



Software Quality Assurance Trend and Practices: A case study of Software Industry in Pakistan.

Muhammad Zainuddin, Shah Muhammad Emad Uddin, Abdul Hafeez Adam, and Muhammad Ahsan

IBA - Karachi, Karachi Institute of Economics and Technology, Usman Institute of Technology, and Karachi Institute of Economics and Technology.

zuddin@iba.edu.pk, emad@kiet.edu.pk, ahadam@uit.edu, and ahsan.worldwide@gmail.com.

Abstract: Rise of the digital era, technology, and easy business setup, these factors provide all required elements to give a boost to the Pakistan software industry. As 65% population consists of youngsters in Pakistan and millions of students rush to set up a business right after their academic completion every year, software firms have become the easiest way to gain the tag of entrepreneur and CEO. However, the software houses have now given the sense of mushrooms in a jungle, very few of them are able to fulfill the quality standard and the major chunk of them just grow in the season. That became the major reason for most of the software houses getting out from the software industry as rapidly as they enter the market. This large evacuation from the software industry gives a wake-up call to existing software houses working right now to give a solid look towards the quality standard of their software products. To get an understanding of the major key of success that helps the software houses to gain the sustainability in Pakistan software industry we conduct a survey from existing software houses of different kinds from successful firm to struggling firm, in order to have a thoughtful culmination of our research.

Keywords: Software Engineering, Quality Assurance, Software Engineering Practices, Software Engineering Trends.

I. INTRODUCTION

Software Development is considered one of the best businesses in the world and in Pakistan where a populace of around 220 million and thousands of graduates in every 6 months with the level of programming building, this market is rapidly extending here as well but the absence of information likewise give a noteworthy downside to this market due to numerous software houses dispatches but many shut down as well to resolve this measure issue Software houses need to adopt a significant way that it becomes meaningful and attractive to their customers. One of the best approaches to achieve this differentiation is Quality [1]. As we all know Quality is one of the major factors in any business especially in software development as competition is very tough in the market so as an organization you can't afford to have errors or didn't meet the customer expectation after deployment because after deployment, every problem will cost you very high and it's also not good for a company reputation [2] so you must have the best practices of software engineering processes and procedures which is known as Software Quality Assurance. SQA define practices such as reviews, inspection, and audit in the early phases of software life cycle which minimizes the chances of errors, lack of resources or wastage of resources and chances of not meeting customer's needs.

To follow SQA it's required to follow a particular standard. Some famous standards to achieve software quality is ISO 9000 series and Capability maturity model integration therefore we decided to do a research survey which provides

best practices of SQA followed by Different types of Pakistan's Software houses and integrate them with respect to the type of which software houses belong so, in the end, we conclude best practices for SQA in different types of Pakistan's software industry. To start this research we divide Pakistan software houses into 4 types,

A. CMMI Certified.

"Capability Maturity Model Integration (CMMI) is an integrated model of several Capability Maturity Models that comprise of top process practices" [3]. It describes the principal and practices underlying software process maturity which helps an organization to improve the maturity of their software processes through an evolutionary process. It may also be used to identify the strengths and weaknesses of software suppliers from an organization's customer point of view [4]. CMMI has five levels each level is associated with sets of key process areas that each software house should emphasize to improve their CMM levels. These five stages are listed below:

- a. Initial
- b. Managed
- c. Defined
- d. Quantitatively Managed
- e. Optimizing.

B. ISO Certified

The International Organization of Standards (ISO) are a guideline that determines the quality framework of requirements which helps to clearly show the existence of

evidence supplier's capability to design and supply a product [4]. This Standard is specified in series of 9000 used by the organization to make sure that the supplier complies with rules on the specific requirements during several stages of development, which includes different phases: design, development, production, installation, and servicing [4]. ISO 9000 standard is used to ensure the Suppliers' quality of the system and it can be used to register third part's quality systems [4]. The scope of an organization of these standards is ensured by a certificate issued by quality-system registrars.

