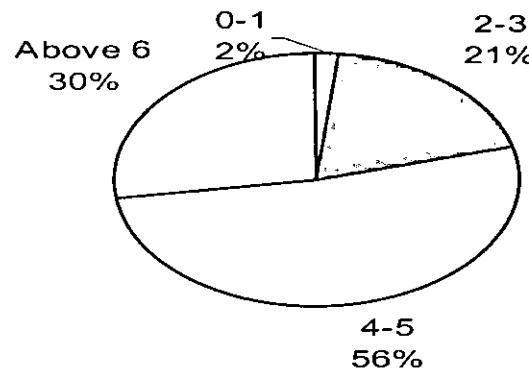
Figure 5.2   Respondents experience in user requirements elicitation process

Most of the respondents (76%) had above six (6) years experience in the software development (SD) field, as shown in **Figure 5.3**.
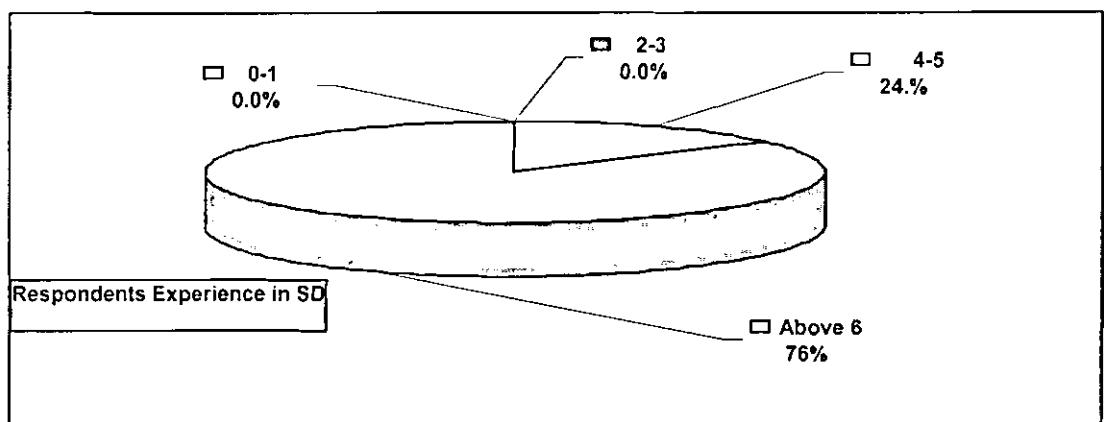
Figure 5.3   Respondents experience in Software Development

About 68 % of the respondents had formal training in user requirements elicitation process during software development (i.e. geographical distributed environment or GSD), as shown **Figure 5.4**. The respondents training include the degrees (university), diplomas and some gaining knowledge from their daily work in software development companies.
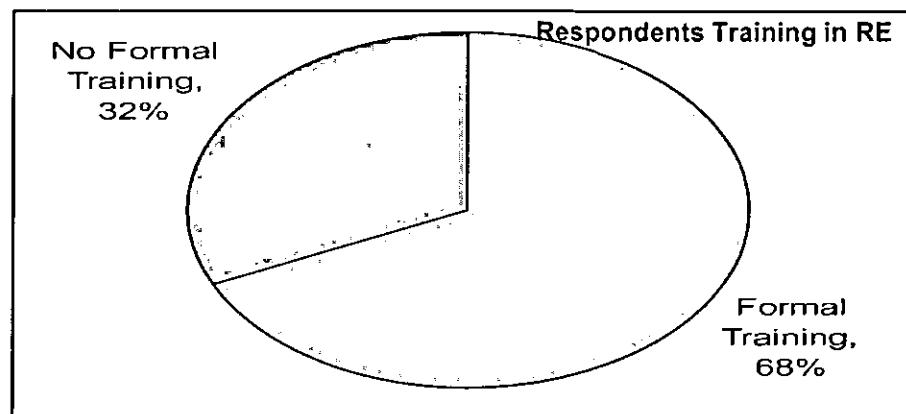
Figure 5.4   Respondents formal training in user RE process during software development

Most of respondents have experience in requirements elicitation process both in-house projects (65%) and external projects (35%), as shown in **Figure 5.5**.
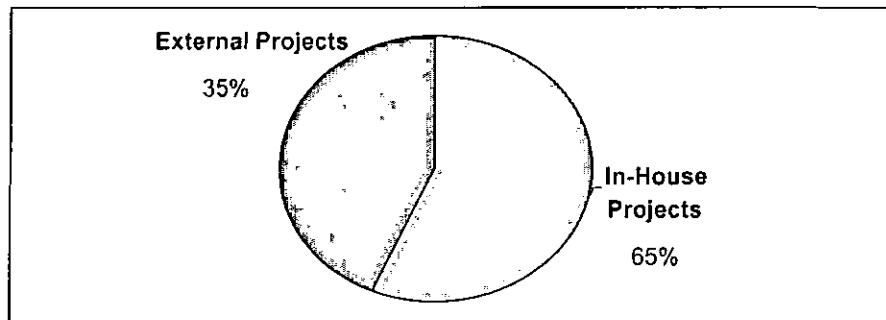
Figure 5.5   Respondents have experience in both in-house projects and external projects

About 51% of the respondents have experience in software development where user requirements elicitation was one of the aspects of projects, as shown in **Figure 5.6**.
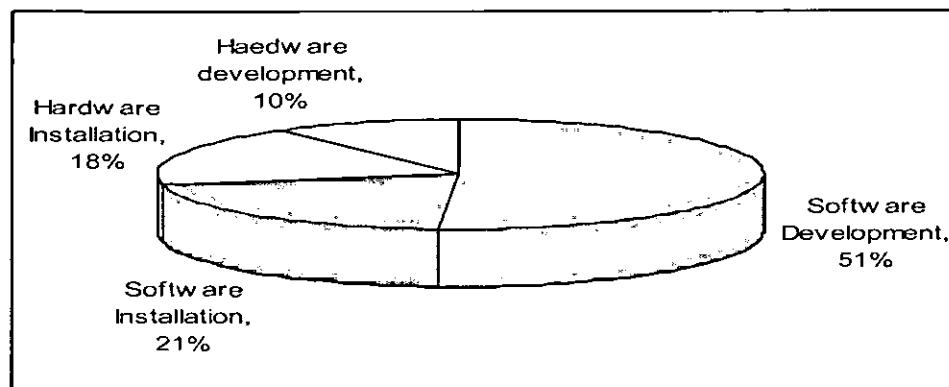
Figure 5.6   Respondents have experience where user RE is the aspects of projects.

5.3.2 Groupware Tools Section

In our local multinational software development organizations, most of the respondents have commonly used E-mail and instant messing groupware tools in requirements elicitation process and the telephone, E-mail and video conference groupware tools are best known by most of the respondents, as shown in **Figure 5.7**. The audio conference and discussion forums groupware tools had not been used by numerous respondents before this questionnaire are shown in **Figure 5.7**. Currently, in our local domain most of the respondent uses E-mail, video-conference and instant messing to elicit the requirements in geographical distributed environments as in **Figure 5.7**.
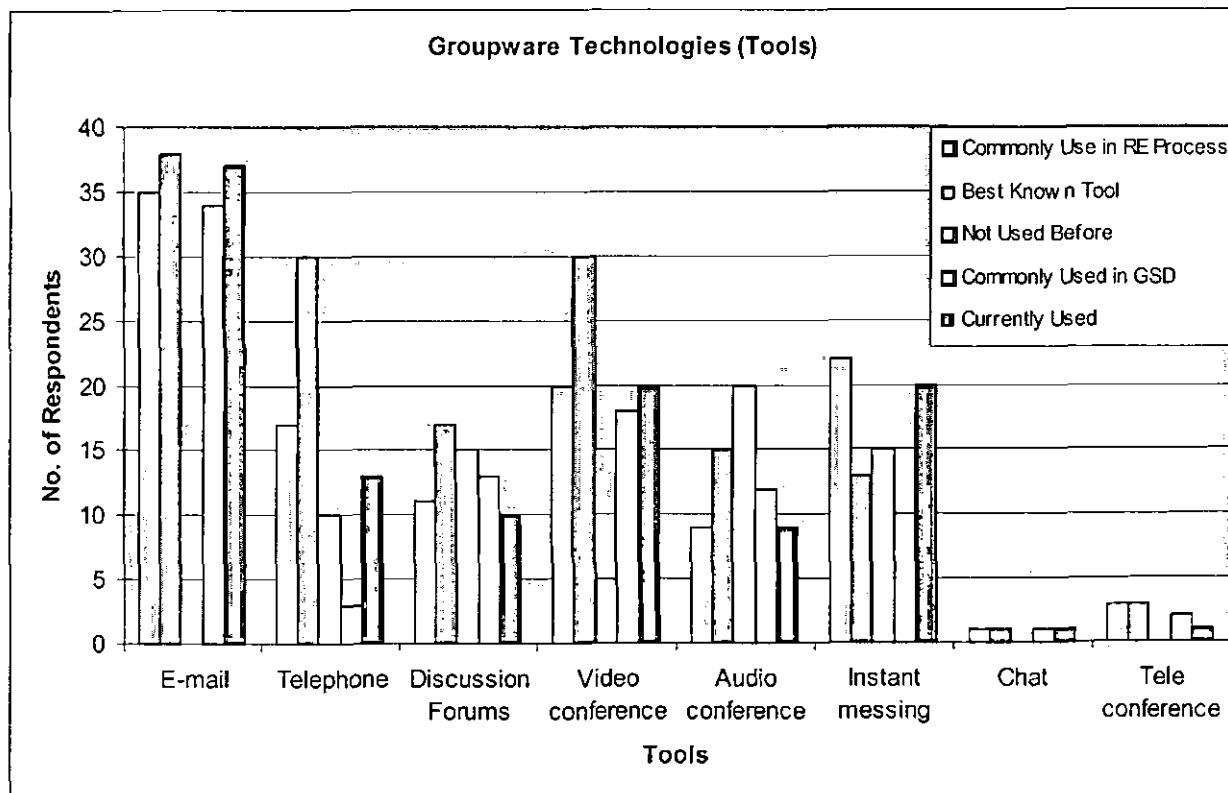
Figure 5.7   Respondents using groupware tools in user RE process

About 60% of the respondents had received groupware tool training and an insignificant number of respondents (12 %) desire to gain knowledge about the use of other groupware tools. The specific respondent's remarks are that they want to get knowledge about the use of other groupware tools and they also want to receive training about their use. The methods which are

important for the success of RE process are shown in **Figure 5.8** and are analyzed by the use of Mean (statistical technique for analyzed 5 point Lickert scales). The respondents' results were sorted according to the mean and ranking are shown in **Table 5.1**. It indicates the 'impact' of e-mail ($\overline{X}$ =1.71) and instant messaging ($\overline{X}$ =1.80) i.e., in terms of mean, on the successes of requirements elicitation process in global software development.

GROUPWARE TOOLS		
TOOLS	Mean	Ranking
E-mail	1.71	1
Telephone	2.22	5
Discussion Forums	2.10	4
Videoconference	2.02	3
Audio Conference	2.44	6
Instant Messaging	1.80	2

Table 5.1   The results of groupware tools for the successes of RE process
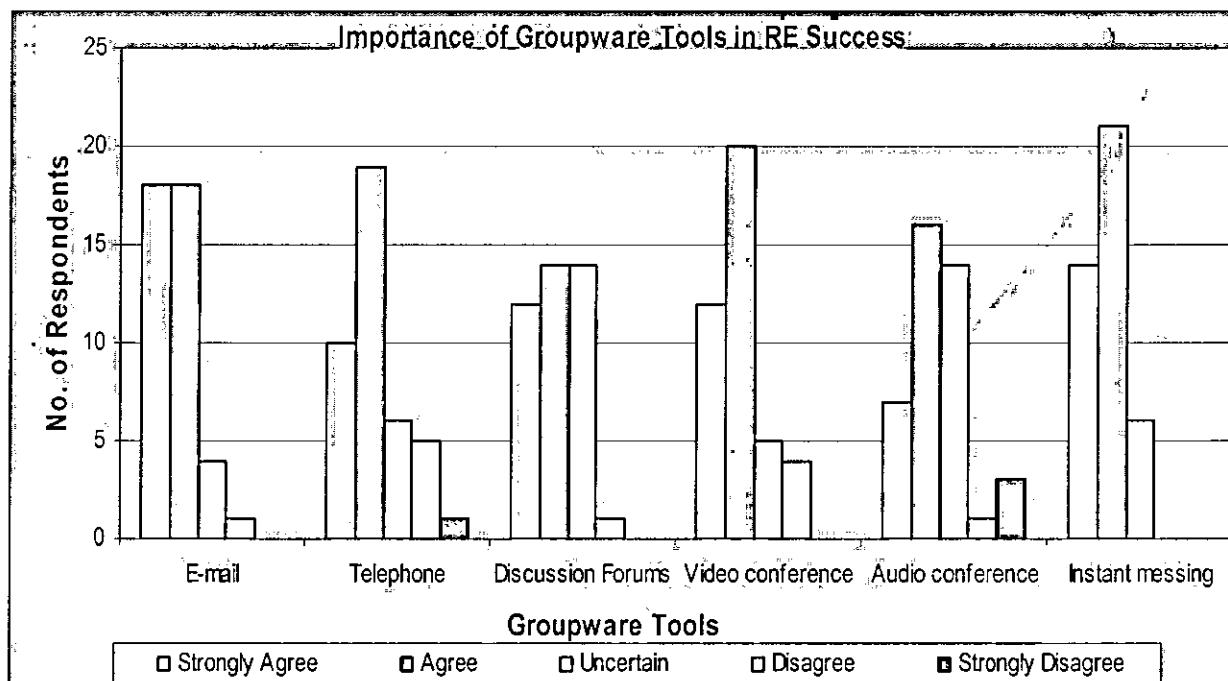
Figure 5.8   The results of groupware tools for the successes of RE process

