Software Requirements Engineer: An Empirical Study about Non-Technical Skills

Faheem Ahmed

Faculty of Information Technology, United Arab Emirates University, Al Ain, UAE
f.ahmed@uaeu.ac.ae

Abstract— Over a period of time software industry has seen a steady growth and the main reason for this growth is increase in the supply and demand of software. In software industry people are hired from different parts of the world having technical and non-technical skills. However, non-technical skills which are equally given importance while hiring a new employee are relatively given little attention by researchers from software engineering community. The main objective of this work is twofold; firstly we provide comprehensive empirical evidence about up to what extent software industry is considering different non-technical skills while hiring a new employee as software requirements engineer. Secondly, we also target to find out whether employers' non-technical skills requirements, as advertised in job postings, in case of software requirements engineering profession are similar across different cultures. We used a dataset of 250 jobs descriptions from four different regions of the world in this study. The broader conclusion of this study shows that there is an explicit requirement of having communication skills in a software requirements engineer. While some other non-technical skills such as analytical and problem solving, interpersonal skills, ability to work independently, and team player have also been given some moderate consideration. Whereas, organizational skills, open and adaptable to changes, innovative, and fast learner skills are given least priority. On the regional side although Australian, Asian and European cultures exhibits more similarity than North American culture on the choice of non-technical skills requirements in hiring new employee in case of software requirements engineering profession but generally we concluded that cultural difference does not have a major impact on this decision.
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Index Terms—Human Factor, Non-Technical Skills, Software Engineering, Empirical Software Engineering.

I. INTRODUCTION

The phenomenon of global software development (GSD) has been receiving increasing attention by software industry due to apparent and observed cost benefits. The term global software industry has broad meaning such as across the world software development which means having development sites at various parts of the world as well as employing people from various parts of the world to carry out software development activities. According to Herbsleb & Mockus [1] GSD involves the development of application software through interactions of people, organizations, and technology across nations with different backgrounds, languages, and working styles. The global software industry hires people from different part of the world having different technical and non-technical skills. One of the form of global software development is outsourcing which is receiving considerable interest in the recent past from North American and European companies in particular because of the reduce development cost. Outsourcing can be within same country or beyond borders but essentially involve third party to perform software development for the customer organization. Software as a profession is a team effort and the composition of the team may have different cultural combinations and further more in case of outsourcing different cultural entities interact with each other. Ebert and De Neve [2] reports that in case of GSD, engineers with all types of cultural backgrounds actively participate to continuously improve the product, innovate new products, and make processes more effective. It is equally important to study the technical and non-technical skills requirements of software development teams.

In the profession of software engineering, the job descriptions (either placed on or off-line) normally divide required skills into two broad categories of "technical skills" and "non-technical skills". It is similar to the other professions as well. Technical skills refer to the technical knowledge and abilities that an individual should have to carry out the tasks associated with the position. For example in case of software designer, it may be required that candidate must have knowledge of object oriented design methodology and familiar with a tool such as Unified Modeling Language. On the other hand non-technical skills have their roots in psychology, human behavior, sociology, and pertain to a broader range of characteristics involving personality types, social interaction abilities, communication, and personal habits. These skills are essential because it shows the way people think, perceive, and react in the working environment. In the collaborative environment of software development the possession and use of non-technical skills also enhances the likelihood of individual's success and contributes positively towards the common goal of the project. Figure 1 illustrates a partial snap shot of an online job description example of software requirements engineer. The advertisement clearly narrates two types of skills. The underlined are non-technical skills such as analytical and problem solving and communication.