C. Uncertified

In this particular category, we have targeted those software houses that are not certified with any international standards still surviving in this industry for more than a year or two. Many software houses in Pakistan is part of this category so in this we mention how this type of software houses are maintaining their software quality and how they can improve their standards which help existing software houses as well as new software houses to what to follow if you exist in this category also provide suggestions of how you can improve your standards and achieve international standards [5].

D. Startups

In this category, we have put newly developed software houses that are new in the market or having experience of less than a year in this we have asked their experience related to SQA [6] that how they manage to ensure quality with a very small team and mostly inexperienced and with cumulative results give best practices and steps for a newly build software house to ensure the quality of their products which meets customer requirement as it's one of the major parts of a new software house which leads them to succeed in this huge market.

II. LITERATURE REVIEW

The use of software standards is to ensure consistency and uniformity in the whole project. One has to be remarkably good in delivering projects and in their quality of work in this software industry; else they won't be able to survive. Many software projects exceed their planned/committed timelines due to poor project management.

Critical reason also includes unrealistic deadlines, lack of specialists who are subject matter experts and lack of following of standards [7].

There are many software standards and practices which were created to be followed to ensure a better software product is made. But these standards or practices are not suitable for every software house or company. So many organizations build their own S.O.P. to be followed [8].

In many organizations, standard procedures are not followed due to peer pressure or out of respect for their seniors, as Pakistan is a conservative society, so this is a major reason why S.O.P is not followed [9]. Carried out a survey which compared experienced organizations with less experienced ones which says that both don't have much difference with respect to a few critical factors of QA such as

trained staff, investment in tools [1]. There is a notable difference with respect to the quality of work between software made for internal use or external use by software development organizations. [10] According to Pressmen's recommendation, 40% of the effort is to be made in software analysis and design for development of software project, however, a very small number of respondents in the survey were following this recommendation [11][12].

Organizations or software houses are not properly following software engineering models like Scrum, XP, or Waterfall. They don't follow the software development and design practices consistently which creates discrepancies and results in failures [13].

Startups work at a very high level of risk. Their design and development are in an ad-hoc manner and they mostly use agile methodology. Startups' main focus is to sell their idea to attract more and more funding so their core focus is not on the actual software. The use of flexible frameworks helps in designing the software easy and time-saving [14].

Pakistan software industry is slow in the adaptation of CMM biggest reason is the lack of awareness in our management teams of software organizations. A small company may rely on a few good and hardworking employees but as the size of the company grows it needs an established, foreseeable process to follow to ensure success [9].

To ensure survival small companies have to focus on customers, so customer satisfaction is the number one priority. Few interviews were taken which showed that employees were aware of standard procedures but didn't follow them due to a shortage of time and resources [15] [16].

In small company's productivity, efficiency and competitiveness is the key to excel in their sales. A small study analyzed two projects which followed scrum and TSPI. This experiment showcased that when the scrum is used productivity can be improved without compromise of quality and efficiency in the final product [17].

Every now and then people argue small projects don't require planning or project management, but few researchers carried out a research and proposed that if the project is successful it will need scaling and it won't be possible to scale it if it hasn't followed proper techniques [18].

Software developed by startup companies is basically product-oriented. Their main focus is on the product and its features. The quality of the software is neglected in the first period to gain results quickly. The software is not designed in a way that could be scalable and the quality deteriorates as time flies by. So they have to rework in order to improve or maintain the quality of software over and over again [19].

CMMI has a more focus on management rather than on development and it is expensive to use so it is not recommended for small companies. Boeing international implemented CMMI and saw a 31% reduction in average cost, 50% reduction in delivery time, and 60% decrease in few other processes. Lockheed Martin another giant started using CMMI and saw some eye-opening changes. 30% rise in productivity, 15 % reduction in the cost of SQA and dev. for defects, and 20% reduction in software cost [20].