5.3.3   Requirements Elicitation Methods

In our local multinational software development organizations, most of respondents have commonly used prototyping, interview and requirement reuse requirements elicitation methods in requirements elicitation process and prototyping, joint application development (JAD), interviews and workshops RE methods are best known by most of the respondents as shown in **Figure 5.9.** The laddering, RAD and participatory design (PD) RE methods had not been used by numerous respondents before this questionnaire, but prototyping, workshop and requirement reuse had been used by many respondents in global software development as shown in **Figure 5.9.** Currently, in our local domain most of the respondent uses workshops and prototyping to elicit the requirements in geographical distributed environments as in **Figure 5.9.**
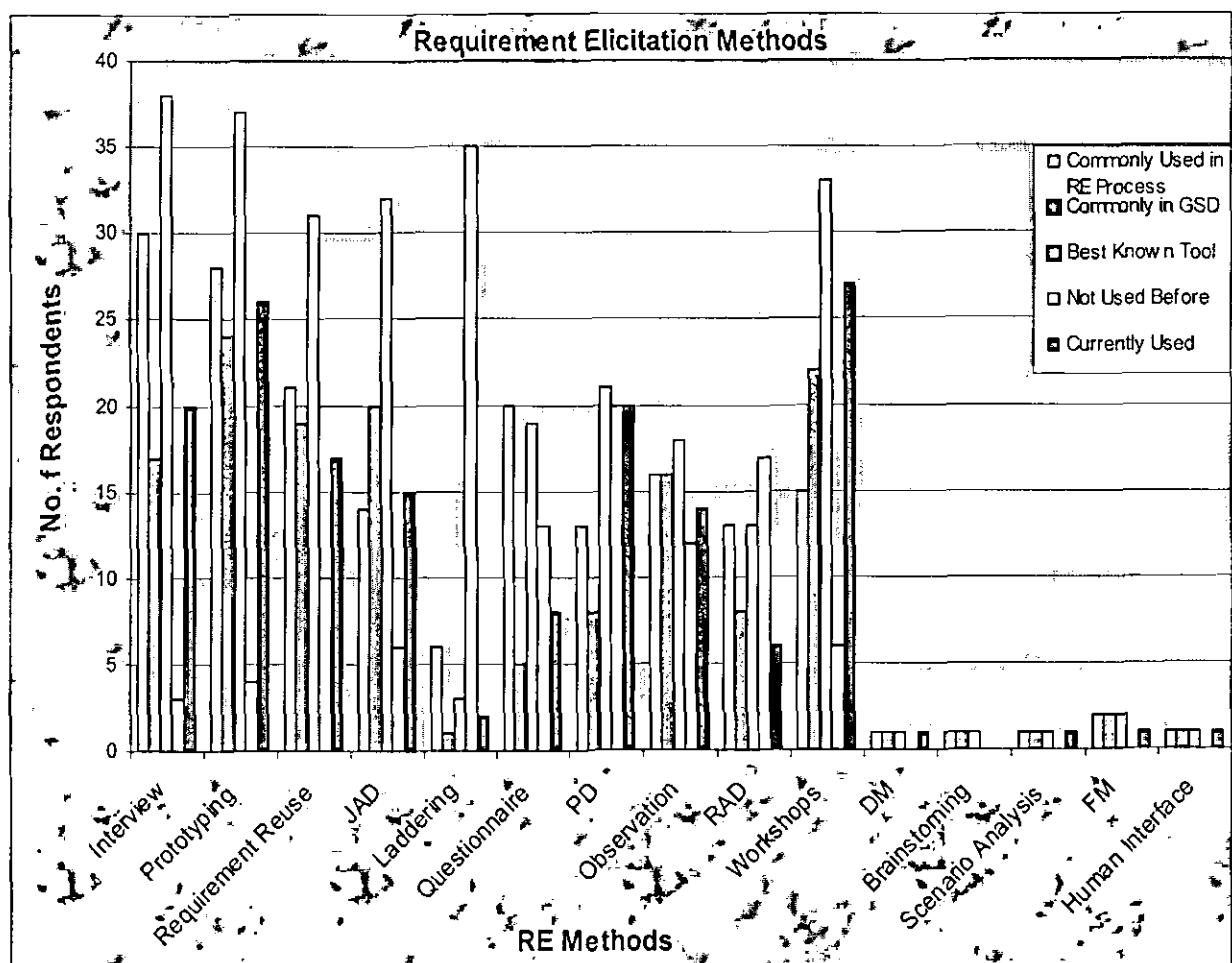
Figure 5.9.   Respondents using RE Methods in user RE process

Earlier, there was a common trend that most of the participants wanted to learn a number of methods that they are no longer using. But this trend was not significant in our multinational software houses. By using any particular method, there was no significant alteration. The methods which are important for the success of RE process were analyzed by using mean. The respondents' results were sorted according to the mean are shown in **Table 5.2**. It indicates the 'impact' of interview ($\overline{X}$ =1.83), prototyping ($\overline{X}$ = 2.15), JAD ($\overline{X}$ = 2.49) and workshops ($\overline{X}$ = 1.88) i.e., in terms of mean, on the successes of requirements elicitation process in global software development.

REQUIREMENTS ELICITATION METHODS		
Methods	**Mean**	**Ranking**
Interview	1.83	1
Prototyping	2.15	3
Requirements Reuse	2.63	5
Joint Application Development	2.49	4
Laddering	3.29	10
Questionnaires	2.71	6
Participatory Design (PD)	3.00	8
Observation	2.95	7
Rapid Application Development	3.02	9
Workshops	1.88	2

Table 5.2. The results of RE Methods for the successes of RE process

The responses given by the respondents about the importance of RE Methods for the success of user requirements elicitation process are given by **Figure 5.10**.
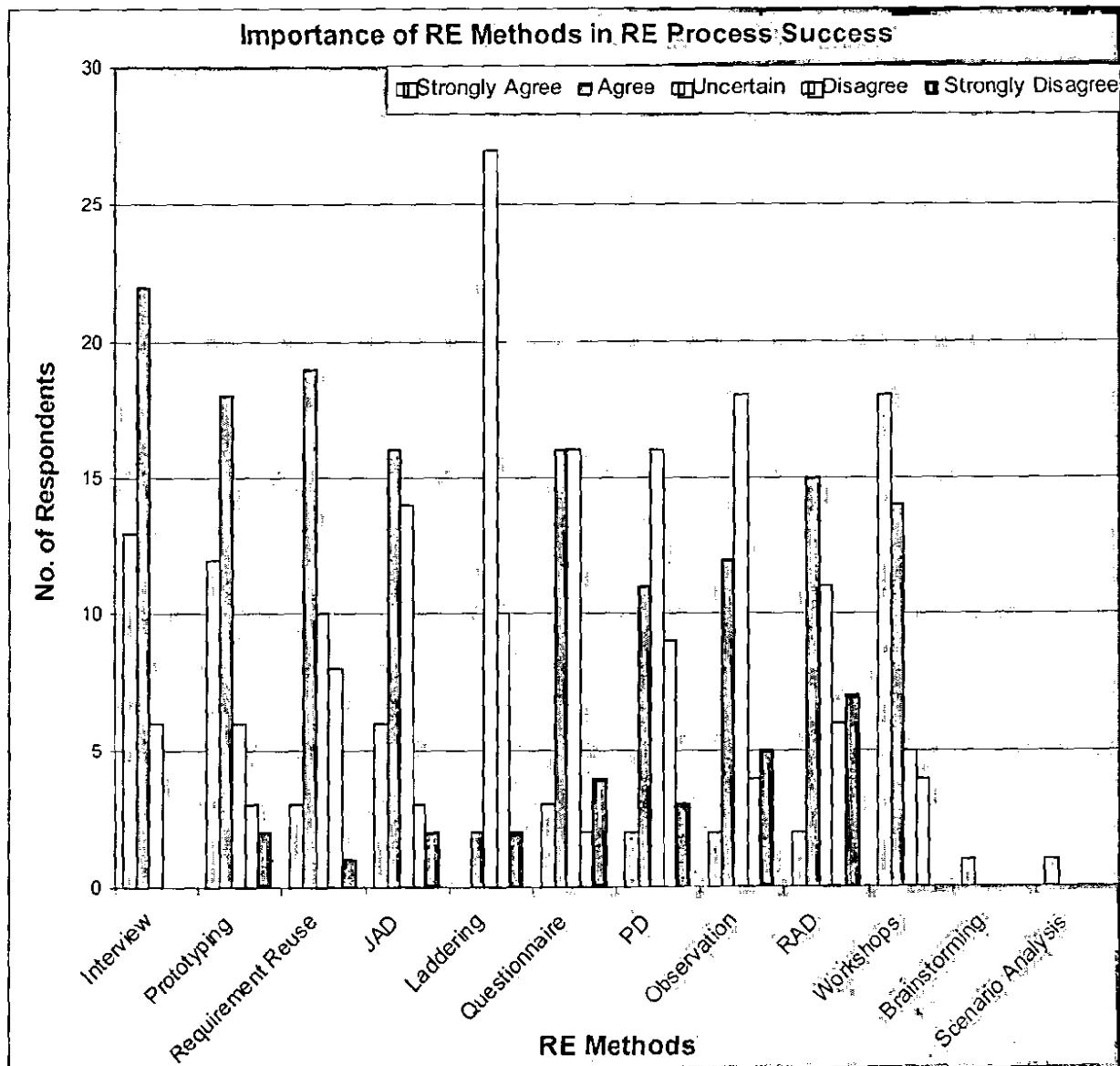
Figure 5.10. The results of RE Methods for the successes of RE process

The comments (given by the respondents) regarding the importance of RE methods in the success of RE process are shown in **Table 5.3**.

Methods	Respondents Comments
Interview	Getting the user involved. Create user interest. Fast way to gather information. Give interaction about the proposed system. Collect high verbal information from the user. Used for participants selection in the process. Getting feedback from the organization process. Build working relationships between expert and users.
Prototyping	Simplifies requirements. Construct requirements. Idea generation should be simulating. Used for validation of requirements. Better method than others.
Requirement Reuse	Desired systems requirements should be identify. Always explore the existing requirements and used for elicit requirements successfully.
Joint Application Design (JAD)	Gather user from various organization. Reduces development cost in RE process. Give users to share ideas (information). Provide groundwork in project success.
Questionnaire	Numerical data should be gathering in short time. Easier analyzes to other methods.
Participatory Design (PD)	Activities should be accurately models. Used for models requirement. Gathering information.
Rapid Application Develop. (RAD)	It helps to making requirements for a system.
Workshops	Helps to Cleary identify user's needs. Always manage user's opportunity for change. Provide a common understanding about the problems. Allow common belief between users.
Brainstorming	Generate ideas about system development.
Scenario Analysis	Allow users in decision making.

Table 5.3   Respondents comments for the importance of the success of RE methods

5.3.4 Requirements Elicitation Techniques Section

In our local multinational software development organizations, most of respondents have commonly used brainstorming and story boards RE techniques in requirements elicitation process and the team building and protocol analysis RE techniques are best known by most respondents as shown in **Figure 5.11**. The card sorting and reparatory grids RE techniques had not been used by numerous respondents before this questionnaire are shown as in **Figure 5.11**. Currently, in our local domain most of the respondent uses team building and brainstorming RE technique to elicit the requirements in geographical distributed environments as in **Figure 5.11**.
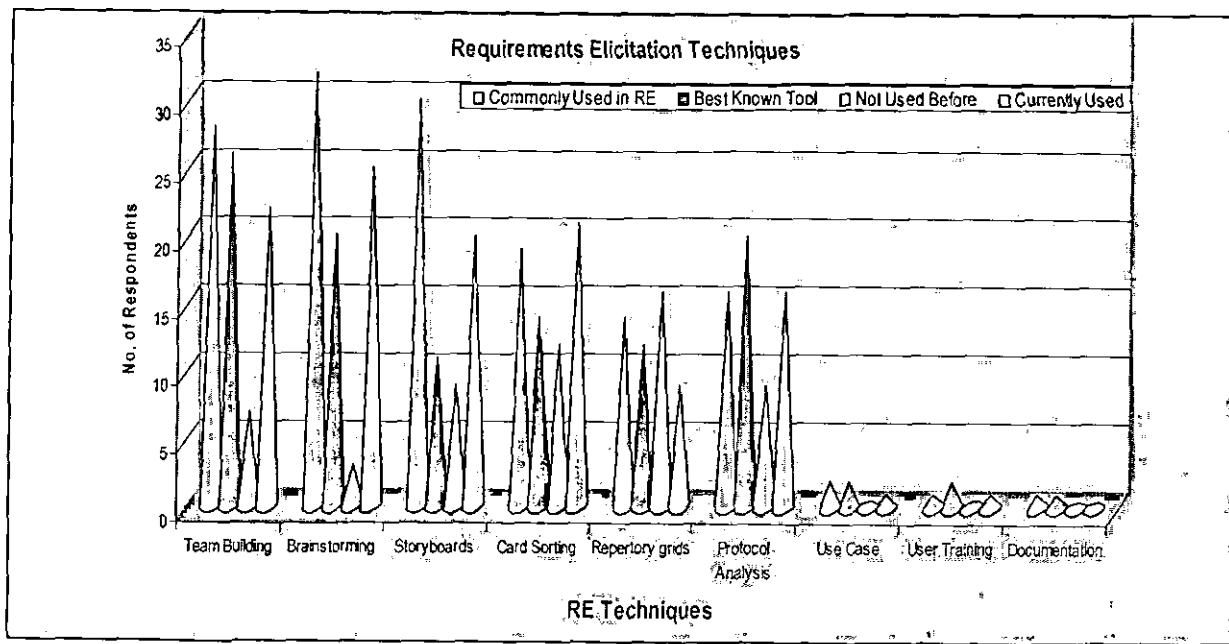
Figure 5.11   Respondents using RE Techniques in user RE process

There was an important trend that most of the participants are involved in the requirements elicitation process during GSD w.r.t. geographical distance. Most of them involved during globally distributed software development environments and mostly using e-mail and video-conference etc. The techniques which are important in the success of RE process were analyzed by using mean. The respondents results were sorted according to the mean are shown in **Table 5.4** and also their responses in **Figure 5.12**. It indicates the 'impact' of team building ($\overline{X}$ =1.98), brainstorming ($\overline{X}$ = 1.73) and storyboards ($\overline{X}$ = 2.32) i.e., in terms of mean, on the successes of requirements elicitation process in global software development.

