

An Investigation of Prototyping Technique in Pakistani Software Industry

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ABSTRACT

Requirements elicitation is one of the important and major activities within the Requirements Engineering phase. There are different techniques used for requirement elicitation process. Selection of any requirements elicitation technique depends on complexity, size, time and other resources of proposed software project. Selection of suitable technique for requirements elicitation is not a trivial process and if it is done properly then it can reduce time, budget, and risk constraints of system being developed. Sometimes researchers have found a gap between theory and practice that is gap between literature and industry practices. Therefore, goal of this paper is to find out the gap between literature and industry practice about requirements elicitation practices in PSI (Pakistani Software Industry). This paper shows the usage and impact of prototyping technique of requirements elicitation on product quality in Pakistani software companies. 29 Software companies following prototyping technique practice were surveyed using questionnaire, to investigate about usage of prototyping technique of requirements elicitation in industry, and impact of prototyping technique of requirements elicitation on product quality in term of schedule, cost and the customer Satisfaction. The appropriate practice of prototyping technique of requirements elicitation can reduce the project failure rate in PSI.

Key Words: Requirement Engineering, Requirements Elicitation, Prototyping Technique, Practices, Industry.

1. INTRODUCTION

Requirement engineering is a process to elicit, develop and organize the requirements in a proper way to produce a right software system [1-6]. Requirements engineering process is implemented on all stakeholders to find out their needs for system being developed [7-10]. There are mainly two types of requirements, that are user requirements and system requirements [11]. System requirements are further divided

into two parts that are functional requirements and nonfunctional requirements [11-13].

The success of software projects and software product depends on capturing suitable requirement for them. Requirement engineering process helps to find out the correct needs of customer in system context [14]. One of the biggest and main reasons for software project failure

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is incorrect requirements [14-18]. Requirement engineering contains tacit knowledge of other fields to tackle requirements in effective and efficient way [19]. Some of the areas used in the requirement engineering include cognitive psychology, anthropology, sociology, philosophy, human psychology and linguistics. These disciplined and well-structured areas put in a lot towards the betterment and advancements carried out in requirement engineering [20].

1.1 Importance of Requirements Elicitation

It has been observed that most of the errors in software system are due to inadequate system requirements [14,21]. It has been observed that 70% of the system faults are paid due to the poor system requirement and 30% faults are paid due to other issues that is design errors. So, if proper requirement elicitation is done then these errors can be eliminated and decrease the probability of system failure [14]. Miscommunication forms foundation for re-modification of requirements [22] Requirement elicitation is the process to communicate with stakeholders and satisfying their needs for system being developed [22-24]. This phase is damaged by 56% defects [25]. The revenue of Pakistan software industry can be increased by applying perfect and correct requirement elicitation technique [21].

1.2 Requirements Elicitation Techniques

There are several techniques of requirements elicitation that are proposed to be useful in requirements elicitation process [26-28]. Every technique has own pros and cons [26-27]. Every technique has specific speciality and used in specific time. Selection of requirements elicitation technique is very critical in terms of project success. It is very difficult to decide which requirements elicitation techniques are appropriate for

software projects [29-30]. Due to improper selection of requirements elicitation techniques most software projects lead to fail [10,14]. The requirements analyst must have more knowledge about these techniques as well as about project domain area [21,31]. Mostly requirements elicitation techniques depend on some constraints which are time, budget, available resources, complexity and size of projects [15]. Before selection of any requirements elicitation techniques for proposed project the requirements engineer must consider the above constraints to get the correct requirements from stakeholders [6,16].

1.3 Collaborative Techniques

Collaborative techniques are those techniques where different stakeholders express their need and expectation about software project. Collaborative techniques play very effective role in requirements elicitation process because there is a freedom of stakeholders to express their opinions, ideas and thinking about software project being developed. Stakeholders feel high level of satisfaction in these techniques because they understand that requirements analyst give more attention to their suggestions and trying to embed their ideas in proposed system. Prototyping technique is one of the collaborative techniques [32-33].

