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Big-Five Personality Traits Mapped with Software Development Tasks to Find Most Productive Software Development Teams

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Abstract: ***The software development lifecycle defines a systematic way of developing good quality software to meet customer expectations about scope, time and budget. Each phase of this development lifecycle is distinct and rigorous which defines an independent body-of-knowledge within the domain of software engineering. Consequently, each phase of development lifecycle demands a different set of skills and personality traits for software engineers to cope-up their work effectiveness to improve the software development process. Hence, it is obligatory to highlight the most relevant personality traits of software engineers working for different phases of development lifecycle. In this regard, this article presents a comprehensive study in which the most relevant personality traits of software engineers have been highlighted for different tasks/phases of software development lifecycle. The big-five personality model has been used to evaluate and correlate the personality of software engineers for each phase due to its wide acceptance in the research and development community.***

Keywords: Big-Five Personality Traits, Correlating Personality Traits, Personality Traits, Personality Traits for Software Engineers, Software Development work tasks

I. INTRODUCTION

Software engineering plays a vigorous role in the development of high quality software to meet the user expectations through the systematic software development process. The systematic process of software development comprises of different activities, which should be carried-out to deliver the envisioned software product on due time, within defined limits of budgets and up to the anticipated level of quality. This systematic process of software development is traditionally known as software development life cycle and is a foundation to all software development models. This software development life cycle is normally encompassed of activities including requirement analysis, design, development, testing and maintenance as is shown in the given figure-1.

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All these activities of software development lifecycle are distinct and rigorous which propose the different work-tasks carried during contemporary software development process. In the following sub-sections, the details of each activity of SDLC are discussed by highlighting the main tasks performed in each activity.

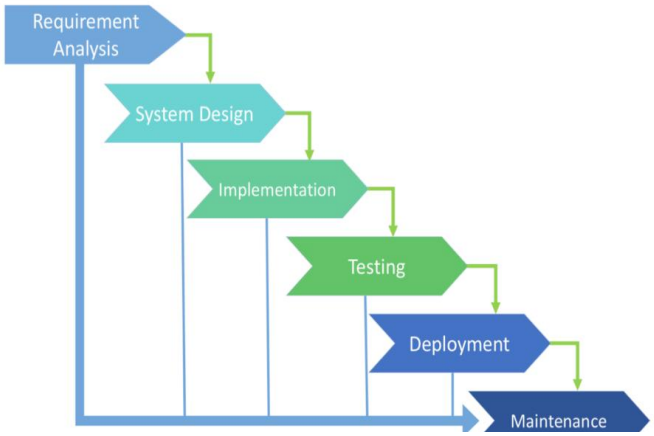

Fig-1. The Software Development Activities

A. Requirements Analysis Stage is concerned to analyze the real business-requirements of end-users and refine the project goals into achievable concrete functions and attributes of the proposed system. The analysis stage is very critical stage among all activities of software development that should be performed as much rigorously as possible to map system requirements with end-user needs. The software requirements specification (SRS) is the main document created during analysis stage.

B. System Design Stage is concerned to conceptualize the top-level system architecture and detailed module-level design using different types of schematics and pictorial notations. The system architecture and design conceptualization are envisaged in such a way that all concerning features and functions of the intended product are fully described and mapped on its static structure. The software architect is the key role who is responsible for creating the top-level architecture and detailed design of the product to meet the obligated specifications.

C. Implementation Stage is concerned with different tools, technologies and programming languages that are used to build the proposed system with its prescribed functionalities and attributes.

The developers may choose to generate the product code using code-generation tools or write the code using selected programming languages. The developers also have the choice of buying some commercial-off-the-shelf components available from third party venders and code the remaining components in-house.

D. Testing Stage is concerned to assess the functional correctness of the developed fine-grained modules as independent units. After that, the units are integrated together to make coarse-grain modules to realize the top-level system architecture along with the accomplishment of integration testing. The integration testing is performed to assess the functional correctness of whole assembly of integrated units to ratify the effects of integration process. After the completion of software testing, the product is deployed in the user specified environment to see the real image of product behavior.

E. Maintenance Stage is concerned to upgrade existing system according to the changing requirements of its end-users to smooth-line product operations and business goals. The upgradation process may include the addition of some new feature in existing system, deletion of some old feature from the existing system and modification of some existing feature in the current system.

The engineers involved in the software development activities possess individual personality traits, which could potentially affect their effectiveness to carry out their roles [1]. For example, software engineers who are extrovert are likely to perform effective requirements gathering when compared to the introvert engineers [2]. Rehman et al. (2012) highlighted that analyst with extraversion and agreeableness personality, designer with openness and agreeableness personality, programmers with extraversion, openness and agreeableness personality, testers with openness and conscientiousness personality and maintainer with openness and conscientiousness personality perform better in their works [3]. In this study, we aim to identify the suitable personality traits for different roles involved in software lifecycle activities. The main essence of this study is to map the big-five personality traits to software development lifecycle activities due to the wide spread use and recognition of this model. This study will help software industry to better compose the software development teams by selecting the team members with most appropriate personality traits according to their intended job requirements.

II. BIG-FIVE PERSONALITY TRAITS

Personality defines the characteristics of thoughts, feelings and behaviors of a person that distinguish him from other persons [4]. It can predict the reactions of a person against different stimulated actions in erratic context of time and situations [5]. The personality traits are the reflector of personality to describe human attitude towards different life matters and their interactions with working environments. There are several personality theories and classification models to categorize people according to their personalities. The big-five personality traits model is the most widely acceptable instrument used by researchers and practitioners to quantify the personality attributes of humans [3].