REQUIREMENTS ELICITATION TECHNIQUES		
Techniques	Mean	Ranking
Team building	1.98	2
Brainstorming	1.73	1
Story boards	2.32	3
Card Sorting	2.54	4
Repertory grids	2.98	6
Protocol Analysis	2.73	5

Table 5.4   The results of RE Techniques for the successes of RE process
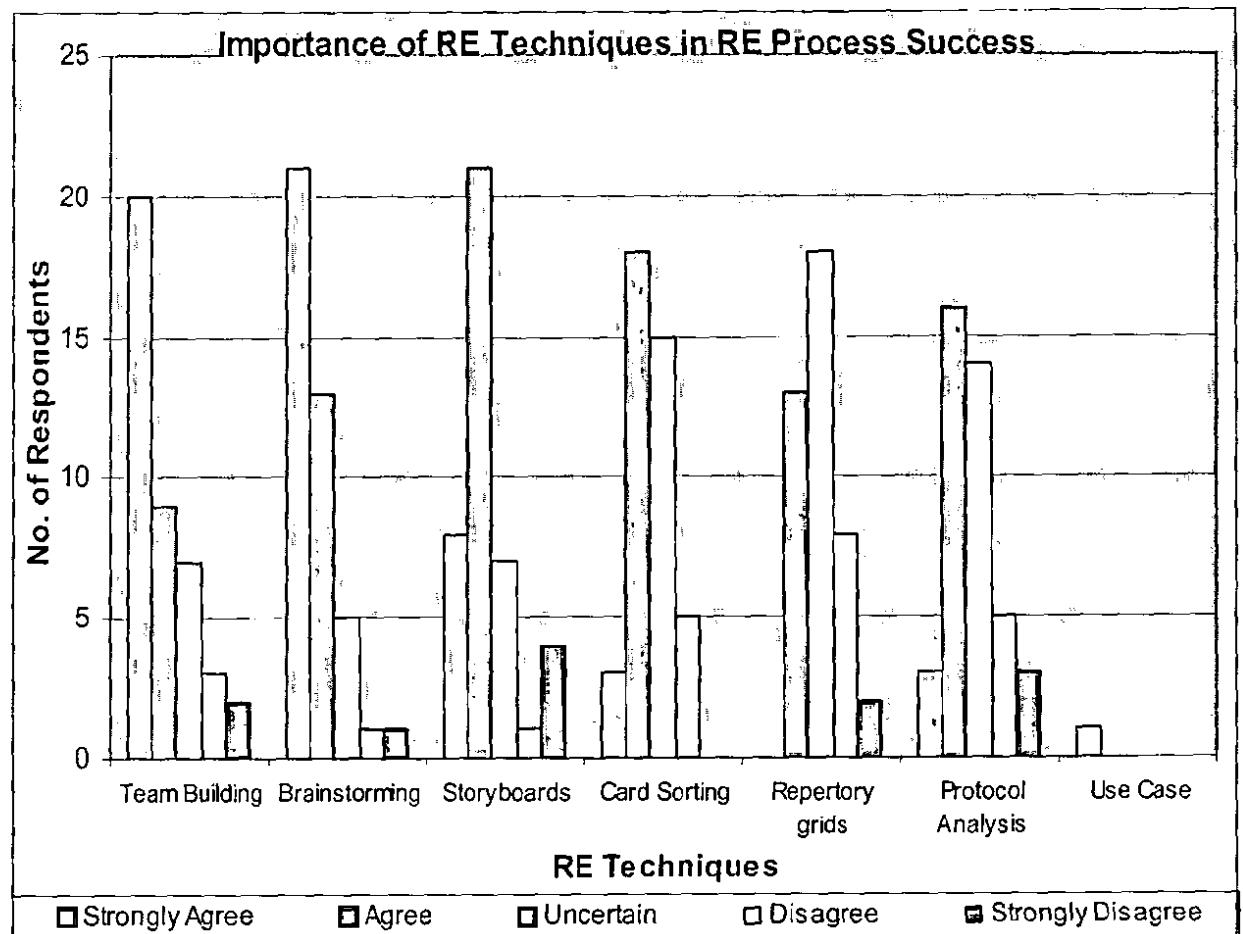
Figure 5.12   The results of RE Techniques for the successes of RE process

5.3.5   Requirements Elicitation Communication Factors Section

There are many Factors, which are important for the requirements elicitation process success. Each factor individually has no meaning, but when it is combined with other factors, plays important role in the success of RE process. The factors which are important for the success of RE process were analyzed by the use of mean. The respondents results were sorted according to the mean are shown in **Table 5.5.** The means of interpersonal communication ($\overline{X}$ = 1.51), project management ($\overline{X}$ = 1.80), technology ($\overline{X}$ = 1.63) and participation ($\overline{X}$ = 1.95) factors show high impact on the success of requirements elicitation process in global software development. The factors which are important for the success of RE process are shown in **Figure 5.13.**

REQUIREMENTS ELICITATION COMMUNICATION FACTORS		
Activities / Factors	**Mean**	**Ranking**
Technology	1.63	2
System Modeling	2.12	7
Standards	1.98	6
Project Management	1.80	4
Participation	1.95	5
Mind set	1.76	3
Personal Appearance	2.49	11
Body Language	2.51	12
Speech	2.37	9
Interpersonal Communication	1.51	1
Ergonomics	2.39	10
Decision-making	2.24	8
Documentation	2.68	13

Table 5.5   The results of RE Communication Factors for the success of RE Process
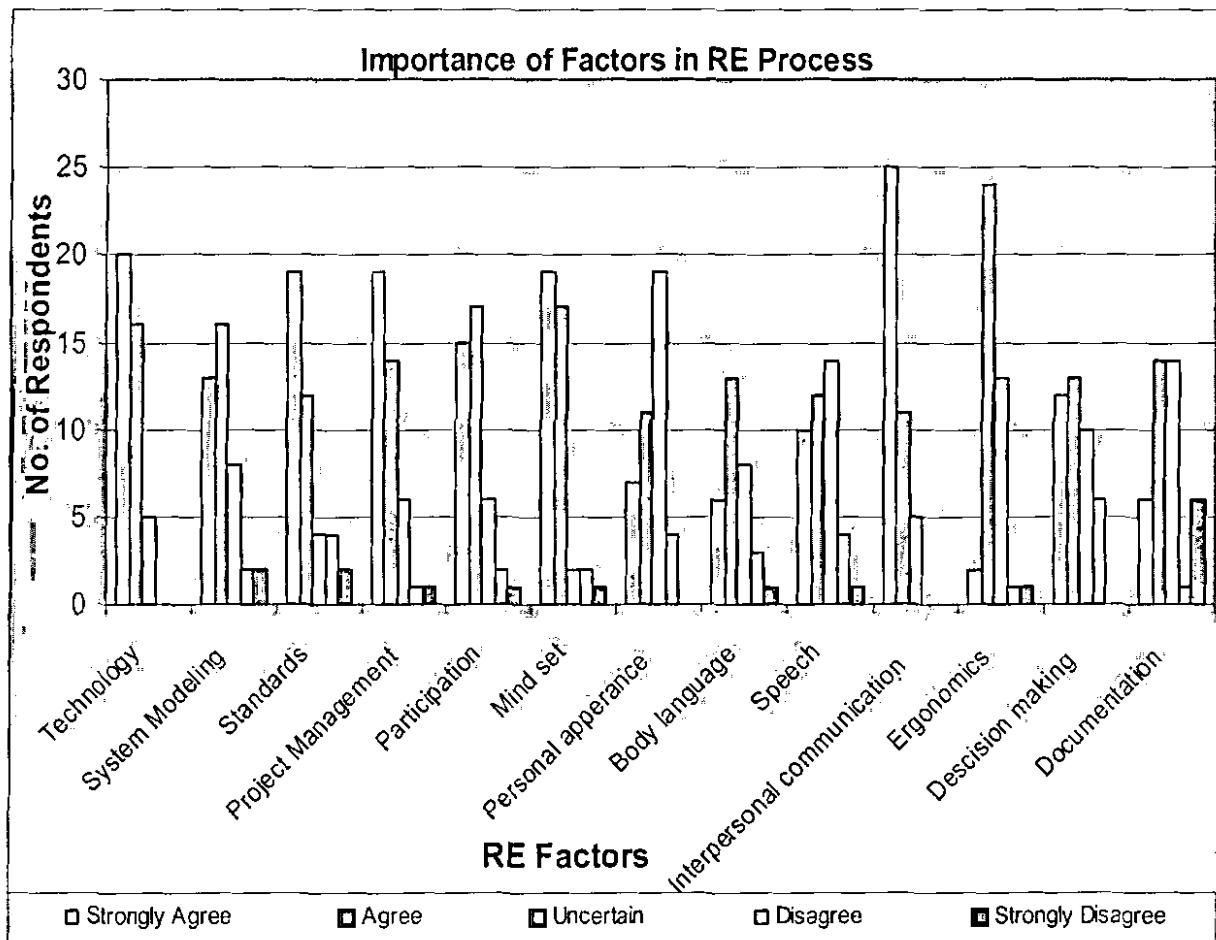
Figure 5.13   Importance's of RE Communication Factors in RE Process Success.

5.3.5.1   Technology Factor

The analysis of technology ($\overline{X}$ = 1.63) factor shows its importance in RE process, mainly indicates the impact of email and messaging ($\overline{X}$ = 1.49), visual aids ($\overline{X}$ = 2.02) and Paper and pen ($\overline{X}$ = 2.22) factors i.e., in terms of mean, on the successes of requirements elicitation process. Like email, used to eliciting and describing the user requirements, the technologies factors which are important for the success of RE process were analyzed by the using of mean. The respondents results were sorted according to the mean are shown in **Table 5.6**. The results of technology factors for the success of RE Process are shown in **Figure 5.14**.

TECHNOLOGY		
Activities / Factors	**Mean**	**Ranking**
E - mail and messaging	1.49	1
Group document handling	2.59	8
Collaborative Internet-based	2.78	9
Paper and pen	2.22	3
Group calendaring and scheduling	2.80	10
Video conferencing	2.46	7
Groupware frameworks	2.39	4
Visual Aids	2.02	2
Workgroup utilities	2.44	6
Groupware applications and services	2.41	5

Table 5.6   The results of Technology Factors for the success of RE Process
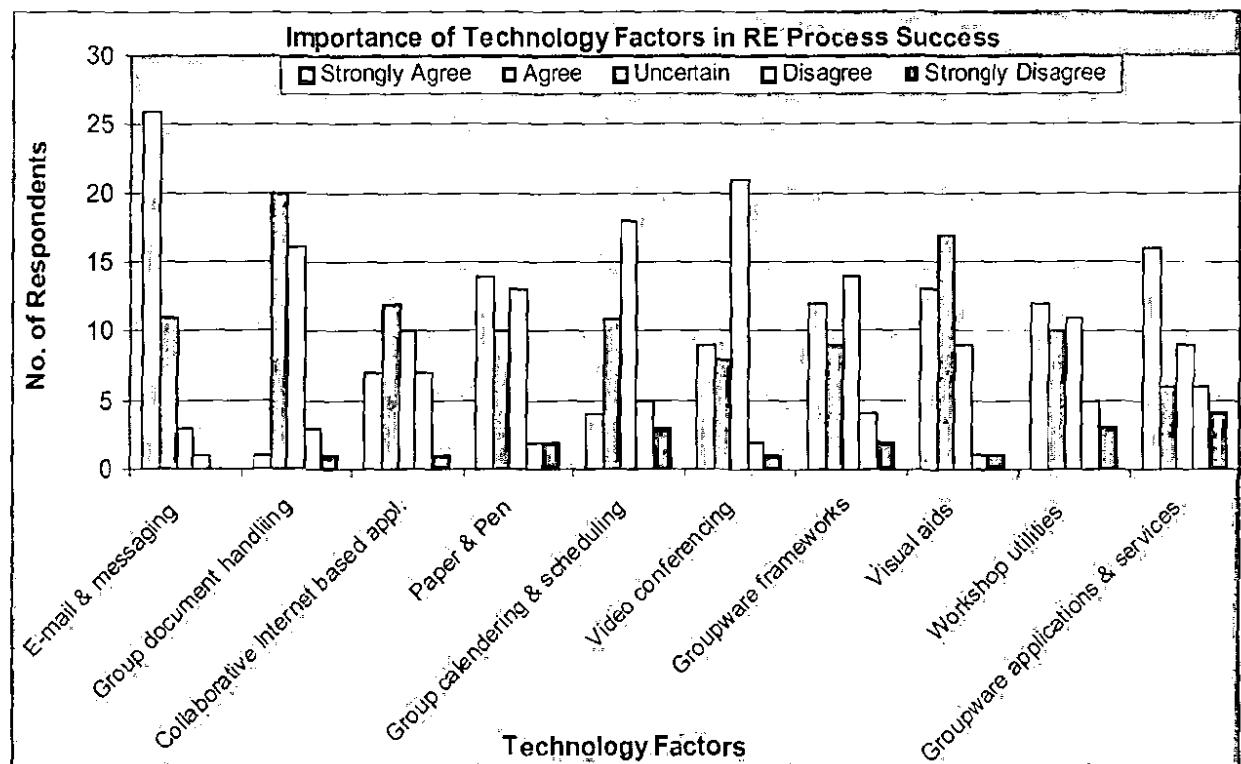
Figure 5.14   The results of Technology Factors for the success of RE Process.

5.3.5.2   System Modeling Factor

The means of system modeling ($\overline{X}$ = 2.12) factor indicates the impact on the success of RE process, mainly through ERD ($\overline{X}$ = 1.12), DFD ($\overline{X}$ = 2.22) and class diagrams and objects diagrams ($\overline{X}$ = 2.00). These are modern modeling techniques and are used as generic in nature. They are belonging to a specific methodology. The respondents results were sorted according to the mean are shown in **Table 5.7**. The results of System Modeling Factors for the success of RE Process are shown in **Figure 5.15**.

