Impact of Elicitation Techniques on Requirement Validation in Software Industry in Pakistan

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***Abstract*- In Requirement Engineering (RE), requirements are collected and formalized from all the stakeholders using various elicitation techniques. Afterwards, these requirements are validated at the validation phase before the actual design and development phases can initiate. At the validation stage of RE, requirement specifications are tailored to ensure that the requirements are correct, consistent, complete, and unambiguous. To achieve these objectives, the RE team should select the most suitable elicitation technique during the RE elicitation process. In Pakistan software industry, these techniques include interviews, prototyping, questionnaires, and observations. From literature, it is observed that most of the IT firms do not hire specialized RE teams for requirement gathering; instead, the requirements are collected mostly by the development team. Therefore, the primary motivation of this article is to provide a guideline for IT firms and software industry in Pakistan to select the right type of elicitation techniques for requirement gathering. This article presents the results of a comprehensive survey to evaluate the impact of elicitation techniques on requirement validation process in Pakistan software industry. We distributed a questionnaire to several IT firms across the country, and collected important data corresponding to their procedures of requirement gathering. We focused on the individuals responsible for RE processes, and our main conclusion is that requirements are mostly gathered by developers rather than specialized RE teams. Our results also show that prototyping is the most effective elicitation technique for mobile development, whereas interviews are preferred in case of Web & Desktop applications.**

***Keywords*- Requirement Engineering (RE), SDLC, Elicitation Techniques, Requirement Validation, IT Industry in Pakistan**

I. INTRODUCTION

Requirement Engineering (RE) is a fundamentally significant and immensely complicated stage in the Software Development Life Cycle (SDLC). A requirement engineer should have an in-depth knowledge and skill corresponding to all the processes and activities performed during the RE phase [1]. For a software developing process, the most complicated issue is the accurate identification of all the modules and interfaces of the product being build. For this purpose, the role of a requirement engineer is to consult the user in order to gather all the relevant product information to satisfy the customer needs [2][3]. As a first step of RE, the customer's needs and understanding of the problem to resolve are formulated; this step is known as requirement elicitation [4][5]. There are several elicitation techniques utilized for software product development, but applying suitable technique for a particular project is the key to its successful completion. The selection of the most appropriate elicitation technique depends on various factors such as, project budgets, deadlines, type of development, business measures, personal choices, and development tools etc. [6][7]. Based on the right technique, the system analysts can develop a viable strategy to encompass all the aspects of the development which include the interfaces, tools, timelines, goals, and management related issues. Subsequently, a document based on these requirements is generated. The system

development team can then utilize this document to build modules and their interfaces, and integrate the modules into the overall system according to customer's needs [4][8]. Therefore, it is of utmost importance to understand and document the requirements during the elicitation stage to avoid incorrect, inconsistent and ambiguous results [9][10]. Hence the user requirements should be documented in an absolutely consistent, clear, and complete manner thereby following strict procedures to make sure that all the stakeholders are satisfied [13][14]. Therefore, the requirement validation process is invoked to ensure the authenticity of user's requirement during the elicitation stage to eradicate any possible inconsistency before the design and development stages [11][12].

In recent years, Pakistan has witnessed an exponential growth in software development industry [28]. More particularly, numerous freelance developers as well as IT firms are developing applications ranging from mobile apps for Google, Apple, and Microsoft Play Stores to web and desktop applications for foreign companies which outsource their projects to low-cost countries. In this scenario, it is extremely important to guide these developers to use the right elicitation techniques before the initiating the development of their products. The primary motive of this research study is to analyze the impact of a particular elicitation technique on requirement validation for different software projects in Pakistan. Therefore in this paper, we present a comprehensive survey to evaluate various elicitation techniques used in Pakistan software industries in terms of requirement validation criteria, i.e., ambiguity, consistency, completeness, and correctness. We collect online data of different software industries and circulate a questionnaire to them across the country. We focused on individuals who are responsible for gathering requirements for software development regardless of their positions in their firms. We discovered that oftentimes, the requirements are gathered from users by the software developers who play an additional role of requirement engineers too. To the best of our knowledge, no previous study has compiled evaluated elicitation techniques in RE in software industry in Pakistan. Our study provides two significant results: a) For Mobile apps development, the most effective elicitation technique is prototyping, and b) for Web & Desktop applications, interviews are considered as the best elicitation technique.