Figure 1: Sample online Job Description

A. Research Motivations & Contributions

Software engineering has been an attractive profession for the younger generation since the recent past and many universities across the world are producing high quality engineers to join this profession. The increased demand and supply of software as well GSD require software industry in a country to hire people from different parts of the world having different cultures and norms. It is common to believe that when people interact the complexity of work relationship has an impact on their productivity. It further complicates the problem when people from different cultural background, believes, norms and societies interact. Although the topic has an immense impact on the productivity of the software development process but little attention has been paid on it from software engineering research community. The absence of studies concerning non-technical skills and software engineering in general highlights the initial motivation of this work. The objective of this study is to provide up-to-date information about which non-technical skills are in high demand in the software industry for a software

requirements engineering profession and which skills are neglected by the software industry despite their importance. More specifically, no concrete work has been reported in the area of non-technical skills and their demand as a part of job requirement sets in diverse cultures. Keeping in view the increasing shift in outsourcing and virtual team development it is worth investigating up to what extent different cultures consider non-technical skills while hiring a new employee. The other contribution of this work is to provide an opportunity to empirical understand and investigate non-technical job requirements in the diverse cultures for the profession of requirements engineering which is one of the leading phase in software development.

B. Study Research Question

A fundamental motivation of this study is to find out the answers of the following research questions from the perspective of the software industry:

Research Question-I (RQ-I): Up to what extent does the software industry consider non-technical skills when hiring a software requirements engineer?

Research Question-II (RQ-II): Are employers' non-technical skills requirements, as advertised in the job postings of software requirements engineer similar across different cultures of the world?

In this study we consider nine non-technical skills which include communication skills, interpersonal skills, analytical and problem solving skills, team player, organizational skills, fast learner, ability to work independently, innovative and open and adaptable to changes. We found these nine non-technical skills most commonly used in the description of job advertisements and in the literature survey, which highlights the reason for their inclusion in this study.

II. LITERATURE SURVEY

In the industry many synonymous for non-technical skills are used such as "soft skills", "emotional intelligence", people skills" etc. Soft skills refer to the cluster of personality traits and attitudes that drives one's behavior [3]. In literature [4][5][6][7] some classical sets of non-technical skills are mentioned as active listening, negotiating, conflict resolution, problem solving, critical thinking, ethics, and leadership skills. It is also arguable but largely acceptable that soft skills complement the technical skills of a job [8]. According to Goleman [9] the possession and use of soft skills contributes more to an individual's ultimate success or failure than technical skills or intelligence. Cappel [10] concluded that non-technical skills such as oral and written communication, problem solving, and the ability to learn apply to virtually all information systems jobs. In a classical sense software is developed by people, used by people, and supports people's work. Therefore it is equally important to understand the characteristics and personality traits of people involved in software development, but little attention has been paid to these aspects [11]. DeSouza et al. [12] observed that human characteristics, behavior, and cooperation are central to practical software development. The success and failure stories of software development projects also highlights human factor as one of the critical dimensions. Bolton [13] reports that 80 percent of individuals, who fail at work, do not fail due to their lack of technical skills but rather because of their inability to relate well with others. McGee [14] found, for example, that 68% of CIOs said that "soft skills," i.e., skills of a non-technical nature such as communication and team building, are more important today than five years ago. Young and Lee [15], and Van Slyke [16] found that employers tend to rate non-technical skills higher than technical skills. Cappel [17] concluded that non-technical skills such as oral and written communications, problem solving, and the ability to learn apply to virtually all IS jobs. According to the survey of Green [18] the job of systems analyst considers behavioral skills such as diplomacy, politics, and sales more important, while users consider technical skills such as programming more important. Khan and Kukalis [19]

concluded that both hard and soft skills are important, but the hard skills are considered less important than soft skills. Leitheiser [20] found that people-oriented and organizational skills were more important than technical skills. Trauth *et al.* [21] examined the perceived importance of skills for information systems professional and their academic preparation. Leitheiser's [22] survey of information systems managers ranked interpersonal communication skills as most important. Wade and Parent [23] found that analysts perceive organizational skill as most important, whereas Green [24] found that behavioral skills, such as diplomacy, sales, and politics are most important. Litecky *et al.* [25] presented an overview of studies dealing with the paradox of soft skills versus technical skills in hiring.