SYSTEM MODELLING		
Activities / Factors	**Mean**	**Ranking**
Entity-relationship diagram (ERD)	1.12	1
Class diagrams and Object Diagram	2.00	2
Activity dependency diagram	2.61	6
Component Modeling	2.51	5
Data flow diagram (DFD)	2.22	3
Entity life-cycle analysis	2.63	7
Matrix analysis	3.15	8
Use cases	2.27	4

Table 5.7   The results of System Modeling Factors for the success of RE Process
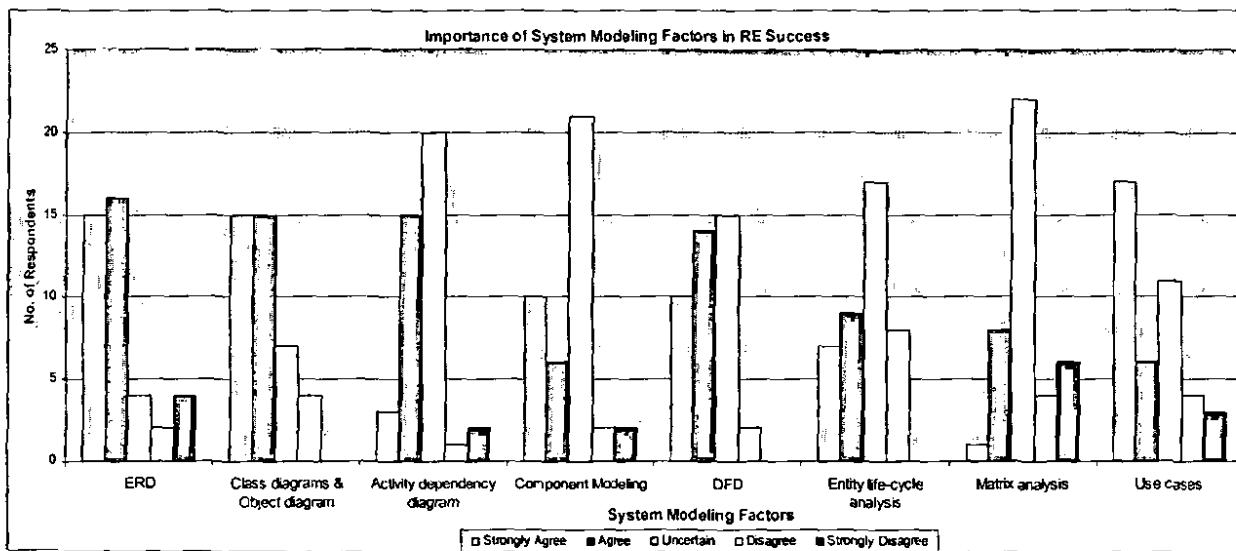
Figure 5.15   The results of System Modeling Factors for the success of RE Process.

5.3.5.3   Standard Factor

The analysis of technology ($\overline{X}$ = 1.98) factor shows the importance in RE process, mainly the quality ($\overline{X}$ = 1.80), estimation and function points ($\overline{X}$ = 2.07) have significant impact (i.e., importance) on the RE process success. The standard factors which are important for the success of RE process were analyzed by using mean. The respondents results were sorted according to the mean are shown in **Table 5.8.**

STANDARDS		
Activities / Factors	**Mean**	**Ranking**
Quality	1.80	1
Metrics	2.83	3
Estimation and Function points	2.07	2

Table 5.8   The results of Standards Factors for the success of RE Process

The standards factors which are important for the success of RE process are shown in **Figure 5.16.**
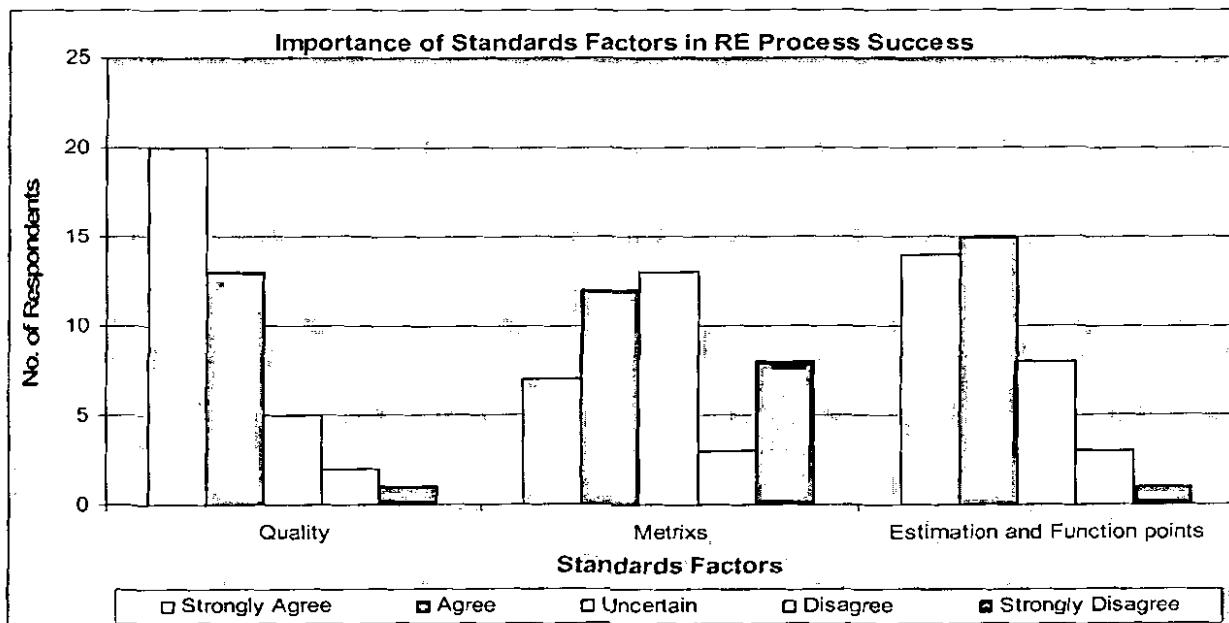
Figure 5.16   The results of Standards Factors for the success of RE Process.

5.3.5.4   Project Management Factor

The project management ($\overline{X}$ = 1.80) factors are very important, mainly the obtain resource and results approval ($\overline{X}$ = 2.17), Scoping of project ($\overline{X}$ = 2.15) have significant impact (i.e., importance) on the RE process success. The respondents results were sorted according to the mean are shown in **Table 5.9**.

PROJECT MANAGEMENT		
Activities / Factors	**Mean**	**Ranking**
Assign preparation assignments	2.61	6
Customize agenda	2.54	5
Gather materials and Notes	2.98	7
Leadership	2.41	4
Obtain resource and results approval	2.17	2
Productivity and Quality control	2.34	3
Scoping of project	2.15	1

Table 5.9   The results of Project Management Factors for the success of RE Process

The Project Management factors which are important for the success of RE process are shown in **Figure 5.17.**
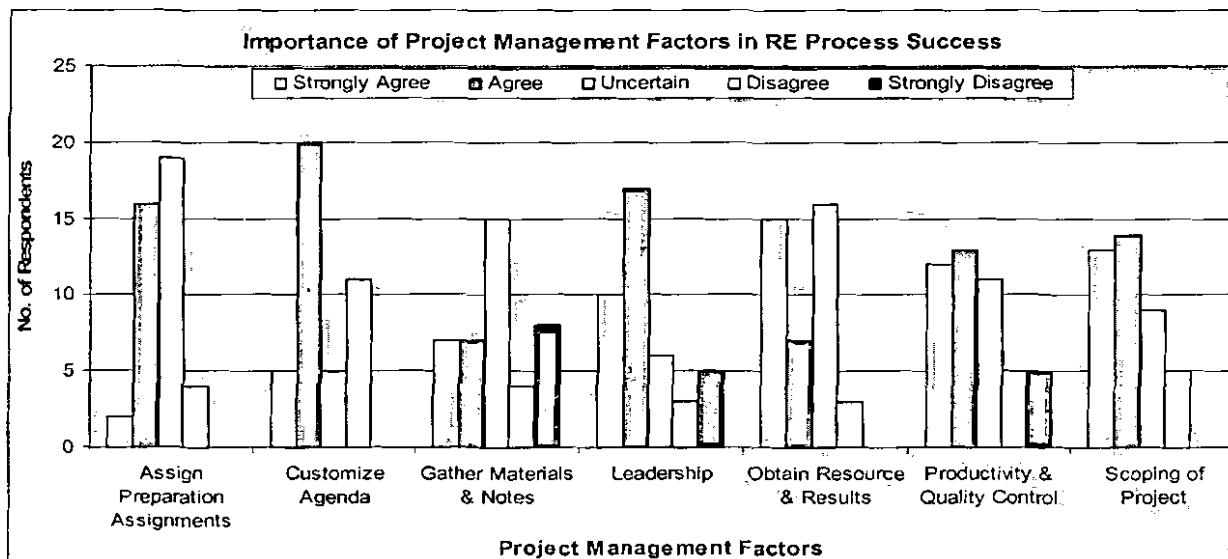
Figure 5.17   The results of Project Management Factors for the success of RE Process.

5.3.5.5   Mind Set Factor

The mind set factors (i.e., behavior and attitude ($\overline{X}$ = 1.90) and memory ($\overline{X}$ = 2.12)) play important role (in terms of their impact) on the success of RE process. The mind set factors which are important for the success of RE process were analyzed by the use of mean. The respondents results were sorted according to the mean are shown in **Table 5.10.**

MIND SET		
Activities / Factors	**Mean**	**Ranking**
Behavior and Attitude	1.90	1
Expectations	2.54	4
Socialization	2.34	3
Values	2.71	6
Memory	2.12	2
Mood	2.66	5

Table 5.10   The results of mind set Factors for the success of RE Process

The mind set factors which are important for the success of RE process are shown in **Figure 5.18.**
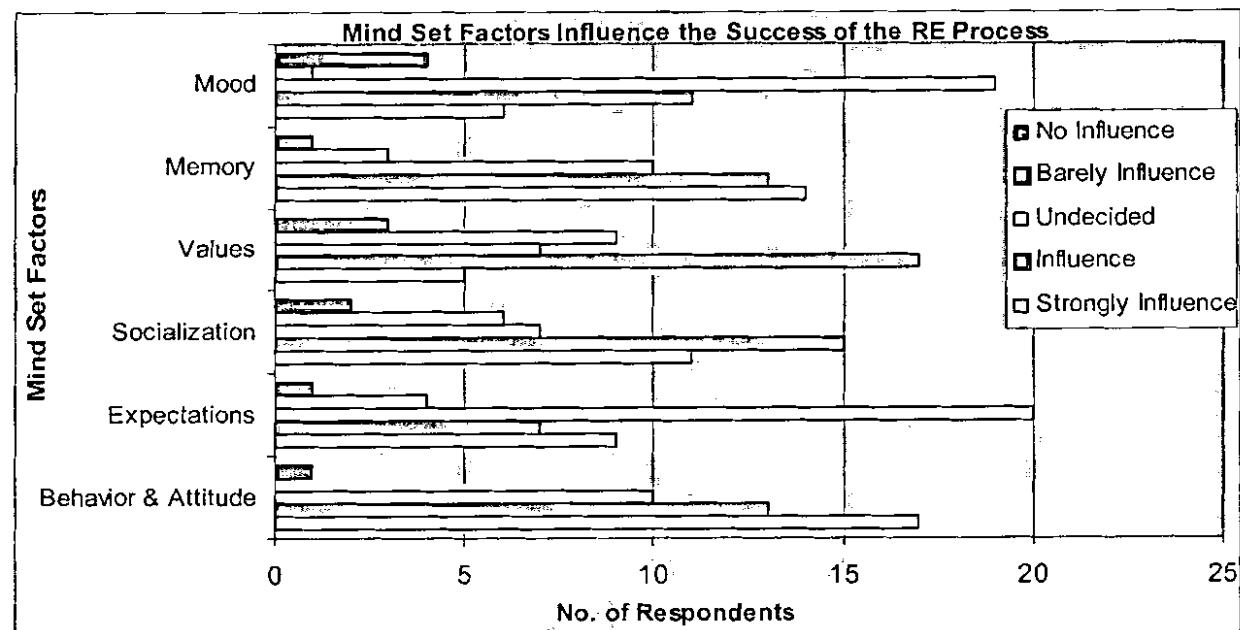
Figure 5.18   The results of mind set Factors for the success of RE Process.

5.3.5.6   Personal Appearance Factor

The personal appearance ($\overline{X}$ = 2.49) are the natural communication tools used in the requirements elicitation process. The appearance of the clothing style and color ($\overline{X}$ = 2.24), body shape ($\overline{X}$ = 2.22), and face ($\overline{X}$ = 2.15) highly influence/ impact the RE process success. The personal appearance factors which are important for the success of RE process were analyzed by the use of mean. The respondents results were sorted according to the mean are shown in **Table 5.11.**

PERSONAL APPEARANCE		
Activities / Factors	**Mean**	**Ranking**
Face	2.15	1
Hair style and Colour	2.63	5
Nose shape / size	2.73	6
Body type / shape	2.22	2
Clothing style and colour	2.24	3
Eye colour	2.56	4

Table 5.11   The results of Personal Appearance Factors for the success of RE Process

The Personal Appearance factors which are important for the success of RE process are shown in **Figure 5.19.**
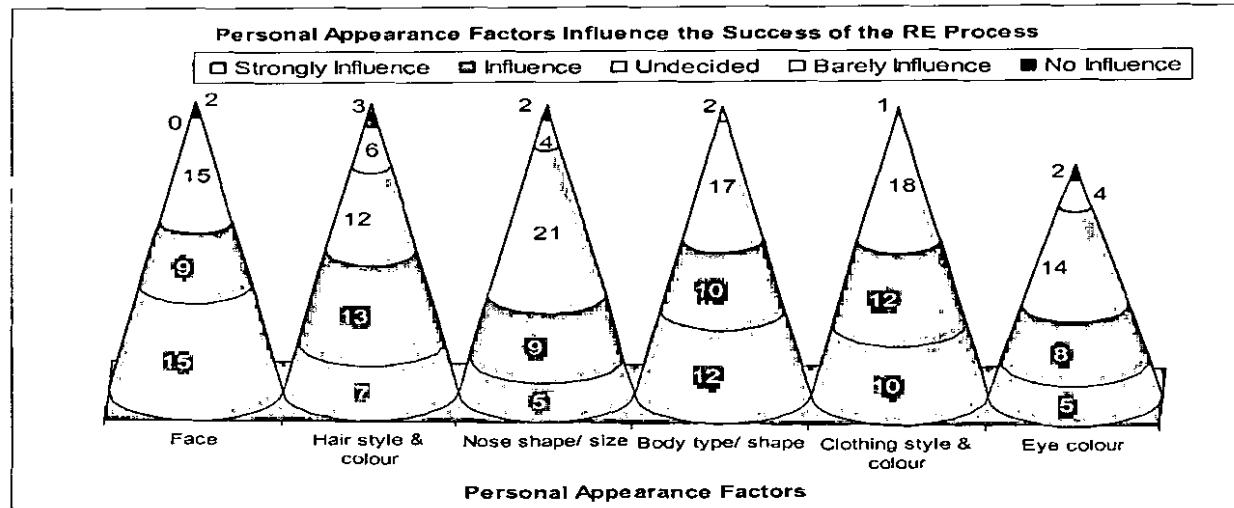
Figure 5.19   The results of Personal Appearance Factors for the success of RE Process.