The rest of the paper is divided into the following sections. In Section 2, we present a thorough literature review on RE and elicitation techniques. We also discuss a theoretical framework of elicitation techniques in software industry. Section 3 provides our methodology to conduct this research study in terms of various steps from problem identification to data analysis. In Section 4, we discuss the results of this study. Finally, the paper is concluded in Section 5 along with some future directions.

II. Literature Review

A. Requirement Engineering (RE)

The IT industry is growing rapidly in the developing world due to the availability of low-cost workforce which acquires projects outsourced from the advanced countries. In Pakistan, various IT firms and freelancing groups are producing quality software, but they have potential to expand in future at exponential rates [15][16][28]. Therefore, proper usage of established processes like Requirement engineering (RE) can play a significant role for successful development of their projects in order to further their growth. Unfortunately in software industry in Pakistan, RE practices are either overlooked or performed by developers instead of requirement engineers [1][17][18]. During the RE process, there are four phases namely, i) Requirement Elicitation, ii) Requirement Analysis, iii) Requirement

Specification, and iv) Requirement Validation [19]. In this study, we focus on elicitation phase in terms of IT projects validation to ascertain the effectiveness of elicitation techniques used at an early RE stage.

B. Issues in Requirement Engineering

In software industry in Pakistan, most of the project failures are attributed to the poor perception of the RE among various stakeholders like developers, requirement engineers, customers, and IT managers [2]. Using appropriate RE techniques is of paramount importance, but they are usually avoided due to their tremendous costs, time constraints, and unprofessional practices such as, poor requirement gathering, documentation, management, and validation [2][20][21]. In addition to these factors, in Pakistan particularly, the most common issues are reported as poor coordination, ambiguities related to the natural languages, lack of field knowledge, lack of will, poor analysis, cultural differences, and weak skills [22][23].

C. Requirement Elicitation Techniques

According to [6], the requirement elicitation techniques used in IT industry in Pakistan are primarily questionnaires, prototyping, interviews, and observation. Figure. 1 presents the percentage of each type of technique used in Pakistan [6]. It is observed that stakeholders in Pakistan IT industry prefer to use interviews for requirement gathering [6][24].

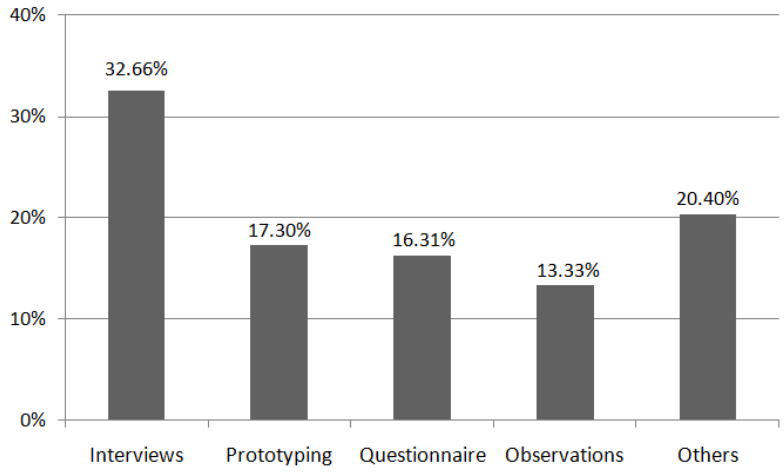

Figure 1. Requirement elicitation techniques used in Pakistan's software industries [6].

Various IT firms and software enterprises work to develop a variety of projects in different application areas, and depending on the customer's needs and nature of a project, the requirement engineers opt for the best possible elicitation technique which ensures to gather complete, consistent, correct, and unambiguous requirements from the customers [25]. In order to achieve these objectives, the requirement engineer should be able to select the right elicitation techniques, because RE elicitation provides the foundation for any project. An improper elicitation technique may lead to an incomplete project or even a totally failed project [3].