Software quality models provide ways to handle problems by providing a methodical tactic. They provide ways to monitor and measure the quality of the product. So this way a product can be accessed and improved. Practically there is a gap between the abstract quality characteristics described in quality models like ISO/IEC 25010 [21] and concrete measurements and assessments [7, 1]. Models are used to characterize the software quality but practically most of them can't be applied to real-world projects. Measurements lack linking to a higher level quality vision of the product [22].

III. METHODOLOGY

The key idea behind our research work is to properly identify the software quality assurance procedures and methods done by different software houses. We then analyzed these difficulties and thought of the accepted procedures to manage the Quality Control and Quality Confirmation of the software and accomplish the most ideal outcomes to deal with challenges faced by the software houses in developing countries.

We began our research work by designing a questionnaire containing question-related to software quality assurance procedures followed in different organizations to test the error-free product. To meet every individual person is quite a difficult job so that's why we make an online questionnaire survey, created on Google Doc for IT experts and representatives who worked in different organizations of Pakistan which conducted online. The survey was comprised of various questions on how SQA has done in their firm, what are the standards they use, and the major issues faced by them when working on a project. The objective of conducting the survey via an online questionnaire was to gather facts and figures about the cause of the major SQA problems and challenges faced in this process of Quality Assurance. We came up with the most ideal approaches to handles these difficulties and how they can stay away from them.

All the participants of this survey are currently working in their respective software houses and most of them are working for more than one year as CEO, Team Lead, Requirement Analyst, Developer, and Project Manager because we are targeting people from different software houses our aim is to collect at least 50 responses from different software houses to get sufficient data to analyze and define a process in conclusion.

IV. RESULTS AND FINDINGS

According to our online survey conducted we have the following findings. Table 1 shows the categories of software houses as per their certified processes.

Table 1: Categories and Experience of Software Houses

Category	Percentage of Software Houses	Years in Market
CMMI Certified	8.3%	10+
ISO Certified	41.7%	5-10
Uncertified	16.7%	2-5

Start ups	33.3%	<2
-----------	-------	----

As shown in Table 1; about 62% of software houses are providing software as services and others are providing the solutions related to Management Systems, Embedded System, and Web Portals project.

Table 2: Use of Project Management Tools

Project Management Tools	Usage
PERT	6.8%
GANTT Chart	2.3%
Jira	18.2%
WBS	4.5%
Agile	61.4%
Basecamp	2.3%
Gantt and Agile	2.3%

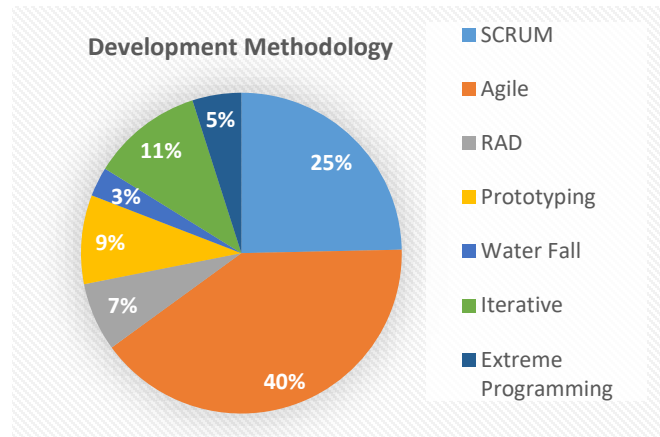


Figure 1: Development Methodology

As per Figure 1 most of the organization are using agile as their development methodology which is around 38% and around 17 are using Iterative approach & SCRUM, other are using Prototyping, RAD, Extreme Programming.