1.4 Prototyping Technique

“Software prototyping refers to the activity of creating prototypes of software applications and it is an incomplete version of the software program being developed” [32]. Actually, prototype is a working and ideal model to analyze the requirements for proposed system [25]. Prototyping is a very effective technique of requirements elicitation. It is also called modern

technique for requirements elicitation. It is bi-directional technique where there is a closed interaction of developer, analyst and end user [33-34]. It is used when customers do not know in advance what are actually required to them in their system [27,29]. It is also used that time when there is an excessive feeling about uncertainty requirements and analyst needs an early feedback of stakeholders to get the requirements for system development [14-15,35-37]. Prototyping technique is actually the process to build a model which represents the actual requirements of customer and end-users. This model is very helpful to validate the user requirements [16,38]. Before making this model, analyst collected the user requirements by other technique like interview, observation and brainstorming etc. to establish the initial set of requirements then for further refining of requirements the analyst used prototyping technique to get the actual requirements of customer and end user [20-21,33,39]. The prototyping model presents the actual requirements in front of stakeholders to get the early feedback of stakeholders and get further requirements of customer and end user [40-42]. After getting feedback of stakeholders the analyst is trying to improve the next version of prototyping by putting the new requirements of stakeholders to satisfy the needs of end-users and also develop a quality software project. Hence prototyping technique is an iterative process and also a part of analysis phase. During analysis phase the analyst presents the current work and current hidden problems of that project [33,39,41-45].

1.4.1 Impact of Prototyping Technique

It is very effective to establish the real requirements of stakeholders and convert customer needs into actual

requirements. Prototyping save, cost of rework and remove ambiguity in system requirements. It facilitates to take the correct design decision [45-46]. Prototyping technique increases the communication between analyst and users that how to make a quality software project according to the actual requirements. This technique shows what are real needs of customer and end-users. If real and actual requirements of customers are not embed in software project, then it's badly affected the software project during working environment. Often customer and end-users surprised when the final product not satisfied their expectations and needs. So, through this technique analyst can perceives the actual requirements of stakeholders and can builds quality software. This technique plays a very important role in the of software project [47]. Prototyping technique provides two types of requirements [46] are as follow:

Product-Level-Requirements: These requirements describe the functionality of proposed system. It explains how system will perform during working environment and how it is useful during working stage. The prototyping model shows the services of system being developed. After version presentation the analyst got the feedback of stakeholders to enhance the functionality of system proposed.

Design-Level-Requirements: These requirements define the interface working of system being developed. It defines the attributes of interface that is describing what the attributes of interface are. Then explains and presents the working of those attributes and elements through visual model at front of stakeholders. Stakeholders react at that time and analyst gain their reaction and enhance the next version of prototyping [47].

1.4.2 Types of Prototype

There are different types of prototypes. Every prototype has own purpose and specific use. These prototypes are textual versus visual, throwaway versus evolutionary, executable versus non-executable prototypes and horizontal versus vertical. Visual prototyping consists of scenarios, state charts and storyboards while textual prototyping method used formal language [32,48]. Throwaway prototype assists the process through a detail information about system requirements but not reusable, while Evolutionary prototype is a reusable version which shows to customer. It is improved according to customer feedback and then fits into original system [38]. Executable prototypes are developed by using high level programming while non-executable prototypes are drawn on paper and then show to customers [49]. Horizontal prototypes are used to remove ambiguity in requirements and deep refinement of requirements but not consist of real functionality of the system while vertical prototype is the part of system and contains the real functionality of system and used as part of system [48].

1.4.3 Phases of Prototyping Construction

- (a) Initial analysis of users' requirements.
- (b) Prototype design.
- (c) Rapid prototype execution.
- (d) Prototype assessment with different stakeholders.
- (e) Iterative improvement of the prototype.
- (f) Enhancement of requirements and specifications.
- (g) Design and implementation of the production system.

Initial Analysis of Users' Requirements: In this stage the analyst finds out the basic requirements of stakeholders by the help of traditional techniques like interview discussion or brainstorming session. The analyst is trying to identify the boundaries of system being developed. The analyst discussed the software project with stakeholders. The analyst collected the initial requirements of system through interview or brainstorming technique.

Prototype Design: Initial requirements provide a base line for Prototype design. The analyst builds a model which presents the services of customer and end-users. The analyst sketched an initial version of prototype which contains the basic requirements of stakeholders.

Rapid Prototype Execution: During this stage the analyst executes the initial version of prototyping. The analyst diagnoses the functionality of this model. The analyst examines what functionality is missing in this model. The analyst checks the prototyping model from three dimensional before presenting it at front of all stakeholders.

Prototype Assessment with Different Stakeholders: During this stage the analyst executes the prototype model at the front of all stakeholders. During this stage analyst finds out the reactions of stakeholders about system proposed. The analyst collected the valuable suggestions and expectation of stakeholders of system being developed. So during this stage the analyst gains the real feedback of stakeholders.