C. Theoretical Framework

Figure. 2 depicts the theoretical framework of the requirement elicitation techniques in software development industry. In the first phase, the software application to be elicited is selected and analyzed from the RE perspective.

In the next phase, the most suitable requirement elicitation technique is selected for the given application. Finally, after applying the technique, requirement parameters are checked on the basis of validation criteria.

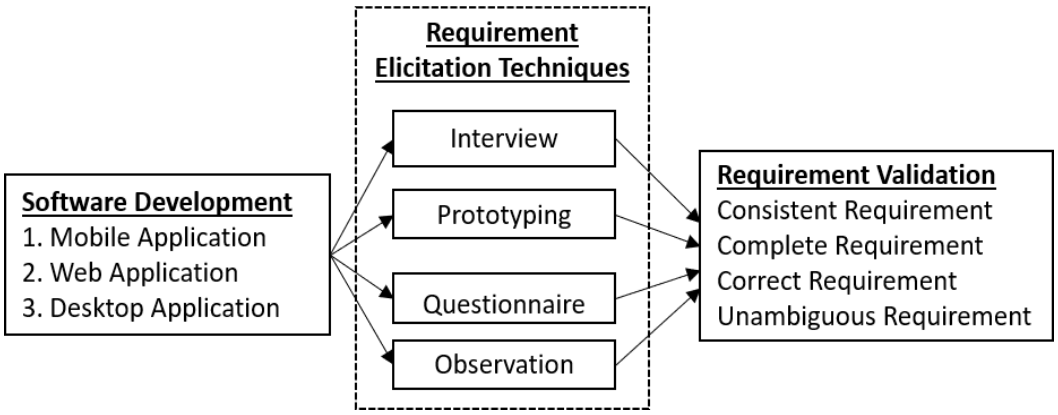

Figure 2. Theoretical framework of the requirement elicitation process in the software industry [27]

III. Methodology

Our study is empirical in nature and the scope of the study covers projects like mobile, web and desktop applications. The unit of analysis was project managers, team leaders, requirement engineers, and developers to target those personal who are gathering requirements for developing software regardless of their position in their firm or organization. More specifically, we have conducted a survey to ascertain each requirement elicitation technique used in Pakistan software industries in terms of the standard validation parameters such as, correctness, consistency, unambiguous, and completeness. For this a Questionnaire was developed with many Multiple Choice Questions (MCQs) using the Google forms portal. We collected data of different software industries from their websites in Pakistan and circulated the Questionnaire in these industries located across the country.

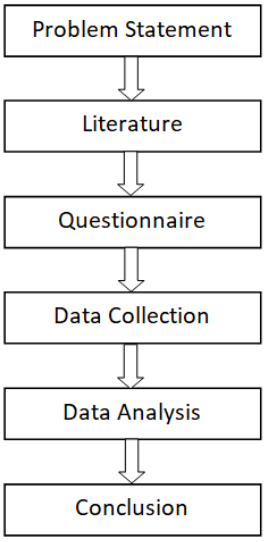

Figure 3. Research Methodology [27]

The data collected from the Questionnaires from all the respondents was presented on the 3-point Likert scaling (1 = High, 2 = Normal, 3 = Low). The acquired scale exhibited very good reliability, because the Cronbach's Alpha values settled on the scale of high reliability i.e. between 0.83 and 0.90 [26][27]. Figure. 3 presents the various steps taken during this research work. First, we identified the problem and analyzed it through literature survey and floated questionnaires among all the stakeholders in the software industry. Subsequently, we collected the data from the responses and analyzed it.

IV. Results and Discussion

A total of 215 questionnaires were circulated in various software firms using the Google Forms to collect the desired data. Out of those 215, we received 143 responses, thereby leading to a response rate of 66.5%. The 143 respondents were further categorized into three types: the mobile developers (62), the web applications developers (50), and the desktop application developers (31).

A. Organizational Profile

From the responses, we concluded that requirement elicitation in almost all software firms is normally performed by the software developers. Figure. 4 presents a breakdown of the personnel in various software firms who perform the elicitation process. It is evident that, of 55% (or 78 individuals) of the total occasions, elicitation is performed by the developers, whereas the requirement engineers perform it only 13.3% of occasions. On other occasions, testers (9.8%) and project managers (22.4%) perform the requirement elicitation tasks.