In a global software development environment people from all across the world join hands in software development teams. The composition of team consists of people from various cultural backgrounds thus have different values, attitudes, religion, and beliefs. Outsourcing of software development process is receiving considerable interest in the recent past from North American and European companies in particular because of the reduce development cost. Hofstede [26] called culture the "software of the mind" because much like an operating system in a computer it provides us with essential code by which we make sense of the world. Samovar and Porter [27] culture is the deposit of knowledge, experience, beliefs, values, attitudes, meanings, hierarchies, religion, notions of time, roles, spatial relations, concepts of the universe, and material objects and possessions acquired by a group of people in the course of generations through individual and group striving. . Faure and Rubin [28] described culture as a set of shared and enduring meanings, values, and beliefs that characterize national, ethnic, or other groups and orient their behavior. Shore and Venkatachalam [29] elaborate the influence of national cultural factors on the approaches to parts of the systems development lifecycle. Harrison et al. [30] highlighted the need for research on the impact of national and cross-cultural issues in case of software development. The soft skills take influence from culture, for example Olson and Olson [31] mention that in the case of United States and Netherlands individualism is very high whereas in the case of China, West Africa, and Indonesia it is more collective. This means that China, West Africa, and Indonesia are more team oriented cultures. Workplace behavior is one of the critical factors in the job performance of the employee, and is effectively the balance between the technical and social (soft) aspects of a given role. The requirements of being social further has a direct or indirect relation with the underlying culture of an individual because culture describes beliefs, values, attitudes, meanings, hierarchies, religion, notions of time, roles, spatial relations, etc. importance for a personality. For example, the need to communicate effectively with internal team members or external stakeholders, language is one of the important aspects of culture because different people have different

mother tongue, the mode of communication is influenced by it.

In this study we covered nine non-technical skills which include communication skills, interpersonal skills, analytical and problem solving skills, team player, organizational skills, fast learner, ability to work independently, innovative and open and adaptable to changes. Here we provide some definitions of these non-technical skills for better understanding. Communication skills are the set of skills that enables a person to convey information so that it is received and understood [32]. The term interpersonal skill refers to the person's ability to behave in ways that increase the probability of achieving the desired outcomes. This means that it is a goal-directed behavior of individual used in face-to-face interactions in order to bring about a desired state of affairs [33]. Analytical skill is the ability to break a situation down into its component parts, recognize what needs to be done and plan a suitable course of action in a step-by-step way [34]. Problem solving skill is the ability to evaluate a situation and to identify an appropriate solution that meets the customers' needs [34]. Innovative is the ability to produce or propose imaginative and practical solutions to business problems [34]. Team player refers to an individual who is good at working closely with other people [35]. Organizational skill is the ability of an individual to assess and prioritize tasks and ensure that they are completed in a timely manner [36]. Open and adaptable to change reflects the personality of an individual to accept changes in the carrying out of tasks without showing resistance. An employee can be defined as a fast learner if they are able to adapt to new tasks, roles, or challenges effectively and with ease [37]. The ability to work independently narrates the individual's capability to operate with a reduced level of supervision in order to plan and successfully complete tasks independently [36].

III. SURVEY SETUP & DATA

This study aims at providing empirical evidence about up to what extent software industry is considering different non-technical skills while hiring a new employee as software requirements engineer. Therefore we collected data concerning nine non-technical skills and the survey consists of 250 jobs advertised across four major regions of the world i.e., North America, Europe, Australia, and Asia. In this survey study we visited some of the leading online job seeking portals such as workopolis.ca (North America), eurojobs.com (Europe), monsterindia.com (Asia), and seek.com.au (Australia). The geographical distribution of the dataset covers North America (31%), Europe (25%), Asia (24%), and Australia (20%). We visited manually each of the above mentioned online job portals to collect the data. We examined jobs advertised under the exact and related titles of "Software Requirements Engineer". The examples of related titles "Requirements Writer", "Requirements Analysts", "Business Analysts", etc.

When we visited a job page the inclusion of the job post in the study dataset was dependent on the categorical presence of at least one of the above mentioned non-technical skills in the job posting. Therefore we looked specifically for the key words which related to these non-technical skills. In some cases we found the exact match of the non-technical skills and some cases we made the selection on the basis of synonymous use of these non-technical skills. An example synonymous use of "communication skills" can be "good oral and written skills", "good presenter", "presentation skills" etc. If we did not find any match then we skipped the job and moved on the next advertisement sequentially. After searching through 250 jobs we selected 165 jobs to be included in our dataset because at least one of the non-technical skills was a part of the advertisement. We used a three point scale of "High in Demand (> 66%)", "Moderate in Demand (> 33% and ≤ 66)", and "Low in Demand (≤ 33%)" to present linguistically the requirement of non-technical skills.