Iterative Improvement of the Prototype: In this stage the analyst enhanced the capability of initial version of prototyping. The initial version is converted into second version by embedding the missing functionalities of system proposed. The analyst makes changes in the second version of prototyping model according to the feedback of stakeholders.

Enhancement of Requirements and Specifications: In this stage the analyst enhanced and improved the final version of prototyping model. The analyst is trying to agree all stakeholders on final version for system development. After negotiation of all stakeholders the process of SRS is started. The analyst developed SRS on the basis of final version of prototyping model.

Design and Implementation of the Production System: This is the final stage of prototyping where the final validation of prototyping model occurs. The design issue of system being developed is discussed. The analyst discussed all requirements for system development with stakeholders by constructing the final version of prototyping of system proposed. The analyst also discussed the attributes and elements of interface of system being developed. On the basis of final requirements, the analyst developed a final version of prototyping which is used as part in final product [48].

Advantages of Prototyping Technique: This technique is very useful in eliciting requirements for novel application. If there is a new software project where customer and end-users do not know what functionalities are required in their new system and analyst developed a new system without stakeholder's requirements, so the final product will be failed according to customer expectations and needs [29,46-47]. The second big advantage of this technique is customer and user's feedback. The stakeholder early feedback is very helpful for further investigation about system features. The analyst finds out what are the deficiencies in the current version by sudden reaction of stakeholders. The analyst records the suggestion of stakeholders and applying in the next version of prototyping model [33,35,49]. The third advantage of this technique that it

is very helpful to develop correct requirements and presents those system requirements in the form of graphical user interface [27]. The analyst also discussed design level requirements with stakeholders, and identifies the expectation of customer and end-users what type of interface they like identify the attributes of design interface and then embedded that in the final version of software project [31].

This technique enhance the system capability in future because it is an iterative process to refine the requirements [15]. All stakeholders involved during requirements elicitation process in prototyping technique and take part as active participants to give suggestions and opinions in free environment. Stakeholders feel more comfortable and more satisfied due to active participation during requirements elicitation phase, and convert their suggestions and needs into actual requirements. So that's why it provides high level of satisfaction to users [20,33,40]. This technique also provides a tremendous help to developer team and save their time. Due to refine requirements there is no need to do rework. So, this technique saved the developers in terms of time from rework and reduces the development cost [48,50].

One of main advantages of the prototyping model is to validate and certify the proposed system during requirements elicitation process because Users are involved throughout the entire software production lifecycle [14,38,50].

2. METHODOLOGY

This research is based on quantitative research method [50-51]. Our research methodology consists of literature

review, Piloting and specific industry survey. From literature review we found out research questions and then surveyed the general Pakistani software industry through questionnaire [52-54]. After general survey we refined and put more questions and forwarded to target software companies. Our survey consists of three phases. In first phase we surveyed general software industry which consists of 14 companies and found out that 90% software companies used prototyping technique for requirements elicitation. In second phase we added more questions in the questionnaire about prototyping technique of requirements elicitation and directed to target companies. The data which are collected in second phase helped to refine and improve the questionnaire in the third phase. In the third phase we refined and modified the questionnaire samples of prototyping technique of requirement elicitation according to area experts and after expert review we directed those questionnaire samples to target software companies. The target companies consist of 29 software companies which are working in Pakistan.

2.1 Survey Design

The Questionnaire is designed accordingly [55-57]. The Questionnaire used in the final phase of this research study is to collect information from different software companies using the software requirements elicitation technique (prototyping). The target software companies which are visited working in different cities of Pakistan. Questionnaire consists of three types of questions [58-61]. Such as open questions, close ended and questions where the answer is plotted on Likert chart. The distribution of questions is made in such a way that they should cover all the research questions. Many modifications and changes were made in the research questionnaire according to new requirements of investigation.

2.2 Questionnaire Distribution

Software companies were selected on the basis of requirements elicitation technique (Prototyping Technique). First of all, interviews of general software industry were conducted to streamline the questionnaire survey and recognize the target group in phase II. The software companies were visited physically not through email and handover the questionnaires and stated to fill within ten days. But some of the respondents returned questionnaires later than said time. After Phase-II, further refine the questionnaires in Phase-III and more companies were visited which followed Prototyping and Questionnaires technique and handover questionnaires to fill within 15 days. But most of the respondents gave late reply than said time. In Table 1, we have presented the list of companies which we have visited and collected the data.