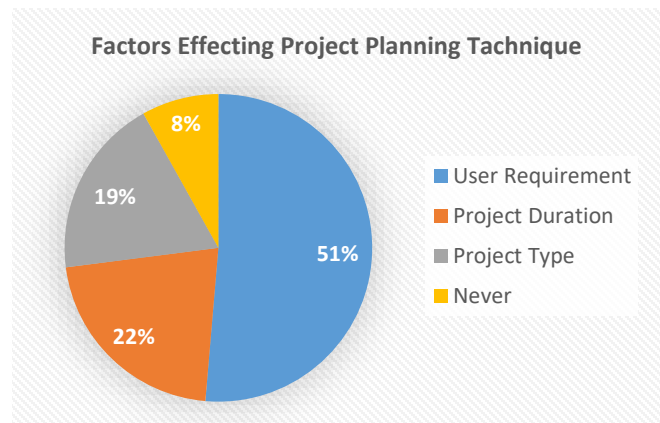


Figure 2: Factors Effecting Project Planning Technique

As per Figure 2, about 51% of the respondents conclude that User Requirement leads the change in Development Methodology

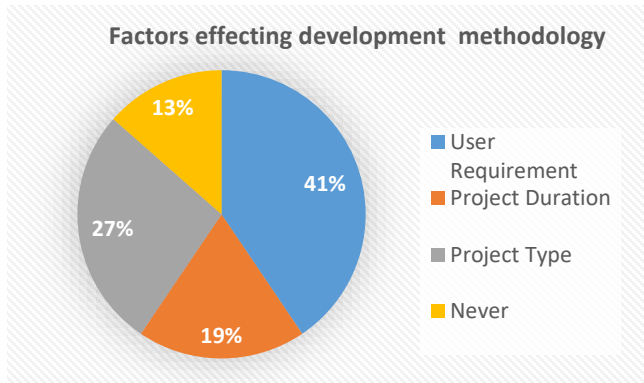


Figure 3: Factors effecting development methodology

As per Figure 3; about 41% of the respondents conclude that User Requirement leads the change in development methodology.

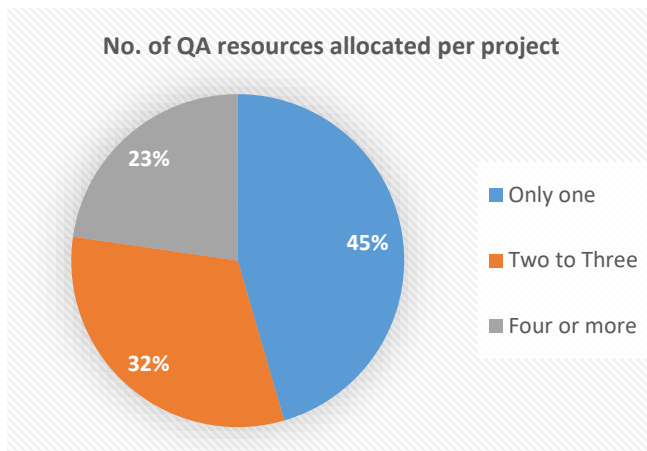


Figure 4: Allocation of QA resources per project

As per Figure 4, 45% of the organization has just only one SQA person to cope with the Quality of software's

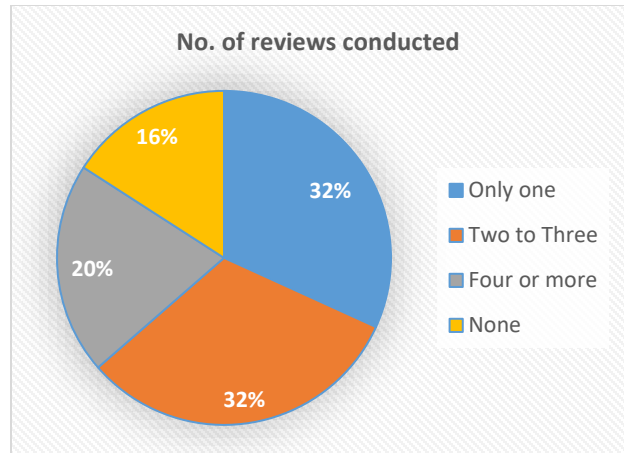


Figure 5: Reviews Conducted

According to Figure 5 most of the organization conducts only two reviews of the software to maintain the quality.