A. Hypotheses & Testing Techniques

In order to empirically investigate the answers of the research questions RQ-II, we hypothesize the following:

H-1:   Employers'   non-technical   skills requirements, as advertised in job postings of requirements engineer are similar across different cultures of the world.

We used the Kendall coefficient of concordance (W) [38] and Kappa statistics [39] to assess agreement or similarity in the non-technical skills requirements as advertised in the job postings and to test the significance of the hypotheses H-1 to H4. Cohen's Kappa statistic is a popular measure for measuring the degree of similarity (or agreement) in two samples and extensions to Cohen's Kappa measure have been proposed for more than two samples [40]. Kendall's coefficient of concordance (W) is a measure of the agreement among several (p) judges who are assessing a given set of n objects and depending on the application field, the "judges" can be variables, characters, and so on [41]. The Kendall coefficient of concordance (W) is often preferred to evaluate inter-rater agreement in comparison to Cohen's Kappa [39] in case of ordinal data [38]. "W" is an index of the divergence of the actual agreement shown in the data from the possible perfect agreement. Values of Kendall's W and Kappa coefficient can range from 0 to 1, with 0 indicating perfect disagreement or dissimilarity, and 1 indicating perfect agreement [42] or similarity. Altman [43] and Fleiss [44] provided interpretation of Kappa values shown in Table-II. The result of the statistical calculations for the Kendall coefficient of concordance (W) and Kappa statistics are reported in Table-III and we used Table-I to interpret the results.

B. Descriptive Statistics & Results

In the collection of 165 software requirements engineering opportunities from North America, Europe, Asia, and Australia, the analysis shows that high demand non-technical skills include communication skills (87 %) only. There is moderate demand for analytical and problem solving (47%), interpersonal skills (48%), organizational skills (36%), ability to work independently (37%), and team player (49%). The least required non-technical skills for a software requirements engineer are and being open and adaptable to changes (30%), innovative (14%) and fast learner (16%).

Figure 2 summarizes the survey results. The analysis shows that although one of the vital non-technical skills, as communication, is in high demand. Some of the important non-technical skills such as analytical and problem solving, interpersonal skills, organizational skills, and ability to work independently, and team player are not given much attention and are in moderate demand. Whereas some of the non-technical skills such as open and adaptable to changes, fast learner and being innovative is not given any priority and are in least demand. The job of software requirements engineer requires much of interaction with the user. Therefore industry should pay attention to the interpersonal skills for this title of the software engineering job because the interaction leads to high chance of conflicts. The software requirements process generally foresee and iterative process which involves changes over the iterations after more elaboration of requirements, therefore the this iterative nature of the software requirements engineering process requires a personality having characteristics of being open and adaptable to changes and having organizational skills. The ability to work independently with minimal support is a vital skill set for software requirements engineer, although there is the moderate demand for this skill set. Still there is a need to further acknowledge this skill set by the software industry. Software development is areas where rapid changes occur, the things which are ten years old and important are now least important. Over a period of time new methodologies, process guidelines, and research requires software engineers to keep themselves up to date and should have the ability to learn fast with the changing environments. The important skill of being a fast learner is least required in the industry which needs further acknowledgement.