3. ANALYSIS RESULTS

3.1 Statistical Analysis of Requirements Elicitation Practice in Pakistani Software Industry

In this section we analyzed statistical data about prototyping technique and found out concrete numerical data to answer research questions about prototyping technique of requirements elicitation. During this analysis we searched out the usage of prototyping technique in software industry, the success ratio and how much it is used by software companies. Further, we found out the impact of this technique during development process and its success ratio than other techniques. First of all, we analyzed it (prototyping technique) on projects. The Fig. 1 shows that 21% software companies used prototyping technique on all projects, 72% software

companies used it on specific projects and 7% companies used prototyping technique on regular basis.

The Fig. 2 indicates that 11% software companies practiced prototyping technique by participating of all stakeholders, 32% software houses practiced it by help of managers, 32% software organizations practiced prototyping technique by help of software developer, and

25% companies practiced it by software developer customer and managers respectively.

The Fig. 3 shows that 20% software companies agreed that prototyping technique decreases the time duration for software projects if it is used properly, 25% strongly agreed, 18% disagreed, 4% strongly disagreed and 3% were neutral.

TABLE 1. LIST OF SOFTWARE COMPANIES

No.	Companies Name	Number of Employees	Size	Location
1.	Earth Factor	200	Large	Islamabad
2.	AKSA	165	Medium	
3.	Protege Global	120	Medium	
4.	Elixir Technologies	210	Large	
5.	DPL	160	Medium	
6.	COGILENTSOLUTIONS	60	Medium	
7.	Jin Technologies	50	Medium	
8.	Makabu	50	Medium	
9.	NET TECH	50	Medium	
10.	TRG Pakistan	300	Large	Karachi
11.	3S Technologies	60	Medium	
12.	Aciano Technologies	40	Medium	
13.	3 Techno Digital	50	Medium	
14.	A2Z Creatorz	60	Medium	
15.	Auriga Solutions	20	Small	
16.	System Limited	300	Large	Lahore
17.	Clicks Tech	300	Large	
18.	Teradata	500	Large	
19.	Computing Solutions	20	Small	
20.	TECH TRACK	15	Small	Peshawar
21.	NSD	45	Medium	
22.	iFaST Solutions	60	Medium	
23.	PRECISE TECH	60	Medium	
24.	TECH-WIZARDS	40	Medium	
25.	IFahja	20	Small	
26.	IT Artificer	15	Small	
27.	STEPNEX	50	Medium	

The Fig. 4 describes that 32% software companies agreed that prototyping technique decreases the development cost, 36% strongly agreed, 18% accepted more than 80, and 14% software companies accepted it with 40 and 18% believed in 60%.