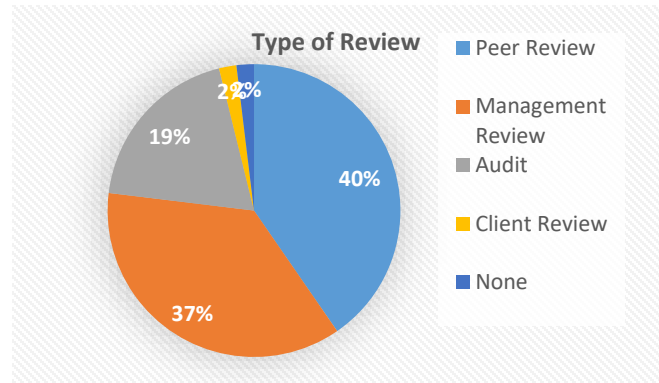


Figure 6: Review Type

According to Figure 6 most organization conduct peer reviews and Management reviews.

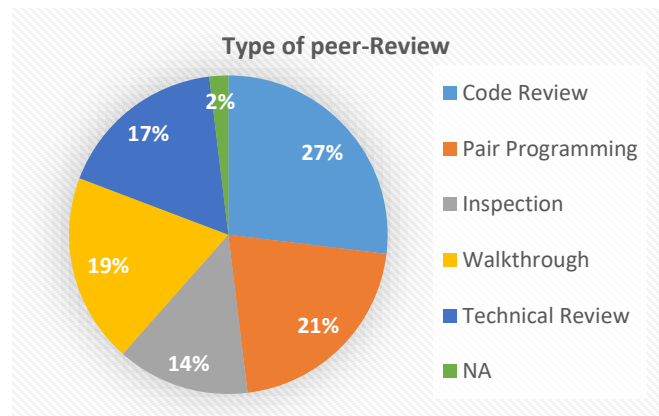


Figure 7: Peer Review Type

According to figure 7 most organization which perform peer review generally conduct code review and pair programming.

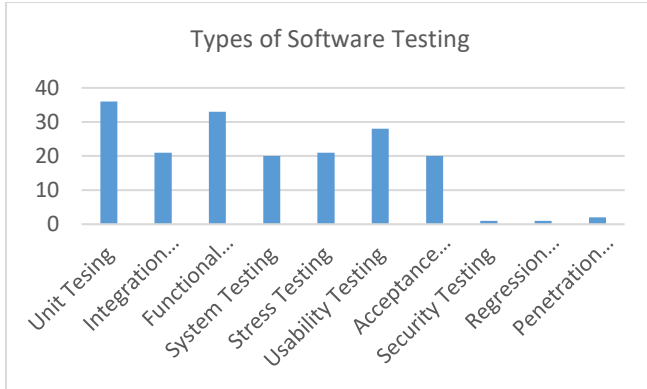


Figure 8: Types of Software Testing Performed

According to Figure 8 mostly organization perform unit testing, functional testing and usability testing.

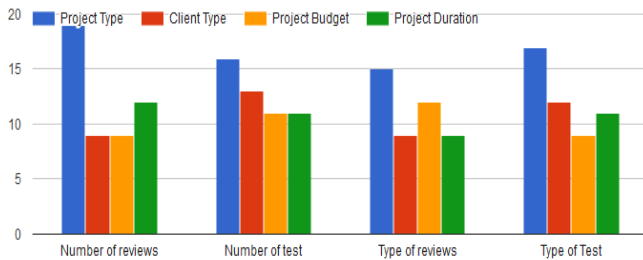


Figure 9: Factors to decide No. of Test and Type of Reviews

According to Figure 9 mostly organization decide number of reviews, Number of test, Type of Reviews and Type of Test on the basis of project Type

Questions	Participant Response	
	Yes	No
Specified post for Software Quality Analyst.	45.5%	54.5%
Particular format of documentation.	61.4%	38.6%
Use of automation testing techniques for testing	52.3%	47.7%
Separate environments for testing, development and production	63.6%	36.4%
Continuous integration techniques.	66.7%	33.3%
Use of source code repository systems.	81.8%	18.2%
Difference in quality of work while developing/testing software made for internal use versus external use	57.6%	42.4%
Use of Project Management tools	66.7%	33.3%

V. ANALYSIS AND DISCUSSION

A In this part of our research paper we have discussed the most important outcomes from our survey and from previously done work and on that basis we have pointed out some best practices for different types of software houses in Pakistan.