C. Cultural Classification

In the collection of 165 requirements engineer opportunities from North America, Europe, Asia and Australia, all four geographical regions of this study show a high demand for communication skills, including North America (92%), Europe (80%), Asia (90%) and Australia (88%). In case of interpersonal skills only North America (77%) shows a high demand whereas all other regions, Asia (35%), Europe (38%), and Australia (34%) show moderate demand. Analytical and problem solving skills is in high demand in North America (76%) and in moderate demand at Asia (55%), Australia (40%), and Europe (34%). Organizational skills are in moderate demand at North America (60%) whereas they are in low demand in Europe (31%), Australia (15%) and Asia (30%). The skill of being a fast learner is given little attention in all four geographical regions and is generally in low demand, North America (20%), Europe (5%), Australia (10%), and Asia (11%). Team player skills are in moderate demand in all the four regions, North America (48%), Europe (45%), Australia (43%), and Asia (40%). The ability to work independently skill is in moderate demand in the North American job market (48%), Asian market (38%) and Europe (39%) while the remaining region consider this as a low demand skill, Australia (30%). Innovative and creative thinking ability is in low demand in North America (15%), Europe (9%), Australia (8%), and Asia (4%). Open and adaptable to changes is only moderately in demand in the North American job market (60%) whereas the rest of the regions are not paying much attention to this skill in job requirements, Europe (16%), Australia (23%), and Asia (31%). Figure 3 summarizes the survey results. The hypothesis H-1 was tested using the Kendall coefficient of concordance (W) and Kappa statistics and the results are reported in Table-III. The hypothesis is accepted based on chi-square value of 16.84 and Kendall coefficient of concordance 0.48 (Moderate Similarity) was significant at $P < 0.05$. The Kappa statistics also further support the acceptance of hypothesis H-1 (Kappa coefficient: 0.42, Z: 8.23, $P < 0.001$) (Intermediate to Good) interpretation of Kappa presented in Table-II. Therefore, we conclude that employers' non-technical skills requirements, as advertised in job postings of software requirements engineer are substantially similar across different cultures of the world.

TABLE I: INTERPRETATION OF KAPPA VALUES

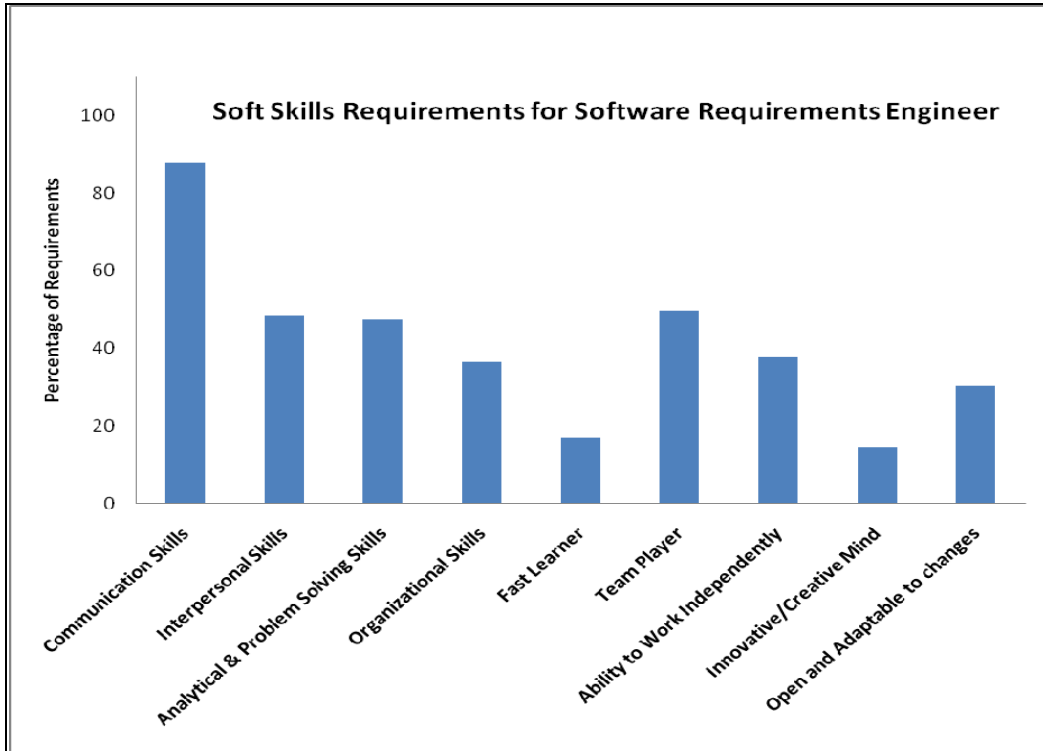| Altman Kappa Benchmark	Fleiss Kappa Benchmark
<0.20 Poor 0.21-0.40 Fair 0.41-0.60 Moderate 0.61-0.80 Good 0.81-1.00 Very Good	<0.40 Poor 0.40-0.75 Intermediate to Good >0.75 Excellent