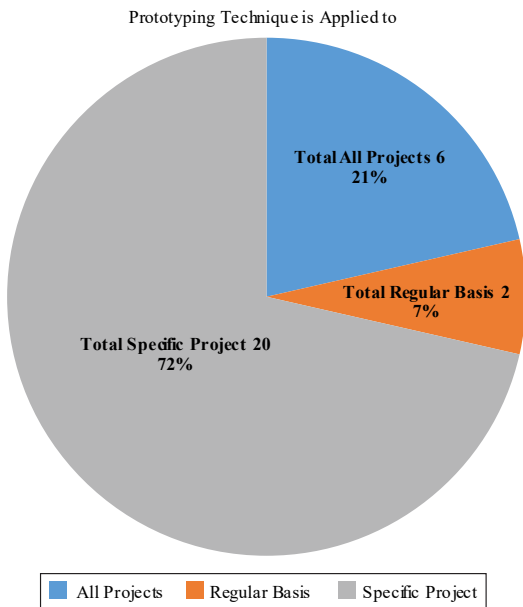


FIG. 1. RESPONSES ABOUT PROTOTYPING TECHNIQUE USAGE ON PROJECTS

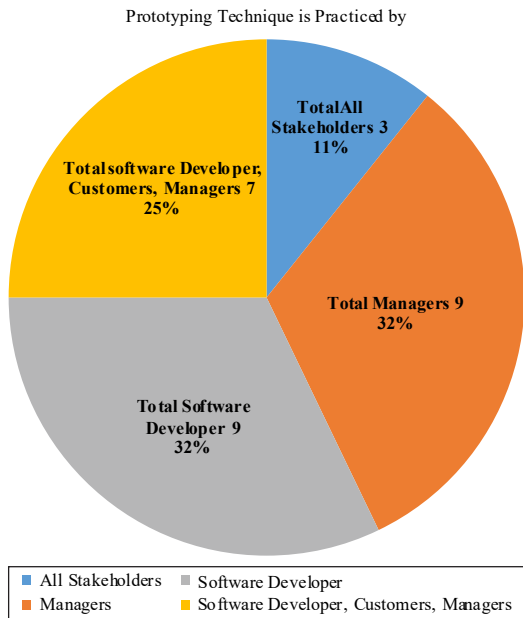


FIG. 2. RESPONSES ABOUT BY WHOM PROTOTYPING TECHNIQUE IS PRACTICED

The Fig. 5 shows that 50% software companies accepted that prototyping technique play 80% role in the success of software projects, 18% accepted more than 80, and 14% software companies accepted it with 40 and 18% believed in 60%.

Prototyping Technique is Followed Because it Decreases Time/Durati on

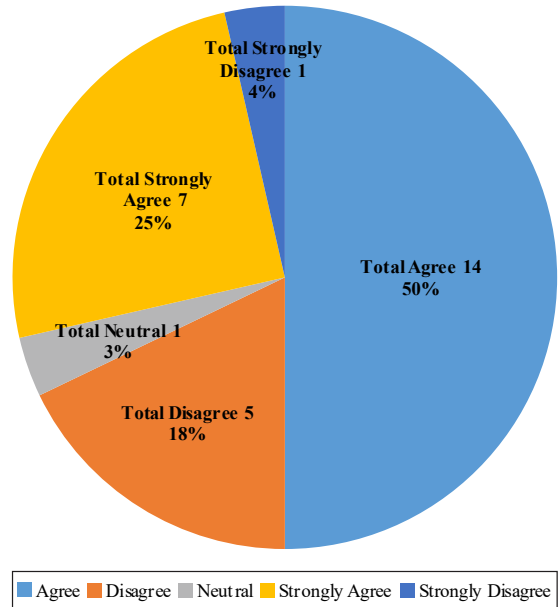


FIG. 3. RESPONSES ABOUT IMPACT OF PROTOTYPING TECHNIQUE IN TERM OF TIME

Prototyping Technique is Followed Because it Decreases Development Cost

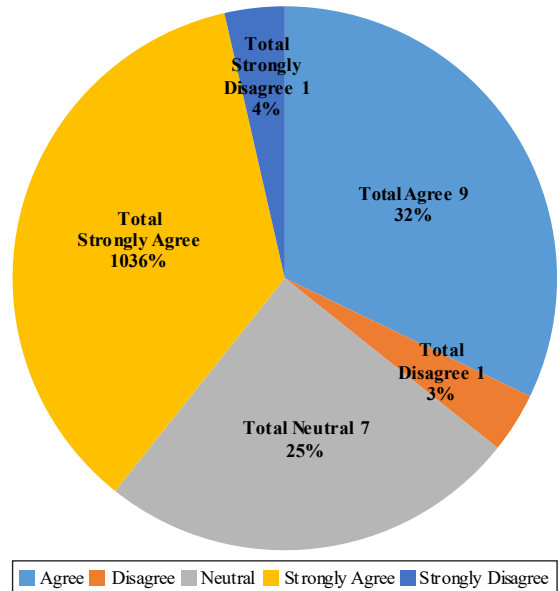


FIG. 4. RESPONSES ABOUT IMPACT OF PROTOTYPING TECHNIQUE IN TERM OF DEVELOPMENT

The Fig. 6 represents that 39% software companies used interviews and brainstorming techniques for initial requirements and after these techniques the software companies used the prototyping technique for further refinements to build a quality software project, 43% companies used interviews before prototyping for initial requirements, 4% software companies used questionnaires and brainstorming and 7% used questionnaires, interviews and brainstorming respectively.

The Fig. 7 signifies that 36% software companies used prototyping technique for large size project, 39% software companies used it for medium size and large size projects respectively, 14% companies used prototyping technique for medium size project and 11% used prototyping technique for small size, medium size and large size projects respectively.