5.3.5.7   Body Language Factor

The body language ($\overline{X}$ = 2.51) factors are also used in the requirements elicitation process success. Among them, the voice ($\overline{X}$ = 1.95), scent (1.81) and breathing ($\overline{X}$ = 2.15) highly influence the RE process (in terms of their impact). The respondents results were sorted according to the mean are shown in **Table 5.12.** The Body Language factors which are important for the success of RE process are shown in **Figure 5.20.**

BODY LANGUAGE		
Activities / Factors	**Mean**	**Ranking**
Body contact and pointing	2.51	6
Breathing	2.15	2
Eye contact	2.59	7
Perspiration	2.93	9
Facial expressions	2.46	5
Hearing / listening	2.68	8
Scent / Smell	2.20	3
Smile	2.29	4
Voice	1.95	1

Table 5.12   The results of Body Language Factors for the success of RE Process
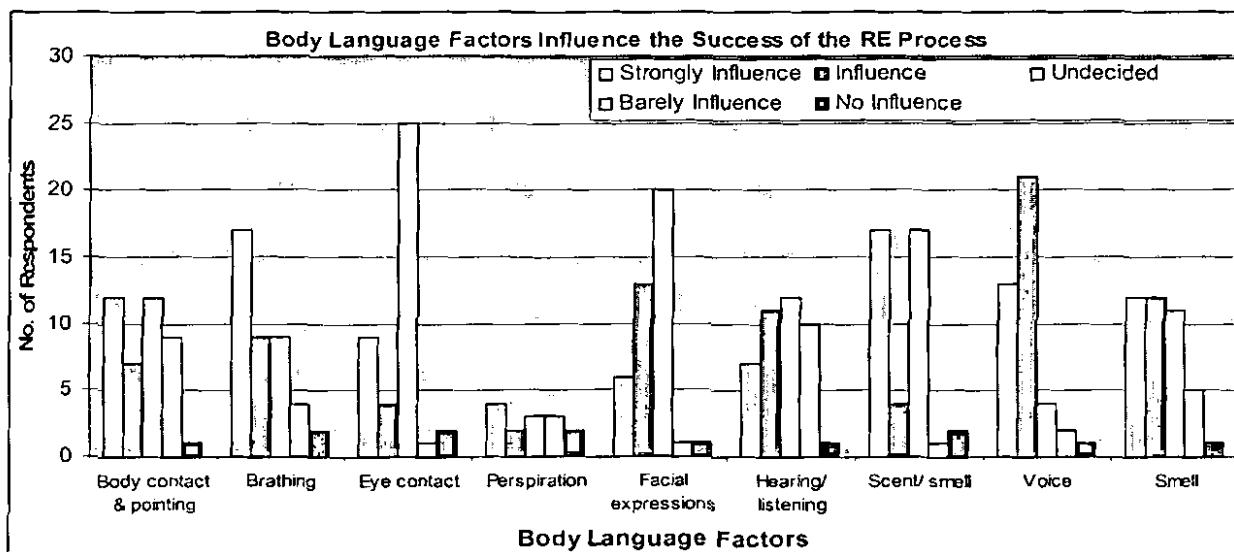
Figure 5.20   The results of Body Language Factors for the success of RE Process.

5.3.5.8   Speech Factor

The analysis of speech ($\overline{X}$ = 2.37) factors will have high influence on the success of RE process. The speech factors Pronunciation and Enunciation ($\overline{X}$ = 1.85) and style and words used ($\overline{X}$ = 2.07) have quite fair impact on the success of RE process. The respondents results were sorted according to the mean are shown in **Table 5.13**.

SPEECH		
Activities / Factors	**Mean**	**Ranking**
Pronunciation and Enunciation	1.85	1
Providing punctuation	2.07	2
Style and Words used	2.46	3
Inflections on words	2.61	4

Table 5.13   The results of Speech Factors for the success of RE Process

The Speech factors which are important for the success of RE process are shown in **Figure 5.21**.
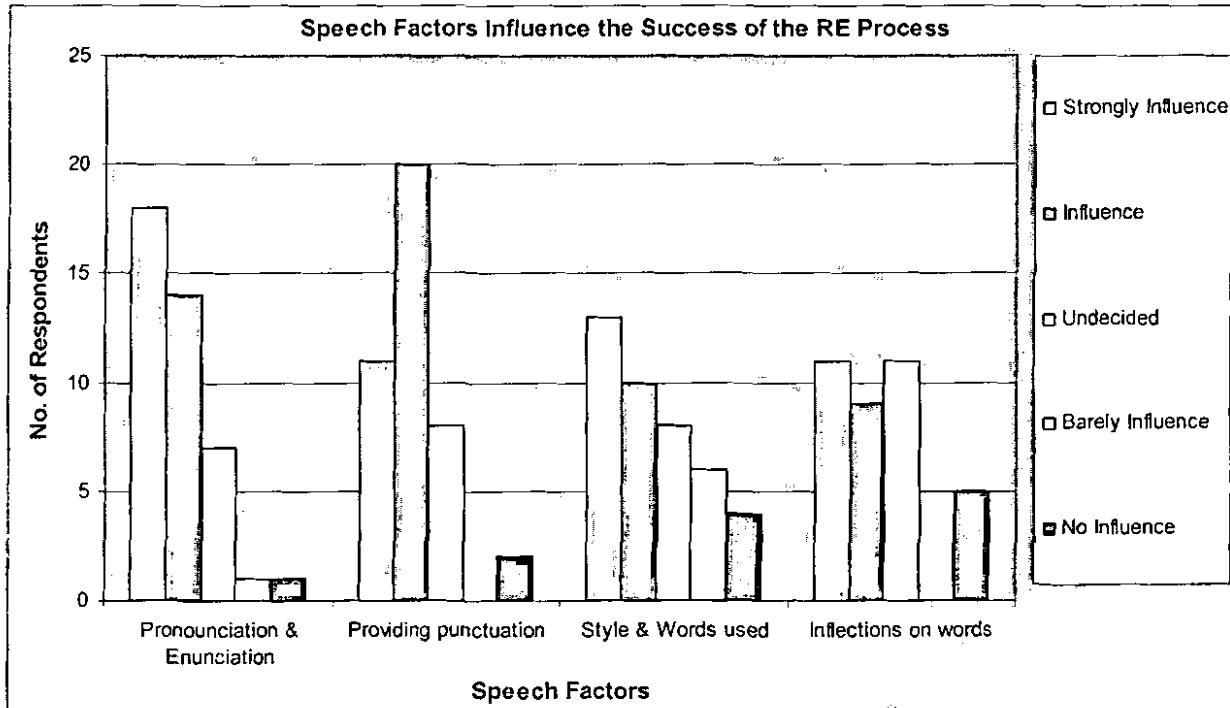
Figure 5.21   The results of Speech Factors for the success of RE Process.

5.3.5.9   Interpersonal Communication Factor

The interpersonal communication ($\overline{X}$ = 1.51) factors are being used for the RE process. All aspects of interpersonal communication, i.e. communication channels ($\overline{X}$ = 1.59), teamwork ($\overline{X}$ = 2.07) and language ($\overline{X}$ = 2.24) are important (in terms of impact) for the success of RE process. The respondents results were sorted according to the mean are shown in **Table 5.14** and the respondents responses are shown in **Figure 5.22**.

INTERPERSONAL COMMUNICATION		
Activities / Factors	**Mean**	**Ranking**
Coaching	2.37	5
Commitment	2.85	8
Communication Channels (networks)	1.59	1
Culture	2.39	6
Informal meetings	2.32	4
Language	2.24	3
Nationality	2.83	7
Norms and Orient	3.02	9
Personality	2.39	6
Teamwork	2.07	2

Table 5.14   The results of Interpersonal Communication Factors for the success of RE Process
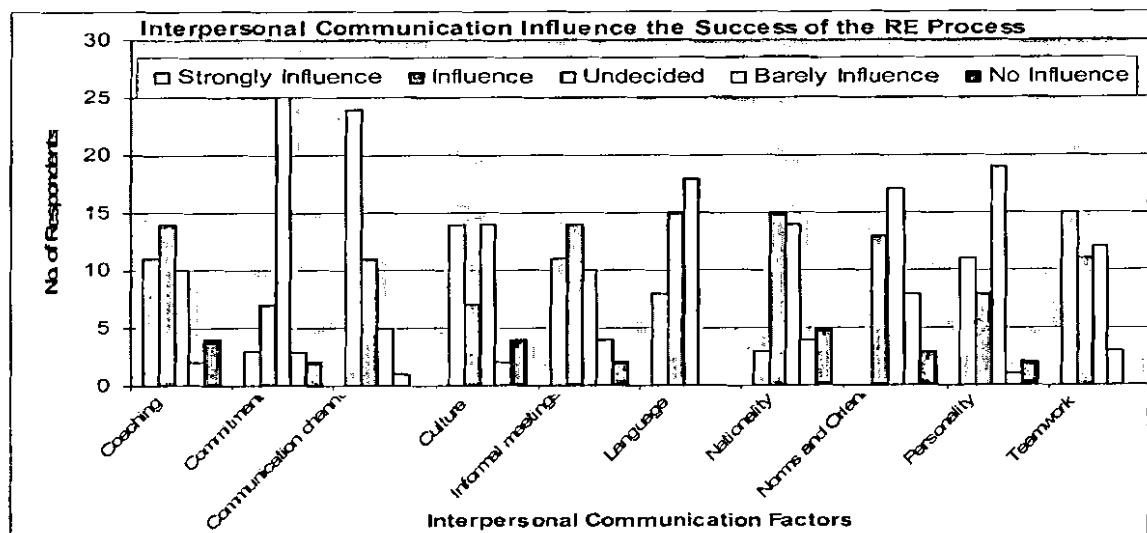
Figure 5.22   The results of Interpersonal Comm. Factors for the success of RE Process.

5.3.5.10   Ergonomics Factor

Ergonomic factors ($\overline{X}$ = 2.39) are important to facilitate an effective requirements elicitation process, but most of the people ignored them in general communication settings. The Position of tools and technology ($\overline{X}$ = 1.59), venue ($\overline{X}$ = 2.02) factors influence the success of RE process. The ergonomics factors which are important for the success of RE process were analyzed by using their means. The respondents results were sorted according to the mean are shown in **Table 5.15**.

ERGONOMICS		
Activities / Factors	**Mean**	**Ranking**
Venue	2.02	2
Position of tools and technology	1.59	1
Position of furniture	2.63	4
Position of people	2.46	3
Type of furniture	2.78	5

Table 5.15   The results of Ergonomic Factors for the success of RE Process

The Ergonomic factors which are important for the success of RE process are shown in **Figure 5.23**.
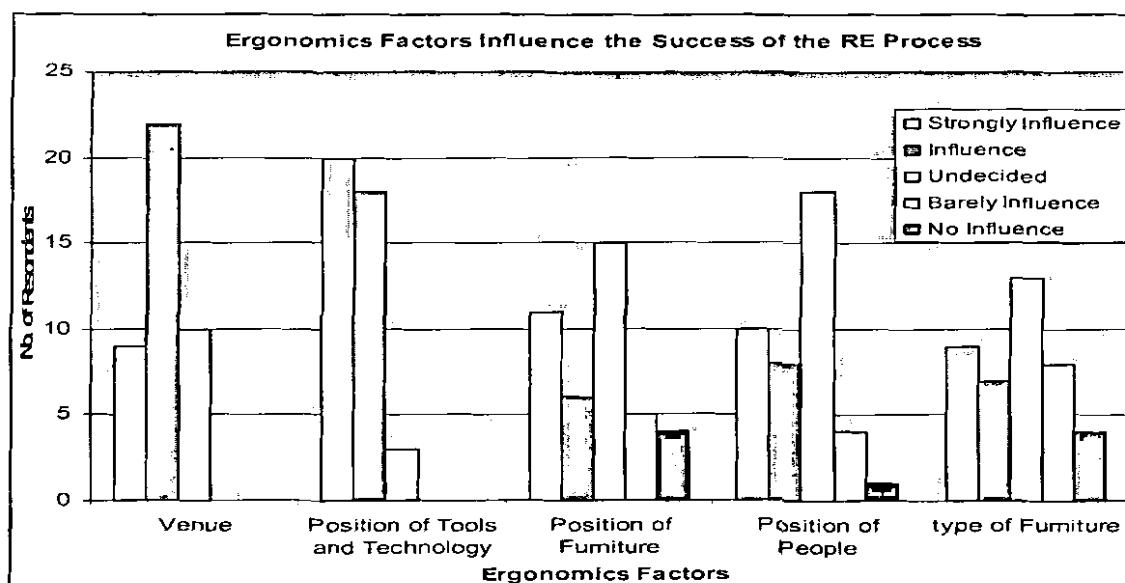
Figure 5.23   The results of Ergonomic Factors for the success of RE Process