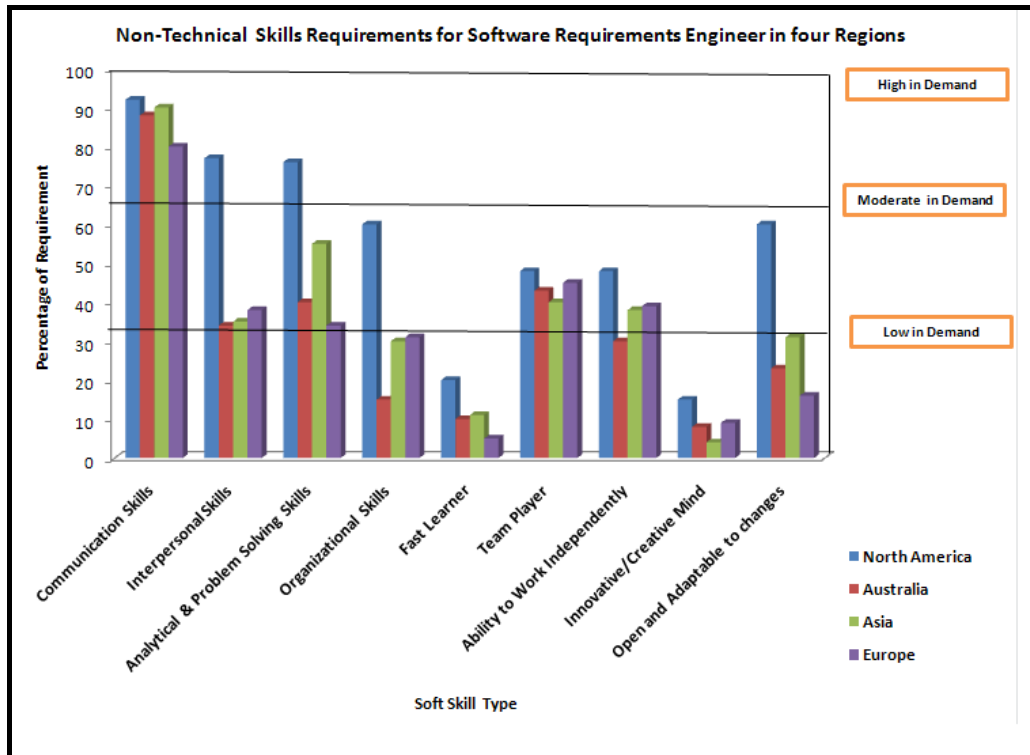Figure 2: Non-Technical Skills Requirements for Software Requirements Engineer

Figure 3: Non-Technical Skills Requirements for Software Requirements Engineer

Table II: Non-Technical Skills Requirements across Different Regions

Non-Technical Skills	North America	Australia	Asia	Europe
Communication Skills	H	H	H	H
Interpersonal Skills	H	M	M	M
Analytical & Problem Solving Skills	H	M	M	M
Organizational Skills	M	L	L	L
Fast Learner	L	L	L	L
Team Player	M	M	M	M
Ability to Work Independently	M	L	M	M
Innovative/Creative Mind	L	L	L	L
Open and Adoptable to changes	M	L	L	L

Table –III: Hypotheses Testing of Similarity

Job Role	Kendall Statistics		Kappa Statistics	
	Kendall's Coefficient Of Concordance (W)	χ^2	Kappa Coefficient	Z
Software Requirements Engineer	0.48	16.84 $P < 0.05$	0.42	8.23 $P < 0.001$