A. A pre define project planning technique should be chosen to ensure quality.

One of the major parts of project Quality depends on what type of project planning technique you chooses if you have a CMMI and ISO certification you can choose any development methodology on the basis of your experience but if you belong to the start-up and the uncertified category it is suggested to choose Agile methodology as Agile methodology provide you customer satisfaction by urgent delivery of their product or you might change your common practice in case the user require and project Duration ask you to do so.

B. Reserved People For Quality Assurance

As we all know in this era of rapid technologies changes and competitive environment Quality Assurance has become a major part of software development so according to our survey if you belong to ISO or CMMI Certification you must have at least four people assign for quality assurance as you have to maintain your standards according to your certification but in case of Startup and uncertified software houses it is suggested to reserve attest one or two person for that purpose depend on your team size also if you have a large in either of the categories it is suggested to allocate a post for Software Quality Analyst.

C. A specific ammount of reviews for better outcome

To assure Quality one of the best practices is to take Reviews and according to our survey it's suggested to take a predefined amount of reviews depends on project type and Project Duration according to our Survey We suggest at least four to five reviews if your organization is Certified from ISO and CMMI and for other two categories it's suggested to take at least two to three reviews depends on client and project

The type of reviews also matter in software Quality in that case we suggested on the basis of our survey to perform Peer Reviews as it provide Code Reviews which almost every type of organization wants to verify and Pair programming as many organization sues agile as their methodology it's suggested performing pair programming to verify each and every attribute.

D. Multiple Testing to assure Product Quality in any enviroment

To ensure quality another major task is testing as we all know Testing makes perfect but in Software Development Testing assure working as a Software is ensure to work in every environment it's suggested to perform different Types of testing which also conclude from our survey that, If you are ISO and CMMI certified you must perform at least four top five different types of testing but in the case of Uncertified and Startup it's suggested to perform at least two to three different types of testing depend on the size of your team and the type of the projects.

E. Automation Testing Techniques must acquire

As Technology Evolves you must have to evolve with the Technology that theory totally implies on software development with the rapid change in technology there are multiple software also made for automation Testing which according to our survey mostly well-known organizations have adopted and it's also very useful full as it saves a lot of human effort and time so it's suggested that in whatever category your software house belong you must use automated testing tools to ensure quality and save a lot of time and money.

F. A separate Enviroment Must be Chosen for Development, and Testing.

As we already discussed that software is meant to perform in every environment and to ensure that possibility it's recommended from our survey to choose a separate Environment for Testing and Development which will assure you that your software will work in any environment with the required specification, it's also seen from our survey that mostly well-known organization uses this methodology to ensure the quality of their product.

G. Every testing and Reviews must be Documented in Specific pattern

A specific format of documentation must be acquired by an organization as it will make sure that everything is done as required in a particular manner mostly new organizations lack in this category but from our survey, it's seen that much well-known organization use this practice which ensures their product Quality so we conclude on that factor that documentation is one of the best practices for quality assurance and by using a standard for your documentation it will help any person to understand your work.

VI. CONCLUSION

Software Quality Assurance is one of the major factors of today's modern software houses and mostly software houses consume a lot of money for this factor so this research paper will be helpful for every type of software houses running in the premises of Pakistan to Acquire these Types of best practices to ensure their quality as well as their progress as we suggested element to with comparison of ISO and CMMI certified well known software houses with startups and uncertified software houses which are running in the market for more than 3 years without any certification. In the future, we also recommend conducting Interviews with these types of organizations to get the best Techniques and ways of Assuring Quality.