5.3.5.11   Decision Making Factor

The decision-making techniques used in the user requirements elicitation process are shown in **Figure 5.24**, which shows that most of the respondents used voting (15) and decision making-Tree (26) and T-chart (14) in the requirements elicitation process.
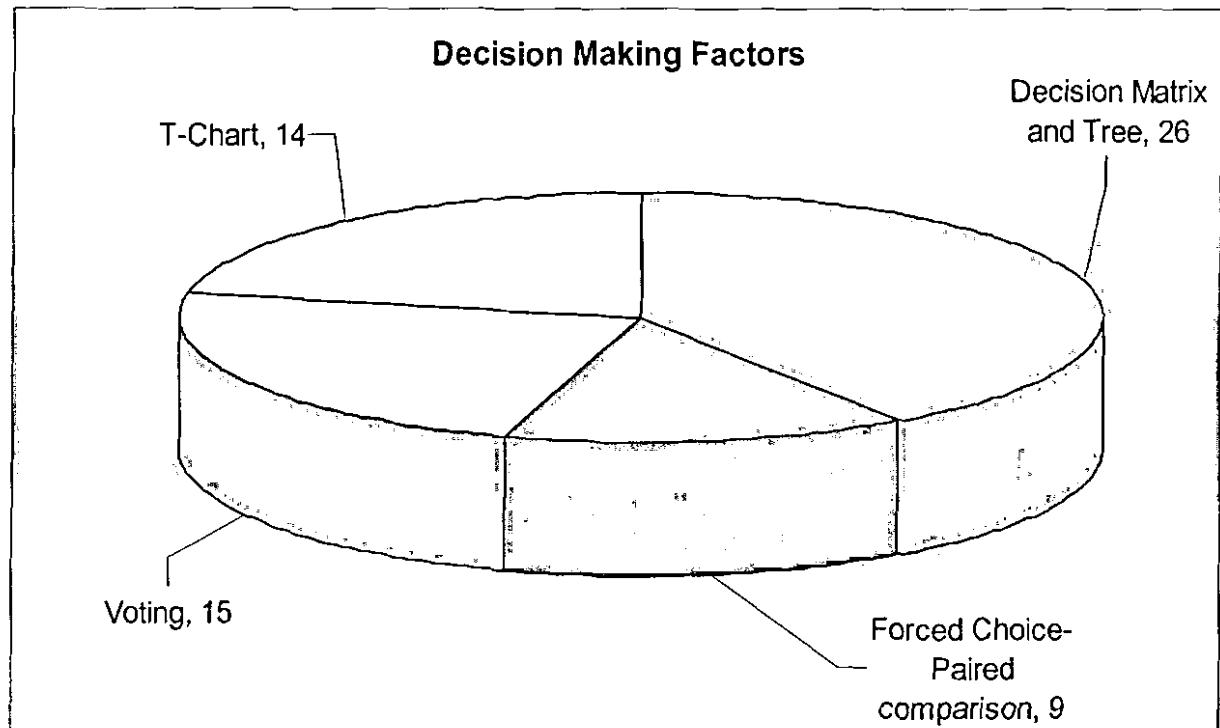
Figure 5.24   Decision Making Factors

5.3.5.12   Documentation Factor

There are many forms of documentation by which we can use it at any time by creating, deleting and updating documents. Most of the respondents use agenda and project schedule in user requirements elicitation process, because they are used for the storage of information of requirements elicitation process, as shown in **Figure 5.25.** Also, most of the respondents do not use hand writing tool in the requirements elicitation process. On the other hand, most of them used word processor as tool for creation of the documentation in requirements elicitation process.
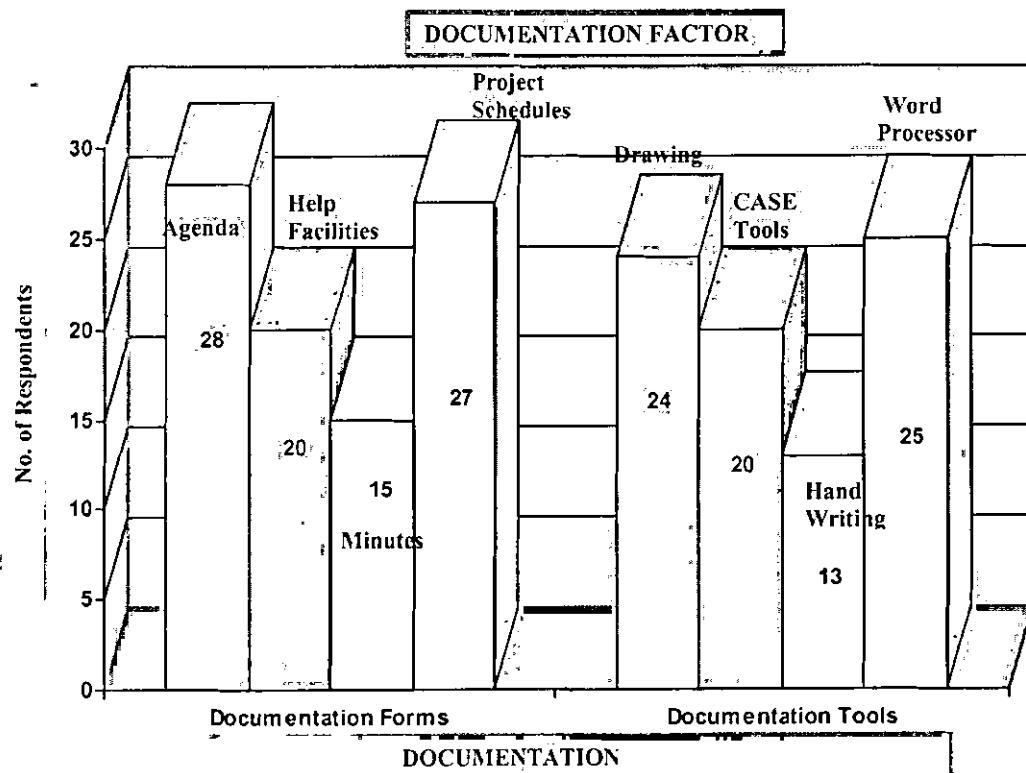
Figure 5.25   Documentation Factors

5.3.5.13   Participation Factor

The analyst and user are mostly involved in the RE process to elicit requirements are shown in **Figure 5.26.** But in requirements elicitation process the analyst, user and developer play important role in the success of software development are shown in **Figure 5.26.**
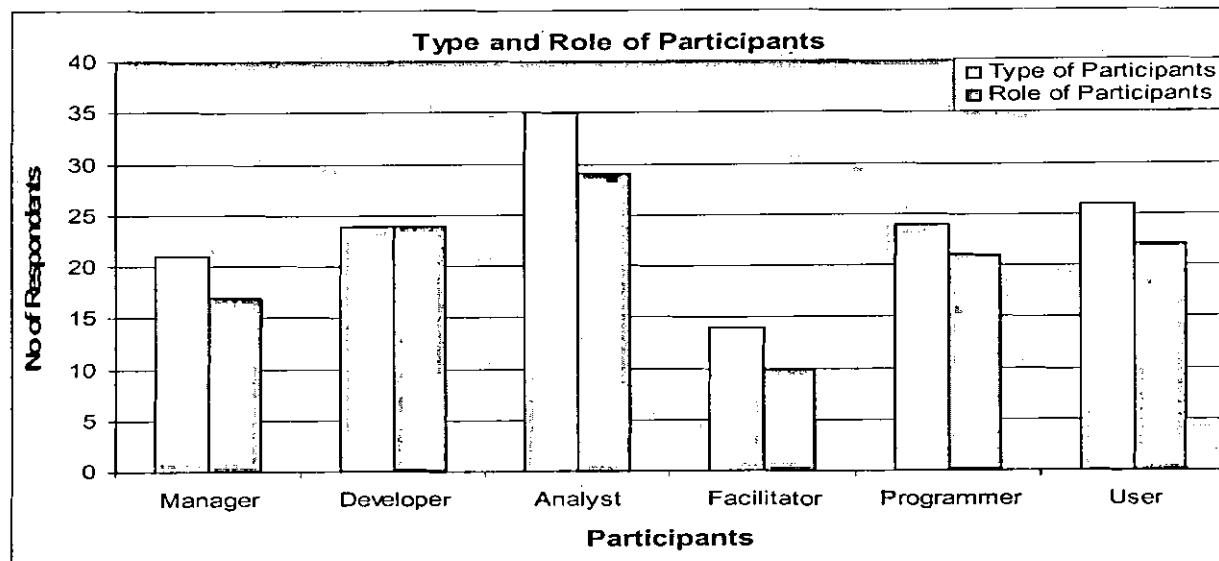
Figure 5.26   The type and role of participants in RE process

5.3.6 Impact of Groupware Tools, RE Techniques, RE Methods & Factors on RE Process

As our research question concerned the impact of groupware tools, requirements elicitation techniques, requirements elicitation methods and requirements elicitation communication factors on the success of RE process in global software development, we mainly focus to investigate the individual impact of distance dimensions on the user requirements elicitation process in GSD as described in sub-headings **5.3.2, 5.3.3, 5.3.4** and **5.3.5** above. The groupware tools, RE techniques, RE methods and factors which are important in the success of requirements elicitation process are analyzed by the use of mean. The means shows individual impact of the four distance dimensions on RE Process as shown in **Table 5.16**. The distance dimensions which have low mean (and low ranking) indicate a higher possibility of agreeness or influence. The communication factors ($\overline{X}$ = 1.93) and groupware tools ($\overline{X}$ = 2.05) demonstrated a higher impact respectively, on the success of requirements elicitation process in global software development (GSD).

Distance Dimensions	#. of Distance Items	Mean
Groupware Tools	6	**2.05**
RE Methods	10	**2.38**
RE Techniques	6	**2.6**
Factors	13	**1.93**

Table 5.16 Means showing the individual impact of four distance dimensions on RE process

The requirements elicitation techniques ($\overline{X}$ = 2.6) and requirements elicitation methods ($\overline{X}$ = 2.38) have a lesser degree of impact on the RE process in GSD.

5.3.7   Bi-variant Correlation Coefficients

5.3.7.1   Correlation between Groupware Tools and RE Methods

The Pearson correlation coefficient (r) between groupware tools and requirements elicitation methods is quite high (i.e., $r = 0.961$), which shows the impact of groupware tools on requirements elicitation methods and vice versa. The null hypothesis (H_0: There is no relationship between requirements elicitation tools and requirements elicitation methods) can be rejected as the probability of Type I error (α: rejection of H_0 when H_0 is true) is quite low. Therefore we conclude the strong relationship between the two variables (Groupware tools and RE methods). The Pearson correlation between groupware tools and RE methods is shown in **Table 5.17**.

		Groupware Tools	RE Methods
Groupware Tools	Pearson Correlation	1	.961(**)
	Sig. (2-tailed)	--	.000
	N	41	41
RE Methods	Pearson Correlation	.961(**)	1
	Sig. (2-tailed)	.000	--
	N	41	41

→ ** Correlation (r) is significant at the 0.01 level (2-tailed).
→ 'r' lies between -1 and 1, i.e., $-1 \leq r \leq 1$

Table 5.17   Correlation between Groupware Tools and RE Methods

5.3.7.2   Correlation between Groupware Tools and RE Techniques

The Pearson correlation coefficient (r) between groupware tools and requirements elicitation techniques is quite high (i.e., $r = 0.983$), which shows the impact of groupware tools on requirements elicitation techniques and vice versa. The null hypothesis (H_0: There is no relationship between groupware tools and requirements elicitation techniques) can be rejected as the probability of Type I error (α: rejection of H_0 when H_0 is true) is quite low. Therefore we conclude the strong relationship between the two variables (Groupware tools and RE techniques). The Pearson correlation coefficients between groupware tools and RE techniques are shown in **Table 5.18**.

		Groupware Tools	RE Techniques
Groupware Tools	Pearson Correlation	1	.983(**)
	Sig. (2-tailed)		.000
	N	41	41
RE Techniques	Pearson Correlation	.983(**)	1
	Sig. (2-tailed)	.000	
	N	41	41

→ ** Correlation (r) is significant at the 0.01 level (2-tailed).
→ 'r' lies between -1 and 1, i.e., $-1 \leq r \leq 1$

Table 5.18   Correlation between Groupware Tools and RE Techniques

5.3.7.3 Correlation between Groupware Tools and RE Factors

The Pearson correlation coefficient (r) between groupware tools and requirements elicitation factors is quite high (i.e., $r = 0.974$), which shows the impact of groupware tools on requirements elicitation factors and vice versa. The null hypothesis (H_0: There is no relationship between requirements elicitation tools and requirements elicitation factors) can be rejected as the probability of Type 1 error (α: rejection of H_0 when H_0 is true) is quite low. Therefore we conclude the strong relationship between the two variables (Groupware tools and RE factors). The Pearson correlation coefficients between groupware tools and RE factors are shown in **Table 5.19**.

		Groupware Tools	RE Factors
Groupware Tools	Pearson Correlation	1	.974(**)
	Sig. (2-tailed)		.000
	N	41	41
RE Factors	Pearson Correlation	.974(**)	1
	Sig. (2-tailed)	.000	
	N	41	41

→ ** Correlation (r) is significant at the 0.01 level (2-tailed).
→ 'r' lies between -1 and 1, i.e., $-1 \leq r \leq 1$

Table 5.19   Correlation between Groupware Tools and RE Factors

5.3.7.4 Correlation between RE Methods and RE Factors

The Pearson correlation coefficient (*r*) between requirements elicitation methods and requirements elicitation factors is quite high (i.e., *r*= 0.978), which shows the impact of requirements elicitation methods on requirements elicitation factors. The null hypothesis (H_0: There is no relationship between requirements elicitation methods and requirements elicitation factors) can be rejected as the probability of Type I error (α: rejection of H_0 when H_0 is true) is quite low. Therefore we conclude the strong relationship between the two variables (RE Methods and RE Factors). The Pearson correlation coefficients between RE methods and RE factors are shown in **Table 5.20**.

		RE Methods	RE Factors
RE Methods	Pearson Correlation	1	.978(**)
	Sig. (2-tailed)		.000
	N	41	41
RE Factors	Pearson Correlation	.978(**)	1
	Sig. (2-tailed)	.000	
	N	41	41

→ ** Correlation (*r*) is significant at the 0.01 level (2-tailed).
→ '*r*' lies between -1 and 1, i.e., $-1 \leq r \leq 1$

Table 5.20   Correlation between RE Methods and RE Factors

5.3.7.5 Correlation between RE Techniques and RE Factors

The Pearson correlation coefficient (*r*) between requirements elicitation techniques and requirements elicitation factors is quite high (i.e., *r*= 0.986), which shows the impact of requirements elicitation techniques on requirements elicitation factors. The null hypothesis (H_0: There is no relationship between requirements elicitation techniques and requirements elicitation factors) can be rejected as the probability of Type I error (α: rejection of H_0 when H_0 is true) is quite low. Therefore we conclude the strong relationship between the two variables (RE Techniques and RE Factors). The Pearson correlation coefficients (r) between RE techniques and RE factors are shown in **Table 5.21**.