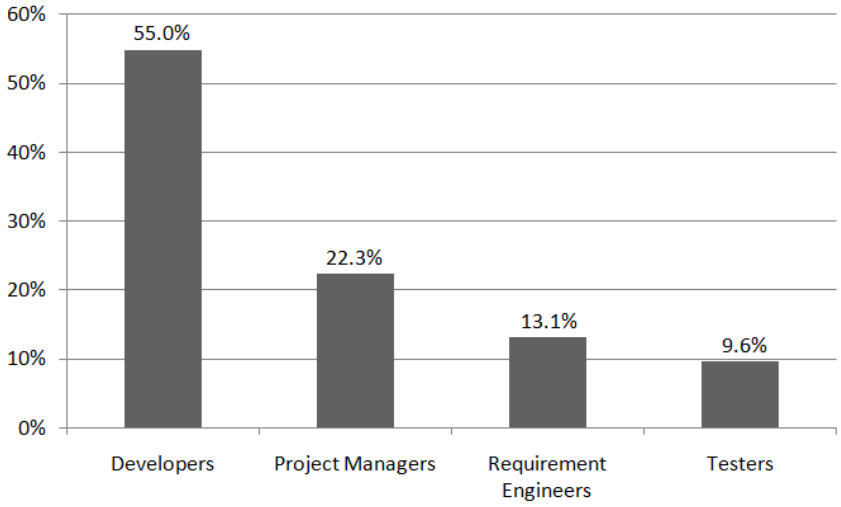

Figure 4. Participants Profile

B. Organizational Size

Figure. 5 presents the sizes of the organizations which participated in our study. It is clear from the figure that the majority of these organizations are of small (<10 employees) or medium (between 10 & 49 employees) sizes. Only 16 organizations confirmed that their employees' strength is more than 50 personnel. In addition, the education levels of the participants were at least bachelor degree or more: 77.6% had BS degree(s) and 22.4% had M Phil/MS degree(s).

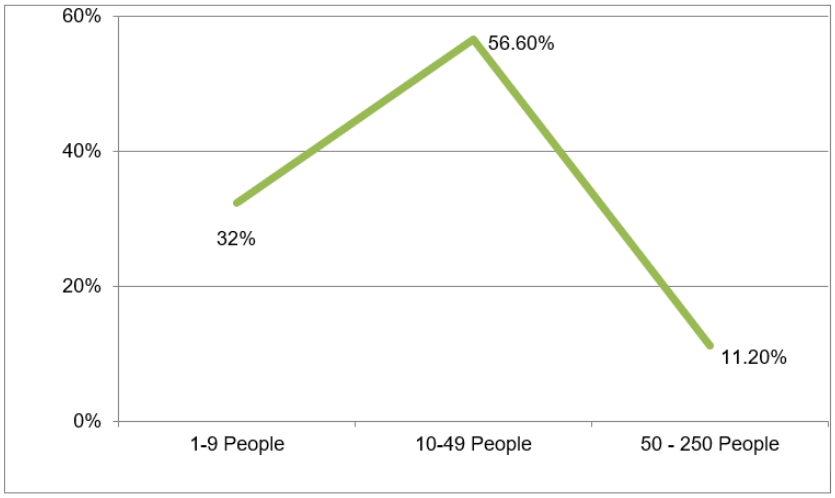

Figure 5. The size of organizations participated in the survey for the study

C. Dedicated Requirement Engineering Team

From the below results, we have concluded that the majority of software industries in Pakistan lack a dedicated RE team, which pose a big problem for project completion at different stages. Most of these organizations depend on a random member of their development team without relying on a qualified RE team. Consequently, this emerges as a big challenge for the industry and ensues in incomplete or incorrect requirements gathering. From Figure. 6, it is clear that only 20% of the respondents confirmed to have a dedicated RE team, while the other 80% organizations do not have dedicated teams, and hence they rely on individuals for requirements gathering.