REFERENCES

[1] Iftikhar, Asim, and Sheikh Muhammad Ali. "Software quality assurance a study based on Pakistan's software industry." *Pakistan Journal of Engineering, Technology & Science* 1.2 (2015).

[2] Javed, Ali, et al. "How to improve software quality assurance in developing countries." *Advanced Computing* 3.2 (2012): 17.

[3] Yoo, Chanwoo, et al. "A unified model for the implementation of both ISO 9001: 2000 and CMMI by ISO-certified organizations." *Journal of Systems and Software* 79.7 (2006): 954-961.

[4] Paulk, Mark C. "How ISO 9001 compares with the CMM." *IEEE software* 12.1 (1995): 74-83.

[5] Hassan, Syed Zahoor. "Software industry evolution in a developing country: An in depth study." *Proceedings of the 33rd annual Hawaii international conference on system sciences*. IEEE, 2000.

[6] Farooqui, Sumeen, and Waqas Mahmood. "A survey of Pakistan's SQA Paractices: a Comparative Study." *29th International Business Information Management Association Conference*, Vienna, Austria. 2017.

[7] Kautz, Karlheinz. "Software process improvement in very small enterprises: does it pay off?." *Software Process: Improvement and Practice* 4.4 (1998): 209-226.

[8] Imam, Asad, Shakeel Ahmed Khoja, and Imranulla Shariff. "Improving Software Quality: a benchmarking approach." (2007).

[9] Manzoor, Kashif. "The Challenge of Implementing Capability Maturity Model (CMM) in Pakistan." (2001).

[10] Javed, Ali, et al. "How to improve software quality assurance in developing countries." *Advanced Computing* 3.2 (2012): 17.

[11] Baharom, Fauziah, Aziz Deraman, and Abdul Razak Hamdan. "A survey on the current practices of software development process in Malaysia." *Journal of Information and Communication Technology* 4 (2005): 57-76.

[12] Bhutto, Arifa, et al. "Formal Approach for UML Components based Development Profile." *University of Sindh Journal of Information and Communication Technology* 2.2 (2018): 125-129.

[13] Kirk, Diana, and Ewan Tempero. "Software development practices in New Zealand." *2012 19th Asia-Pacific Software Engineering Conference*. Vol. 1. IEEE, 2012.

[14] Giardino, Carmine, et al. "What do we know about software development in startups?." *IEEE software* 31.5 (2014): 28-32.

[15] Sánchez-Gordón, Mary-Luz, and Rory V. O'Connor. "Understanding the gap between software process practices and actual practice in very small companies." *Software Quality Journal* 24.3 (2016): 549-570.

[16] Caballero, Edgar, Jose A. Calvo-Manzano, and Tomás San Feliu. "Introducing scrum in a very small enterprise: A productivity and quality analysis." *European Conference on Software Process Improvement*. Springer, Berlin, Heidelberg, 2011.

[17] Ibrahim, Muhammad. "Trends and Challenges in Requirement Analysis for; Modern Web Applications, Web Services, and Web of Things." *University of Sindh Journal of Information and Communication Technology* 3.1 (2019): 55-63.

[18] Richardson, Ita, and Christiane Gresse Von Wangenheim. "Guest editors' introduction: Why are small software organizations different?." *IEEE software* 24.1 (2007): 18-22.

[19] Giardino, Carmine, et al. "Software development in startup companies: the greenfield startup model." *IEEE Transactions on Software Engineering* 42.6 (2015): 585-604.

[20] Omran, Ahmed. "AGILE CMMI from SMEs perspective." *2008 3rd International Conference on Information and Communication Technologies: From Theory to Applications*. IEEE, 2008.

[21] Hussain, Azham, and Emmanuel OC Mkpojiogu. "An application of the ISO/IEC 25010 standard in the quality-in use assessment of an online health awareness system." *Jurnal Teknologi* 77.5 (2015): 9-13.

[22] Wagner, Stefan, et al. "Operationalised product quality models and assessment: The Quamoco approach." *Information and Software Technology* 62 (2015): 101-123.