		RE Techniques	RE Factors
RE Techniques	Pearson Correlation	1	.986(**)
	Sig. (2-tailed)		.000
	N	41	41
RE Factors	Pearson Correlation	.986(**)	1
	Sig. (2-tailed)	.000	
	N	41	41

→ ** Correlation (r) is significant at the 0.01 level (2-tailed).

→ 'r' lies between -1 and 1, i.e., $-1 \leq r \leq 1$

Table 5.21   Correlation between RE Techniques and RE Factors

5.4 Summary

This chapter briefly presented the data analysis and results of our research. The results of our research shows that prototyping, workshops and interview are the most important methods in RE process during software development in our local domain. The email, instant messaging and video conference are the important groupware tools for RE process success and the team building and brainstorming are the important RE techniques in requirements elicitation process in our local domain.

CHAPTER - 6

FRAMEWORK DEVELOPMENT FOR REREQUIREMENTS

ELICITATION PROCESS

6.1   Introduction

This chapter presents a Framework, which evaluates the impact of human interaction in the global requirements elicitation process (in GSD context). This framework represents the human communication with respect to a single communication model in the global requirements elicitation in the light of the findings of our analysis, already discussed in chapter 4. The analysis of the data reveals the principles of human communication framework in global requirements elicitation and also describes the relationships of the elements within the framework, which represents the communication aspects of requirements elicitation in Pakistan multinational software houses context. The aim of this chapter is to explain the process of requirements elicitation in a globally environment. This explanation is presented in the form of a human communication model in global requirements elicitation.

6.2   Framework Development in Requirements Elicitation Process

Interpersonal communication is the interaction of two or more people. It is highly complex process, as it depends on the success of two or more participant's interaction. In literature, very little but non-significant work has been done about the human communication model in the requirements elicitation process. So on the basis of our comprehensive literature survey and the analysis of empirical study support human communication in RE (analysis of existing communication models) is then combined with the knowledge of requirements elicitation process and GSD process (w.r.t. to geographical distance) to produce a composite standard framework to support human communication in global RE process. This framework then examines the groupware tools and RE techniques in communication process which actually facilitates this framework.

This framework draws the interpersonal communication factors, identified in the literature [24,58]. The combination of these factors describes the requirements elicitation process as a means of human communication perspective. It is important to note that each and every factor when exist in individual form, have no meaning. When it combined with other factors, then they play an important role in the success of communication process in requirements elicitation. Hence, it means that the success of communication process depends upon the factors combination. Each factor in the combination plays respective role in the communication

environment and influences the success of requirements elicitation process in communication model.

The framework which we have developed contains numerous common human communication principles. This framework solves those issues which are directly relating with project failure or successes. This framework also explores those issues (discussions), which are found in the literature, reflecting the requirements elicitation process as described by international researchers and authors. The framework of interpersonal communication in a requirements elicitation shows all aspects of communication model. This framework denotes the communication between an analyst and participants (mean sender and receiver) within the requirements elicitation process.

Also, this framework reflects the knowledge of other former communication models [33,37], GSD process framework for requirements elicitation (RE) [12,17,27], the generic communication models for requirements elicitation process (REP) [5,30,59]. They focus on predicting communication problems and the possible solutions of these problems to avoid or tolerate their impact on the GSD project performance. Hence, it is necessary to determine the aspects which we considered and to determine their inter-relationship in the framework, as shown in **Figure 6.1**.

6.2.1   Resources

Resources like, time, money etc., protection is based on any of the process part [46]. Resources such as technology, information etc are necessary to enter the process at suitable times. (As in our case resources influence the availability of the model).

6.2.2   Task

Task is an aspect which has wide effects on the human utilities in the virtual environment [16]. The resources must support tasks which are performed by people, tools or machine as a part of requirements development process in RE.
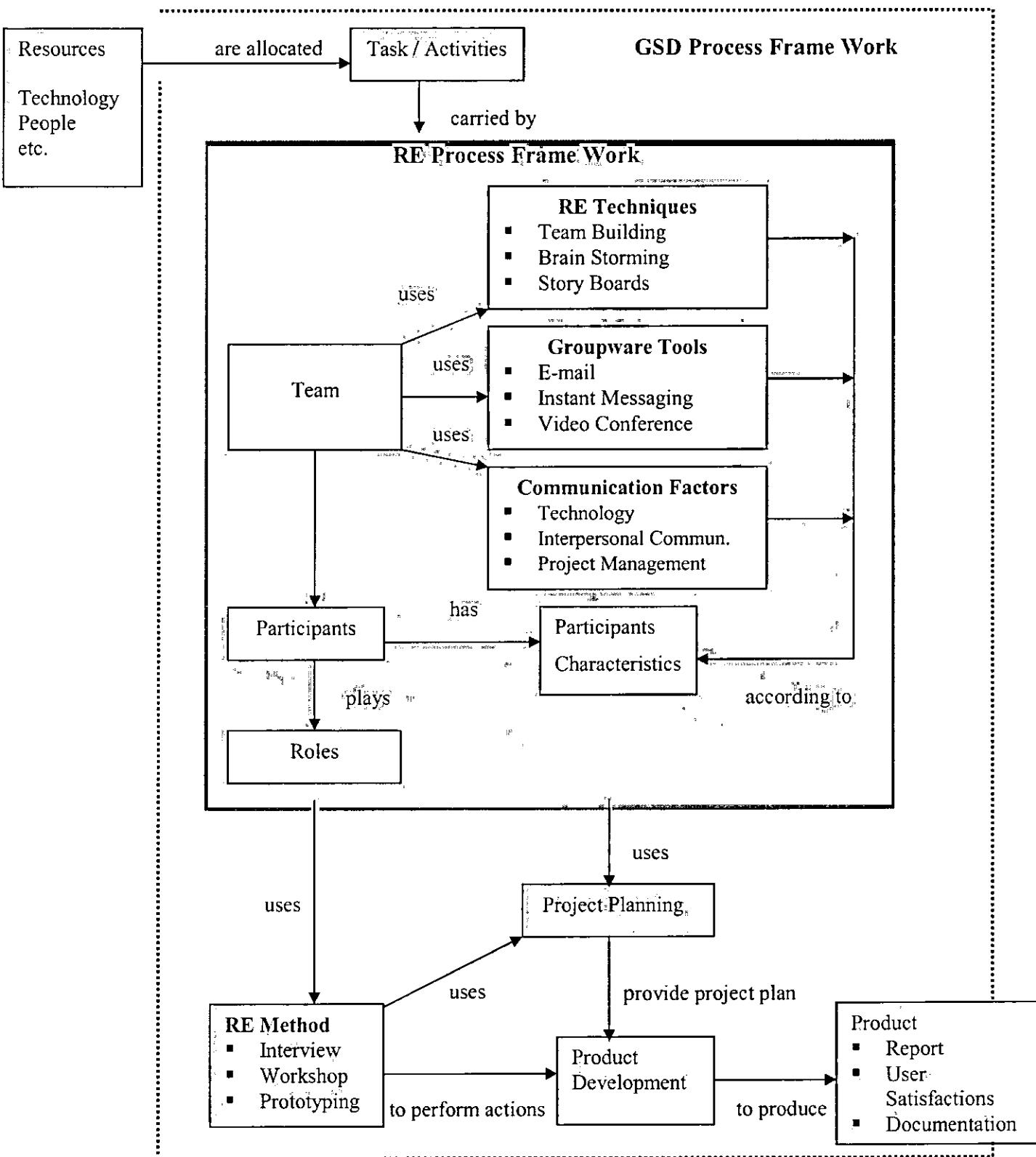
Figure 6.1   Framework to Support Human Communication in Global RE Process

6.2.3   Requirements Elicitation Process

The requirements elicitation process represents a single communication model that determines all aspects of human communication. In our case, the requirements elicitation process includes team, participants (users and analyst) selection and schedule and their characteristics and also selection of groupware tools and techniques. The project manger uses the requirements specification, report and documentation in order to create a project plan, which will be used for the new product implementation [59].

- **Team**

The team represents a group of participants which are working together within a common task. In our case, team uses groupware tools (instant messing, email, etc) and requirements elicitation techniques (i.e. team building, brain storming etc.) according to participant's characteristics.

- **Participants**

During RE process, it is important to obtain the information about participants [4]. Participants play an important role in requirements elicitation process. In our case, participants act as analyst and users (those who operate the system) having similar jobs, because successful software development highly depends on the interaction of the users and analysts. During RE process, the analyst tries to elicit and identify the needs of the users and the organization [32].

- **Groupware Tools**

According to [5], groupware is the software which is used to enable communication. Participants communicate with each other by using some groupware tools (in our case E-mail and instant messing and video conference have highly impact on RE process success). Each groupware tool shows different ways of information in verbal or visual modes and synchronous or asynchronous modes.

- **Requirements Elicitation Techniques**

Requirements elicitation is a human centric activity where communication plays a role of transactional [78]. There are some requirements elicitation techniques (i.e. storyboards, prototyping etc.) which are adoptable to the requirements elicitation process (REP) [31]. These

requirement elicitation techniques are chosen according to participant's information (characteristics). The main aim of these techniques is to make participants at ease in RE process and also improve their performance in RE process. As in our case storyboards and brain storming plays quite impact to elicit the requirements elicitation process in geographical distributed environment. Each RE technique shows different ways of information in verbal or visual mode.

▪ Requirements Elicitation Communication Factors

There are numerous human communication factors, which are used in the success of user requirements elicitation process. But in my case technology, interpersonal communication, project management factors have high impact in requirements elicitation process success.

▪ Participants Characteristics

The participant's characteristics are influenced by groupware tools (i.e. email, instant messaging, etc.) and RE techniques (team building and brain storming). The participant's characteristics play important role for the success of the RE process.

6.2.4 Project Planning

The project planning helps in the identification and the creation of a project plan. All of the participants involved should be informed about the project plan which will surely help the participants in the product development.

RE Methods

RE Tools and Techniques   **Project Planning**   Project Plan

                                                                          Create

RE Communication Factors
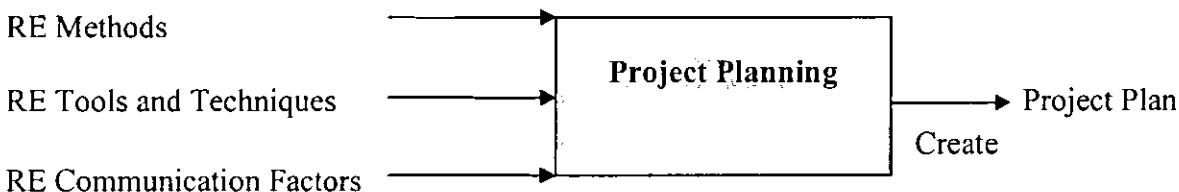
Figure 6.2   The inputs and outputs of Project Planning

6.2.5 Requirement Elicitation Methods

The requirements elicitation methods provide strategies for requirements development [42]. The requirement elicitation methods focus the knowledge of the requirements and then create an executable model. The quality of software development by such methodologies using interview, prototyping and workshop, highly depends on the skills and knowledge of participants. The

workshop helps and uses the participants in the starting of software development process which help to find the requirements which are used for the deriving the structure of the system.

Prototyping are used to derive these requirements in to model and new idea generation. Interview helps in participant's selection and collect, edit, authenticate and simplify facts and finally identify requirements. They provide a means of verbal communication between two or more people in RE process. As in our case prototyping, interviews etc. are mostly impact in RE process success methods.

6.2.6 Product Development

In the product development step, the requirements are designed (modeled), implemented and then tested to produce a new product (the collection of sub-products). This is the last step of a framework to support human communication in global RE. So the resources management process ends and the resources move to other phases of current projects.

RE Methods ⟶ | Product Development | ⟶ create | Product | ⟶
Project Plan ⟶ |
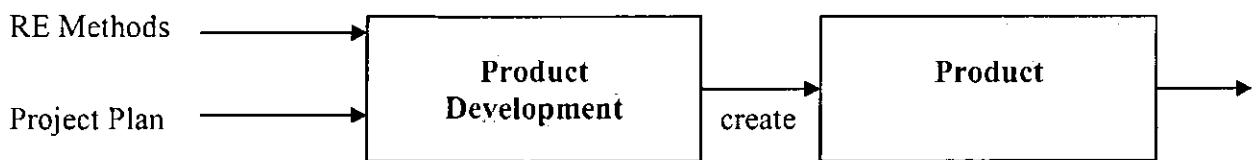
Figure 6.3   The inputs and outputs of product development

6.3 Summary

This research aims in the development of a framework. This framework evaluates the impact of human interaction in the global requirements elicitation process. In this research, the development of the framework is based on geographical distributed environment. This framework will provide conclusive information about the former communication models/ frameworks, the generic communication models for requirements elicitation process (REP) and the GSD process framework for requirements elicitation Process (REP). This quality information will in turn help in guessing communication problems and suggesting various strategies to avoid or decrease their impact on the GSD project performance.

CHAPTER - 7

CONCLUSION AND FUTURE RESEARCH

7.1   Conclusion

Nowadays many software houses (organizations) want to develop software's in distributed global software development environment's, where participants are not positioned in the same location and are communicated by using some groupware tools (i.e. e-mail, tele-conference, etc.). The requirements elicitation process is a critical activity where communication is more difficult then other phases of the software development projects. The choice of these groupware tools, requirements elicitation techniques, requirements elicitation methods and requirements elicitation communication factors (distance dimensions) in global software development environment is the main theme of researcher's nowadays. Software development process is affected by many human factors in the requirements elicitation process that's why communication becomes more difficult.

In this scenario, we need to develop a new communication model to improve the requirements communication process and requirements elicitation process in geographical distributed environment. We proposed a framework, which is based on the literature/ theoretical study while and on the empirical study. The framework demonstrates the human communication aspects of requirements elicitation process in Pakistan. The main theme of this framework is to provide a project plan to all participants and to facilitate all of them (i.e., participants) to achieve a common goal. So, the framework clearly describes the ways in which communication between participants should be improved.