The Fig. 8 shows that 54% software companies believed that prototyping technique is very helpful to validate the

What is the Impact of Prototyping Technique in Term of Software Project Success

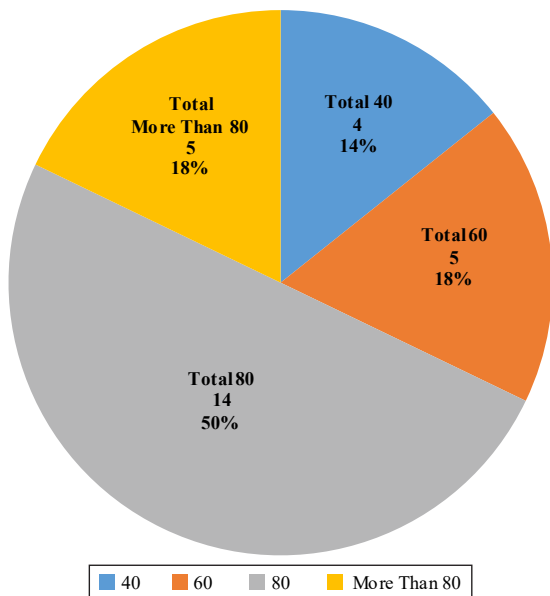


FIG. 5. RESPONSES ABOUT PROTOTYPING TECHNIQUE IN TERM OF SOFTWARE PROJECT

requirements of customers and end-users, and 21% companies agreed with more than 80, and 14% agreed

Which Techniques Your Organization Used Before Prototyping Technique for Initial Requirements

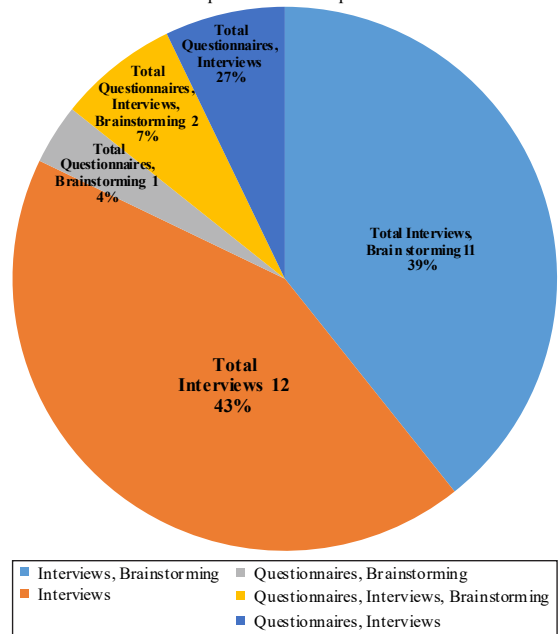


FIG. 6 RESPONSES ABOUT OTHER TECHNIQUES FOR INITIAL REQUIREMENTS

For which Type of Software Project Your Organization Used the Prototyping Technique

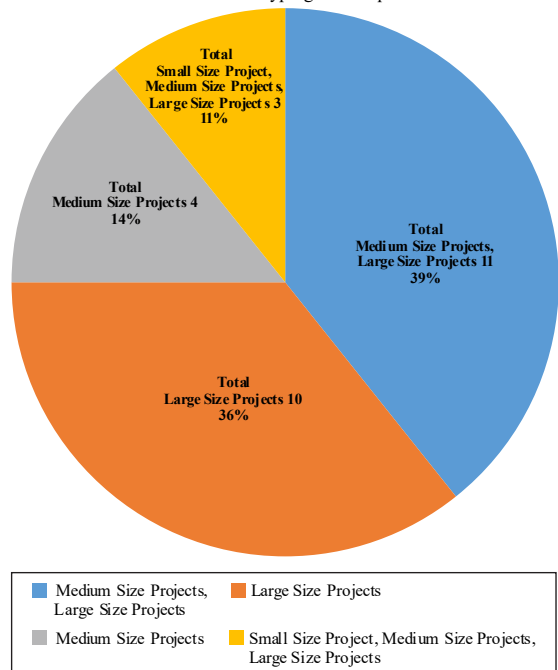


FIG. 7. RESPONSES ABOUT SOFTWARE PROJECTS SIZE

with 60, and 7% companies agreed with 40 and 4% software companies agreed with 20%.

The Fig. 9 describes that 54% software companies believed that prototyping technique is verified the requirements of software projects up to 80, and 21% agreed with 60, and 14% companies agreed with more than 80, and 4% agreed with 40 and 7% agreed with 20%.

The Fig. 10 represents that 47% software companies believed that the success ratio of software projects is 80% by using prototyping technique than other techniques, 14% software companies agreed with 40% in 14% software companies agreed with more than 80, and 21% software companies agreed with 60 and 4% software companies with 70%.