The descriptive statistics illustrates that in cases of communication skills, being a fast learner, team player and being innovative similarity in requirements of non-technical skills exist, and that the remaining five skills have varying requirements across different cultures specifically North American. The analysis shows that the North American job market considers communication, interpersonal skills, analytical and problem solving skills, to be in high demand while the ability to work independently, open and adaptable to changes, organizational skills, and team player, are in moderate demand. Whereas being fast learner, and innovative are in low demand at the North American market. The Australian job market exhibits a high demand for communication skills only, while team player, analytical and problem solving, and interpersonal skills are in moderate demand. On the other hand the remaining five non-technical skills under this survey such as ability to work independently, open and adaptable to changes, organizational skills, fast learner and innovative and creative mind are in low demand. Asian job market also weighs only communication skills in high demand whereas analytical and problem solving, team player, interpersonal skills, and ability to work independently are in moderate demand. Organizational skills, Fast learner and innovative and creative mind, and open and adaptable to changes skills are in low demand in the Asian software industry. In the case of European software industry communication skills is in high demand and interpersonal skills, analytical and problem solving skills, team player

and ability to work independently are in moderate demand. While organizational skills, fast learner and innovative and creative mind, and open and adaptable to changes, are in low demand. The analysis clearly shows that in cases of Australia, Asia and Europe, eight skills out of nine under this study are similar in requirements. Which concludes that non-technical skills requirements in cases of Australia, Europe and Asia are substantially similar, whereas in case of North America it is different. In case of North American job market only two skills are in low demand and rest of the seven skills are either in moderate or high demand, which clearly highlights a better understanding of requirements of these skills in workplace. Opposite to this only communication, interpersonal skills, analytical and problem solving skills, and team player skills are mostly in high or moderate demand in cases of Australia, Europe and Asia. The rest of the four skills are mainly in low demand in these regions.

IV. LIMITATIONS OF THE STUDY & THREATS TO EXTERNAL VALIDITY

All empirical investigations and surveys are subject to certain limitations and there are always threats to external validity. This is equally true is the case of this study. The first limitation is the selection and participating non-technical skills variables of the study. In this study we

collected data concerning nine non-technical skills which include communication skills, interpersonal skills, analytical and problem solving skills, team player, organizational skills, ability to work independently, innovative and creative mind, fast learner and open and adaptable to changes. We found these nine non-technical skills to be the most commonly used in the advertisement of the jobs and in literature. In addition to the selected nine skills there may be other non-technical skills that influence the performance of software development which have not been included in this study. Some other contributing factors to performance of software development, such as: organization size, economic, experience in software development and political conditions were not considered in this study because we chose to investigate solely the impact of non-technical skills. There are some limitations of this study related to data collection. We collected data from four regions of the world, i.e. North America, Europe, Asia, and Australia. This geographical diversity reduces the threats to external validity, however as we used only one source of data collection i.e. online job portals from each region, this may pose a potential threat to external validity. Conversely, the selection of these job portals for data collection was primarily based on the popularity of these websites amongst job seekers and employers and the volume of data posted. No specific consideration was given to the selection of timing for the data collection the choice was simply random. In this study we collected the data from online job portals and after analysis we reported the results. We did not do any further investigation, e.g. who was interviewed, what questions were asked, who got the job, etc.

V. CONCLUSION

In global software development software development teams are usually composed of members from a variety of countries and cultural backgrounds. How these individuals having varying technical and non-technical skills operate within the development team is a challenge that has been generally ignored by researchers and professionals. Non-technical skills are usually overlooked in software development because the relationship between software development and these skills is extremely complex to investigate and involve many different domains. This survey provides vital information in the form of descriptive statistics about non-technical skills requirements in four different regions of the world in the case of software requirements engineering profession. We concluded the answer of the research question (RQ-I) of this study that there is an explicit requirement of having communication skills in a software requirements engineer. While some other non-technical skills such as analytical and problem solving, interpersonal skills, ability to work independently, and team player have also been given some moderate consideration. Whereas, organizational skills, open and adaptable to changes, innovative, and fast learner skills are given least priority. We also concluded the answer of RQ-II that a substantial similarity exits in the

requirements of non-technical skills across different cultures specially in cases of European, Asian and Australian whereas some dissimilarity exits in case of North American market. Overall, since we observed substantial similarity in case of three cultures we conclude that cultural difference does not have a major impact on the choice of non-technical skills requirements in hiring new employee in the case of requirements engineer.

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