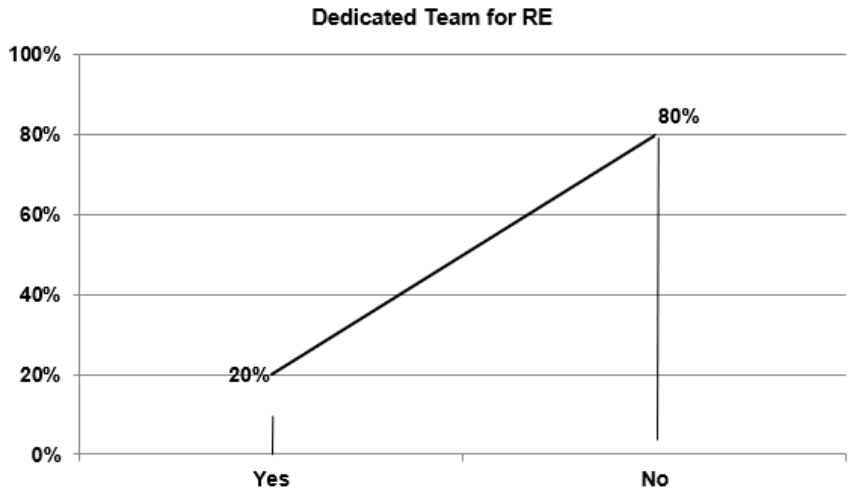

Figure 6. Only 20% of the respondents indicated that their organization has dedicated RE teams

D. Professional Experience

Figure. 7 depicts the working experience of various participants in their field. It can be observed that a sizeable majority of participants have experience of five years or less. A total of 29 respondents (or 20%) confirmed that their work experience is between 1 & 2 years, whereas 41 (or 29%) responded with work experience of 3 to 5 years.

Similarly, 58 participants indicated that they have work experience in software industry between 6 to 9 years. Only 15 individuals confirmed that they have experience of more than 10 years in this field.

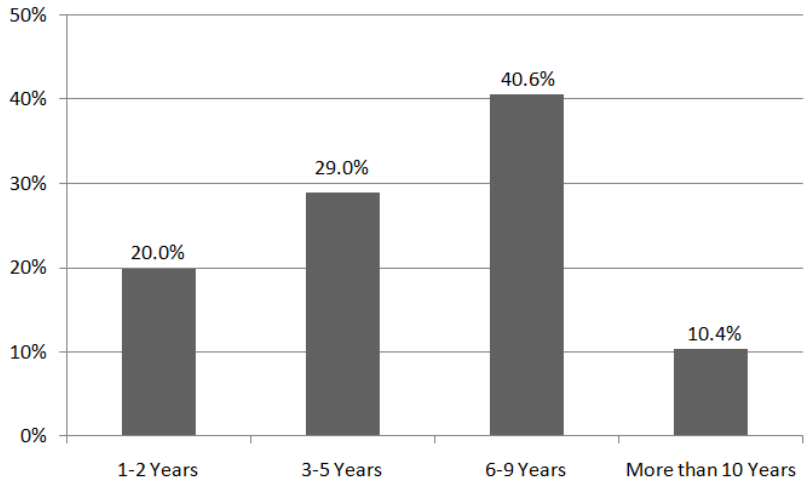

Figure 7. Professional Experience of various participants in the survey

E. Validation Criteria

A software developer expects absolutely clear, correct, complete, consistent, and unambiguous requirements. An RE team should be able to formalize the requirements to specify the details of all modules to be developed. Furthermore, it should ensure that the specifications are detailed enough to proceed to the advanced stages of the development process. Table 1 presents various results of our survey in terms of validation criteria of completeness, correctness, consistency, and unambiguous requirements for three different classes of applications: Mobile, Web, and Desktop applications.