The Fig. 11 represents that 50% software companies believed that 80% customers are well satisfied from the

proposed project by using prototyping technique, 18% agreed with more than 80, and 20% companies agreed with 60, and 14% agreed with 40%.

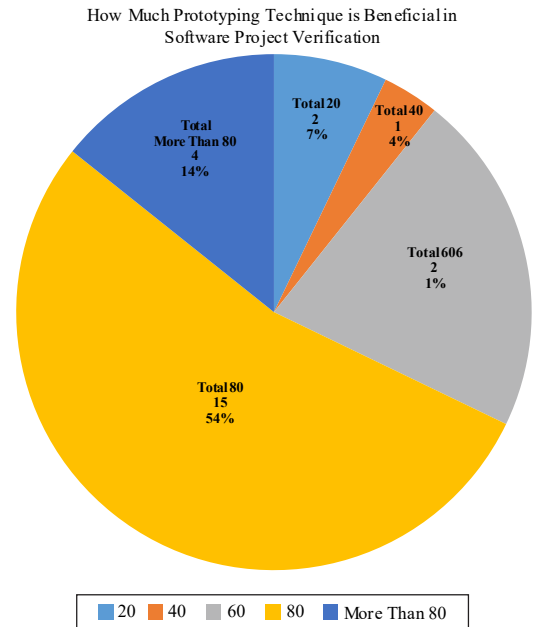


FIG. 9 RESPONSES ABOUT IMPACT OF PROTOTYPING TECHNIQUE IN TERM OF VERIFICATION

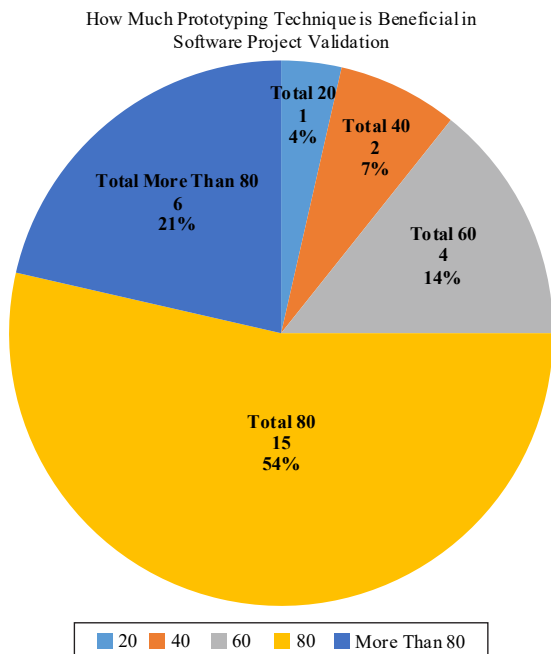


FIG. 8. RESPONSES ABOUT IMPACT OF PROTOTYPING TECHNIQUE IN TERM OF VALIDATION

What are the Successful Ration of Software Projects by Using Prototyping Technique Than Other Techniques