This research explores the requirements elicitation in a geographical distributed environment. This exploration is presented in the form of a framework that support human communication in global RE which is based on general principles of human communication and takes them into account and solves software project failure issues. This exploration also reflects the principles and structure of the framework to support human communication in requirements elicitation process w.r.t. geographical distance.

The results indicate the impact's of distance dimensions on RE process in global software development. On the basis of these results (i.e., results of our empirical study), the framework supports email and instant messaging as groupware tools, while brain storming and team

building as requirements elicitation techniques. This framework is also based on prototyping and workshop methods and will ensure the success of the human communication in RE process.

7.2   Future Research

In future, we want to implement this work in a real software development project(s) undertaking requirements elicitation process during global software development and to improve our understanding about the human communication issues in RE during GSD.

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APPENDIX - A

ABBREVIATIONS

ABBREVIATIONS

- **GSD** (Global Software Development)

- **RE** (Requirements Elicitation)

- **GD** (Geographical Distance)

- **GRE** (Global Requirements Elicitation)

- **GDSD** (Globally Distributed Software Development)

- **REP** (Requirements Elicitation Process)

- **CM** (Communication Model)

- **HCM** (Human Communication Model)

APPENDIX - B

QUESTIONNAIRE

	Date:	
	Start Time:	

DEMOGRAPHICS

Name..

Position..Time in such Position..........Years.......Months......

Company...Type of Company..

Telephone #.. E – Mail..

<u>(Please " √ " the responses that best represents Your Judgments in the appropriate block).</u>

How many years of experience you have in global software development (GSD)?	0 – 1 years	2 – 3 years	4 – 5 years	Above 6

How many years of experience you have in user requirements elicitation?	0 – 1 years	2 – 3 years	4 – 5 years	Above 6

How many years of experience you have in software development (SD)?	0 – 1 years	2 – 3 years	4 – 5 years	Above 6

Are you received any formal training in the user requirements elicitation process?	Yes	No

If "yes", then what type of training you have (name the degrees / diplomas etc.)?

Please mentions the projects in which you had been involved, where user requirements elicitation was one of the aspects of the project?

In-house Project...

External Project...

Other (specify):...

Please mentions the projects in which you had been involved, where user requirements elicitation was one of the aspects of the project?

Software Development...................................... ....

Software Installation.......................................

Hardware Installation ....

Hardware Development ....

Other (specify):...

2. GROUPWARE TECHNOLOGIES

2.1 Which groupware tool(s) you have commonly used in user requirements elicitation process?

2.2 Which Groupware Tool(s), you know best about them?

2.3 Which Tool(s) you have not used before (which containing in this questionnaire)?

2.4 Which Technique(s) you have commonly used in global software development w.r.t. to GD?

2.5 Now a days, what Groupware tools you are using to elicit requirements in global software development w.r.t. to geographical distance?

(Please " √ " the responses that best represents Your Judgments in the appropriate block).

	Question number				
	2.1	2.2	2.3	2.4	2.5
E – mail					
Telephone..					
Discussion Forums..					
Videoconference...					
Audio conference..					
Instant messing					
Other (specify):...					

2.6 Are you have received any training about the use of Groupware Tool(s)? | Yes | No |

2.7 Are you want to learn about the use of Groupware tools? | Yes | No |

2.8 If "Yes", then what you can do for it?

2.9 Which groupware tool(s) are important for the success of user requirement elicitation Process? (Please "Circle" the responses that best represents Your Judgments in the appropriate block).

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
E-mail	1	2	3	4	5
Telephone	1	2	3	4	5
Discussion Forums	1	2	3	4	5
Video Conferance	1	2	3	4	5
Adeio Conferecce	1	2	3	4	5
Instant messing	1	2	3	4	5
Other (specify):					
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

3   <u>REQUIREMENT ELICITATION TECHNIQUES</u>

3.1   Which Technique(s) you have commonly used in user requirements elicitation process?

3.2   Which Technique(s), you know best about them?

3.3   Which Technique (s) you have not used before (which containing in this questionnaire)?

3.4   Presently, what technique(s) you are using to elicit requirements in global software development w.r.t. to geographical distance?

(Please " √ " the responses that best represents Your Judgments in the appropriate block).

	Question number			
	3.1	3.2	3:3	3.4
Team building...				
Brainstorming				
Story Board...				
Card Sorting..				
Repertory grids				
Protocol Analysis...				
Other (specify):..				

3.5   Are you involved in requirements elicitation process during global software development w.r.t geographical distance (mean geographically or distribute dispersed)? | Yes | No |

3.6 If " Yes ", please describe the Environment in terms of the Technology used.

3.7   Which technique(s) are important for the success of user requirement elicitation Process? (Please "Circle" the responses that best represents Your Judgments in the appropriate block).

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Team Building	1	2	3	4	5
Brainstorming	1	2	3	4	5
Story Board	1	2	3	4	5
Card Sorting	1	2	3	4	5
Repertory Grids	1	2	3	4	5
Protocol Analysis	1	2	3	4	5
Other (specify):					

	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

4.   REQUIREMENT ELICITATION METHODS

4.1   Which method(s) have you commonly used in user requirements elicitation process??

4.2   What method(s) you have commonly used in global software development w.r.t. to GD?

4.3   Which Method(s), you know best about them?

4.4   What method(s) you have not used before (which containing in this questionnaire)?

4.5   Presently, what method(s) you use to elicit requirements in global software development, w.r.t. to geographical distance?

(Please " √ " the responses that best represents Your Judgments in the appropriate block).

	Question number				
	4.1	4.2	4.3	4.4	4.5
Interview..					
Prototyping..					
Requirement Reuse...					
JAD (Joint Application Design / Development)....................					
Laddering...					
Questionnaire..					
Participatory Design (PD)..					
Observation..					
RAD (Rapid Application Development)...........................					
Workshops..					
Other (specify):..					

4.6   Are you want to learn about the use of other Method(s)?

4.7 If "Yes", then what you can do for it

4.8 Which method(s) are important for the success of user requirement elicitation Process? (Please "Circle" the responses that best represents Your Judgments in the appropriate block).

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Interview	1	2	3	4	5
Prototyping	1	2	3	4	5
Requirements Reuse	1	2	3	4	5
JAD (Joint Application Design / Dev)	1	2	3	4	5
Laddering	1	2	3	4	5
Questionnaire	1	2	3	4	5
Participatory Design (PD)	1	2	3	4	5
Observation	1	2	3	4	5
RAD (Rapid Application Development)	1	2	3	4	5
Workshops	1	2	3	4	5

Other (specify):

	1	2	3	4	5
	1	2	3	4	5

4.9 What, in your opinion, is significant about the method(s) which you ranked the highest (what makes it (them) better than the others)?

5.   <u>REQUIREMENT ELICITATION FACTORS</u>

Which Factors are used for the contribution of the Process of User Requirement Elicitation? (There are many Factors, which contribute to the process of user requirements elicitation. These factors have been grouped into categories. Please indicate the AGREMENT of each category to the user requirements elicitation process).

<u>(Please " Circle " the responses that best represents Your Judgments in the appropriate block).</u>

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Technology	1	2	3	4	5
System Modeling	1	2	3	4	5
Standards	1	2	3	4	5
Project Management	1	2	3	4	5
Participation	1	2	3	4	5
Mind set (user and developer)	1	2	3	4	5
Personal Appearance	1	2	3	4	5
Body Language	1	2	3	4	5
Speech	1	2	3	4	5
Interpersonal Communication	1	2	3	4	5
Ergonomics	1	2	3	4	5
Decision-making	1	2	3	4	5
Documentation	1	2	3	4	5

5.1. <u>TECHNOLOGY</u>

What "TECHNOLOGIES" factors are used for the agreement of success of the user requirements elicitation process?

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
E - mail and messaging	1	2	3	4	5
Group document handling	1	2	3	4	5
Collaborative Internet-based applications	1	2	3	4	5
Paper and pen	1	2	3	4	5
Group calendering and scheduling	1	2	3	4	5
Video conferencing	1	2	3	4	5
Groupware frameworks	1	2	3	4	5
Visual Aids	1	2	3	4	5
Workgroup utilities	1	2	3	4	5
Groupware applications and services	1	2	3	4	5

Other (specify):

	1	2	3	4	5
	1	2	3	4	5

5.2. SYSTEM MODELLING

What "SYSTEM MODELING" factors are used for the agreement of success of the user requirements elicitation process?

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Entity-relationship diagram (ERD)	1	2	3	4	5
Class diagrams and Object Diagram	1	2	3	4	5
Activity dependency diagram	1	2	3	4	5
Component Modeling	1	2	3	4	5
Data flow diagram (DFD)	1	2	3	4	5
Entity life-cycle analysis	1	2	3	4	5
Matrix analysis	1	2	3	4	5
Use cases	1	2	3	4	5

Other (specify):

	1	2	3	4	5
	1	2	3	4	5

5.3. STANDARDS

What "STANDARDS" factors are used for the agreement of success of the user requirements elicitation process?

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Quality	1	2	3	4	5
Metrics	1	2	3	4	5
Estimation and Function points	1	2	3	4	5

Other (specify):

	1	2	3	4	5

5.4. PROJECT MANAGEMENT

Which "PROJECT MANAGEMENT" factors are used for the agreement of success of the user requirements elicitation process?

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
Assign preparation assignments	1	2	3	4	5
Customize agenda	1	2	3	4	5
Gather materials and Notes	1	2	3	4	5
Leadership	1	2	3	4	5
Obtain resource and results approval	1	2	3	4	5
Productivity and Quality control	1	2	3	4	5
Scoping of project	1	2	3	4	5

Other (specify):

	1	2	3	4	5
	1	2	3	4	5

5.5. PARTICIPATION

How many people involved in the user requirements elicitation process?

Are you agree that many types of people involved in the user requirements elicitation process? (Please "Circle" the responses that best represents Your Judgments in the appropriate block).

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
	1	2	3	4	5

What "types" of people participates in the user requirements elicitation process? (Please " √ " the responses that best represents Your Judgments in the appropriate block).

Manager ....

Developer ....

Analyst ....

Facilitator ....

Programmer...

User ....

Other (specify):

What type of "role" plays participants in the user requirements elicitation process? (Please " √ " the responses that best represents Your Judgments in the appropriate block).

Manager ....

Developer...

Analyst...

Facilitator...

Programmer ....

User ....

Other (specify):

5.6. MIND SET

To what extent do the following MIND SET factors influence the success of the RE process?

	Strongly Influence	Influence	Undecided	Barely Influence	No Influence
Behavior and Attitude	1	2	3	4	5
Expectations	1	2	3	4	5
Socialization	1	2	3	4	5
Values	1	2	3	4	5
Memory	1	2	3	4	5
Mood	1	2	3	4	5
Other (specify):	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

5.7. PERSONAL APPEARANCE

To what extents do the following "PERSONAL APPEARANCE" factors influence the success of the RE process?

	Strongly Influence	Influence	Undecided	Barely Influence	No Influence
Face	1	2	3	4	5
Hair style and Colour	1	2	3	4	5
Nose shape / size	1	2	3	4	5
Body type / shape	1	2	3	4	5
Clothing style and colour	1	2	3	4	5
Eye colour	1	2	3	4	5

Other (specify):

	1	2	3	4	5
	1	2	3	4	5

5.8. BODY LANGUAGE

What "BODY LANGUAGE" factors are used for the influence of requirements elicitation process?

	Strongly Influence	Influence	Undecided	Barely Influence	No Influence
Body contact and pointing	1	2	3	4	5
Breathing	1	2	3	4	5
Eye contact	1	2	3	4	5
Perspiration	1	2	3	4	5
Facial expressions	1	2	3	4	5
Hearing / listening	1	2	3	4	5
Scent / Smell	1	2	3	4	5
Smile	1	2	3	4	5
Voice (accent, inflections, loudness, pitch)	1	2	3	4	5

Other (specify):

	1	2	3	4	5
	1	2	3	4	5

5.9. SPEECH

What "SPEECH" factors influence the success of the requirements elicitation process?

	Strongly Influence	Influence	Undecided	Barely Influence	No Influence
Pronunciation and Enunciation	1	2	3	4	5
Providing punctuation	1	2	3	4	5
Style and Words used	1	2	3	4	5
Inflections on words	1	2	3	4	5

Other (specify):

	1	2	3	4	5
	1	2	3	4	5

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5.10. INTERPERSONAL COMMUNICATION

What "INTERPERSONAL COMMUNICATION" factors influence the success of the requirements elicitation process?

	Strongly Influence	Influence	Undecided	Barely Influence	No Influence
Coaching	1	2	3	4	5
Commitment	1	2	3	4	5
Communication Channels (networks)	1	2	3	4	5
Culture	1	2	3	4	5
Informal meetings	1	2	3	4	5
Language	1	2	3	4	5
Nationality	1	2	3	4	5
Norms and Orient	1	2	3	4	5
Personality	1	2	3	4	5
Teamwork	1	2	3	4	5
Other (specify):	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

5.11. ERGONOMICS

What "ERGONOMIC" factors influence the success of the requirements elicitation process?

	Strongly Influence	Influence	Undecided	Barely Influence	No Influence
Venue	1	2	3	4	5
Position of tools and technology	1	2	3	4	5
Position of furniture	1	2	3	4	5
Position of people	1	2	3	4	5
Type of furniture	1	2	3	4	5
Other (specify):					
	1	2	3	4	5
	1	2	3	4	5

5.12. DECISION-MAKING

What "DECISION-MAKING" techniques DO you use in the user requirements elicitation process? (Please " √ " the responses that best represents Your Judgments in the appropriate block).

Decision matrix and Tree................................

Forced Choice-Paired comparison ....

T-chart...

Voting ....

Other (specify and briefly describe):

5.13. DOCUMENTATION

There are some forms of "DOCUMENTATION", do you use / create / read / update during the process of user requirements elicitation?

Agenda ....

Help facilities..

Minutes...

Project Schedules......................................

Other (specify):

Which of the following tools do you use to create the DOCUMENTATION?

Drawing...

CASE (systems development) tool ....

Hand writing ....

Word processor.......................................

Other (specify):

End Time:

Thank you very much for taking the time to complete this survey.