TABLE I: EVALUATION OF REQUIREMENT ELICITATION TECHNIQUES FOR RE VALIDATION CRITERIA FOR MOBILE APPLICATIONS DEVELOPED IN PAKISTAN SOFTWARE INDUSTRIES

Mobile Application												
Requirement Validation Criteria	**Prototyping**			**Interview**			**Questionnaire**			**Observation**		
	High	**Normal**	**Low**	**High**	**Normal**	**Low**	**High**	**Normal**	**Low**	**High**	**Normal**	**Low**
Completeness	88%	7%	5%	70%	22%	8%	40%	28%	32%	18%	10%	72%
Consistency	91%	3%	6%	75%	16%	9%	36%	40%	24%	10%	43%	47%
Correctness	79%	10%	11%	76%	18%	6%	40%	27%	33%	23%	39%	38%
Unambiguous Requirement	85%	12%	3%	86%	6%	8%	29%	33%	38%	12%	32%	56%

From Table I, it is evident that the participants preferred to utilize the prototyping technique if they are looking to develop mobile applications. The respondents suggested that in order to obtain correct, unambiguous, complete, and consistent requirements, prototyping is the most suitable elicitation technique to acquire the requirements. Their second most preferred option is interviewing to get the requirements, followed by questionnaires and observations.

TABLE II: EVALUATION OF REQUIREMENT ELICITATION TECHNIQUES FOR RE VALIDATION CRITERIA FOR WEB APPLICATIONS DEVELOPED IN PAKISTAN SOFTWARE INDUSTRIES

Mobile Application												
Requirement Validation Criteria	**Prototyping**			**Interview**			**Questionnaire**			**Observation**		
	High	**Normal**	**Low**	**High**	**Normal**	**Low**	**High**	**Normal**	**Low**	**High**	**Normal**	**Low**
Completeness	81%	5%	14%	86%	6%	8%	40%	38%	22%	23%	13%	64%
Consistency	75%	14%	11%	85%	7%	8%	31%	45%	24%	27%	23%	50%
Correctness	60%	22%	18%	72%	19%	9%	37%	23%	40%	18%	21%	61%
Unambiguous Requirement	56%	39%	5%	68%	10%	22%	29%	46%	25%	35%	19%	46%

TABLE III: EVALUATION OF REQUIREMENT ELICITATION TECHNIQUES FOR RE VALIDATION CRITERIA FOR DESKTOP APPLICATIONS DEVELOPED IN PAKISTAN SOFTWARE INDUSTRIES

Mobile Application												
Requirement Validation Criteria	**Prototyping**			**Interview**			**Questionnaire**			**Observation**		
	High	**Normal**	**Low**	**High**	**Normal**	**Low**	**High**	**Normal**	**Low**	**High**	**Normal**	**Low**
Completeness	61%	20%	19%	73%	19%	8%	28%	26%	46%	23%	14%	63%
Consistency	72%	17%	11%	78%	12%	10%	36%	19%	45%	12%	32%	56%
Correctness	64%	23%	13%	81%	10%	9%	31%	31%	38%	33%	19%	48%
Unambiguous Requirement	70%	19%	11%	74%	14%	12%	27%	25%	48%	17%	21%	62%

For Web & Desktop applications, the respondents preferred to utilize the option of interviewing the user as shown in Table II and III. Subsequently, they prefer prototyping as their second best option, followed by observation and questionnaires. Therefore, in order to get correct, complete, unambiguous, and consistent requirements for their Web & Desktop applications before development, the industry prefers to take interviews of their customers and other stakeholders. The results presented can play a vital role in the development of professional procedures, proper documentation process, and clarity before development in various IT firms, freelance individual developers, and the overall public/private software industry.

III. CONCLUSION AND FUTURE WORK

In this paper, we presented the results of our survey in order to observe the processes of Pakistan's software industry to gather requirements using various elicitation techniques. For better and accurate results, the sample size of the population (i.e., IT firms) that is participating in the survey should be more representative of various organizations and a larger portion of the stakeholders [9]. Our sample size is medium, but it is still reasonable considering the recently-growing software industry in Pakistan. Therefore, our results give an insight into the requirement elicitation methods used in Pakistan. From the published SDLC literature, we reckoned that the most common software practices are prototyping, interviewing, observation, and questionnaires. From our results, we observed that IT firms do not hire dedicated engineers for requirement gathering. More specifically, our study indicates that only 20% of the software firms have hired dedicated RE teams.

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