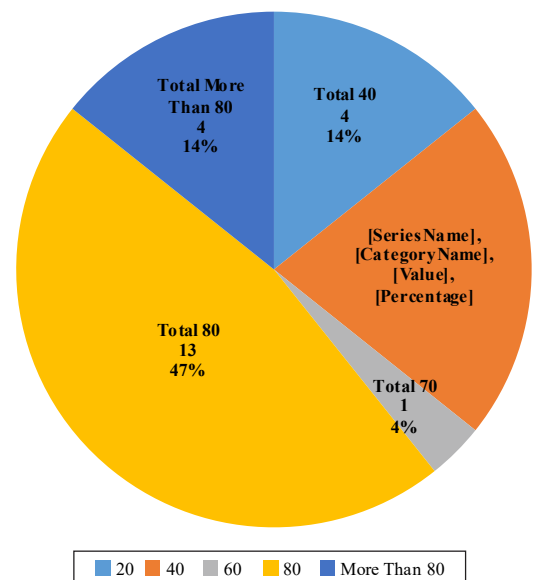


FIG. 10. RESPONSES ABOUT SUCCESS RATE PROTOTYPING TECHNIQUE THAN OTHER TECHNIQUES

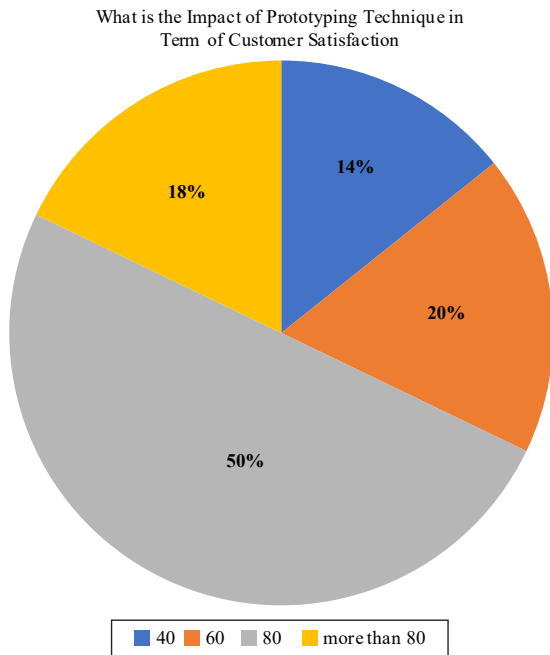


FIG. 11. RESPONSES ABOUT CUSTOMER SATISFACTION

4. CONCLUSION

Impact of Prototyping Technique in Term of Schedule:

First of all, we will discuss the impact of prototyping technique of requirements elicitation on the quality of software product in terms of schedule.

It is observed during literature survey that prototyping technique saved time of developer team if it is used properly. If prototyping technique is used in right way the requirements come in refine form then obviously the actual requirements for system proposed is easily understandable by developer team. The ambiguity is removed through revision of requirements by using version of prototyping technique and convert needs of customer into actual requirements. Prototyping technique is an iterative process and needs of customer and end user are converted into real needs in term of proposed system through iterative versions of this technique. Hence it is proved from literature that prototyping technique is very beneficial technique of requirements elicitation in terms of time saving technique for developer team.

Impact of Prototyping Technique in Terms of Customer Satisfaction:

It is studied that prototyping technique is very good technique to get high level satisfaction of customer and end user. It is observed through questionnaire responses that almost all software companies in Pakistan agreed that customers are well satisfied from their projects, whenever companies used prototyping technique for requirements elicitation. It is also considered and point out from literature that all stakeholders take part in requirement elicitation process as active members to satisfy their needs. During first version of prototyping technique the early feedback of stakeholders are observed and noted for further enhancement of proposed system. In the next version and so on of prototyping technique the deficiencies which are observed during previous version of prototyping technique are removed and more opinions of stakeholders are kept in observation for further improvements of system development to build a quality software product at the end. It showed that in prototyping technique the involvement of all stakeholders are essential, and importance is given to the suggestions and opinions of all stakeholders during requirements elicitation process so they feel more comfortable during requirements session. Hence it is proved that prototyping technique is high level customer satisfaction technique.

Impact Prototyping Technique in Terms of Software Project Success in Pakistani Industry:

It is observed through questionnaire responses that almost all software companies in Pakistan used prototyping technique for requirements elicitation and all organizations accepted that it is very beneficial technique in terms of schedule and customer satisfaction. It is also detected and observed that most of the software companies believed that prototyping technique is plays an important role in the software validation, verification and project success that is almost 80% software companies accepted it.

It is also observed from responses that some software companies used prototyping technique at initial stage of requirements gathering for requirements analysis, some at the middle stage of requirements gathering and some at the final stage of requirements gathering to evaluate the requirements. Hence it can be concluded that no one used prototyping at a complete sense that is almost all software companies used prototyping technique as partial technique for requirements analysis. If prototyping technique is used in complete form for requirements elicitation that is for initial requirements to final requirements, then software industry can get high satisfaction of customer and end user; and can produce a successful software product at the end.

Limitation of Study: Currently the research work is focused in Pakistan software industry. This research can be passed onwards by exploring and examining foreign countries. So, by this way it will occupy more sample space and adds to validity of results.

5. FUTURE WORK

Independently Dealing Project and Product Based Software Companies: It is observed in this research that all software development companies are not same. The variation is due to project and product-based development. It is studied that both project and product-based development software companies have separate and distinct problems and observations. Hence it may be a good future work of research to study the impact of this technique (Prototyping) separately in both domains.

Searching Direction of more techniques may be a good future work of research to study the impact of other

techniques of requirements elicitation in Pakistan and explore further techniques and make comparison among those techniques in term of preferred technique by Pakistani software industry.

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