The big-five personality model is based on five mega traits of *openness*, conscientiousness, extraversion, agreeableness and *neuroticism* (sometimes known as OCEAN) as shown in figure-2.

Fig-2. The Big-Five Personality Traits

Consider the table-I, which shows the most prominent characteristics of big-five personality traits including openness, conscientiousness, extraversion, agreeableness and neuroticism.

III. RELATED WORK

The role of personality traits in software development remained an active area of interest for researchers since last few decades. Some studies discussed the role of personality traits on performance of software development teams and their relevancy with the team climate. For example, *Soomro et al. (2016)* presented a study in which they explored that team climate comprised of multiple relating factors in the domains of behavioral and management sciences [6]. In their study, they assess the personality of software development teams by revealing the personality traits taxonomy. *Acuña et al. (2016)* showed that there is a positive relationship between all four-climate factors and satisfaction in software development teams [12]. The teams whose members score highest for the agreeableness personality factor have the highest satisfaction levels. Some researchers have also discussed the effects of personality traits on performance of software testers and testing techniques. *Kanij et al. (2015)* presented a study in which they collected personality profiles using the big five model of more than 200 software development practitioners [9]. Their analysis indicated that software testers are higher on conscientiousness than other software development practitioners are.

Table-I: Characteristics of Big-five Traits [3, 15]

Big-Five Trait	Prominent Characteristics
Openness (O)	Curious, Imaginative, Solution-Oriented, Explorative, Creative, Intellectual, Multi-directional, Analytical, Adventurous, Unusual Ideas
Conscientiousness (C)	Organized, Responsible, Hardworking, Punctual, Practical, Serious, Businesslike, Competent, Achievement Striving, Deliberation
Extraversion (E)	Talkative, Sociable, Exhibitionist, Energetic, Adventurous, Outspoken, Loud-Voiced, Ambitious, Dominant, Enthusiastic, Outgoing, Assertive
Agreeableness (A)	Friendly, Kind, Cooperative, Unselfish, Helpful, Adoring, Sympathetic, Generous, Thoughtful, Compliance, Modesty, Tolerant, Trusting, Caring
Neuroticism (N)	Anxious, Feared, Frustrated, Tense, Depressed, Self-Conscious, Impulsive, Moody, Vulnerablele, Emotionally Unstable, Envied

Researchers discussed the software practitioners' personality traits in some studies. Yilmaz et al. (2017*)* revealed the personality traits of software practitioners with an aim to explore effective software team structures [7]. Their findings indicated that effective team structures are teams with higher emotional stability, agreeableness, extroversion, and conscientiousness personality traits. *Ribaud et al. (2015)* presented a study about the relationship between competencies, profiles and personality types in information and communication technology [8].

The competency frameworks established the definition of competences required and deployed by ICT professionals. *Barroso et al. (2016*) presented a study to evaluate the MBTI personality model applied to software developers and to understand how human personality influences professionals' work [10]. They found that personality traits significantly affect the professionals work. *Smith et al. (2016)* presented the results from a survey about beliefs, practices, and personalities of software engineers in a large software company [11], [13]. They observed no personality differences between developers and testers; managers were conscientious and more extraverted.

IV. JOB REQUIREMENTS AND RELATED MAJOR SOFT SKILLS

Capretz et al. (2010) analyzed the job descriptions for software engineers running in renowned newspapers, magazines, posted on monster.com and other job portals [14]. Rehman et al. (2012) also repeated a similar kind of job analysis in their study about big-five personality traits [3]. Both studies determined the preferable skills and related them to soft skills requirements of human personality. Afterward, they mapped the determined skills rated as desirable and highly desirable for efficiently accomplishing the tasks in each phase to Myers-Briggs Type Indicator (MBTI) dimensions. The job descriptions for software engineers demand two kinds of skills, which include hard skills and soft skills. The hard skills generally refer to the technical skills of software engineers based on their concrete knowledge of the tools, technologies and processes related to their job tasks.

While the soft skills refer to the psychological aspects such as personality traits, communication skills, social interaction abilities and personal habits that a software engineer is expected to possess along with hard skills [3, 15]. Accordingly, two studies [3, 14] investigated the relationship between job requirements (or hard skills) and the personality requirements (or soft skills) for different software development positions. The analyzed positions are related to the different software development stages including system analysts, software designers, software programmers, software testers, and software maintainers. The investigations performed in the studies [3, 14, 15] highlighted eleven major soft skills required for software development lifecycle activities including following seven top skills as shown in table-II.

Table-II: Soft Skills for Software Developers

Skill No	Skill Description
S1	Communication Skill
S2	Interpersonal Skills
S3	Analytical & Problem-Solving Skills
S4	Open and Adaptable to Changes Skills
S5	Organizational Skills
S6	Team Player Skills
S7	Ability to Work Independently Skills

In the following sub-sections, the recommended job requirements of each position of software development lifecycle have been mapped to the corresponding soft skills related to them.

A. Analysis Stage: The "system analyst" (also known as "requirements analyst" or "requirements engineer") is the designated role for performing different tasks during analysis stage of software development lifecycle. The job descriptions for post of system analyst posted by different software companies were reported in Rehman et al. [3] and Capretz & Ahmed [14]. The list of requirements for this designation is shown in table-III.

Table-III: System Analysts Job Requirements And Soft Skills Requirements [3, 14]

Job Requirements	Soft Skills Requirements						
	S1	S2	S3	S4	S5	S6	S7
Extensive liaison with internal/external clients	Y	Y					
Performs existing system analysis for user environments			Y	Y			
Client's requirements translation into project briefs	Y	Y	Y				
Identifying potential solutions suitable for current scenario			Y				
Logical and innovative solutions creation for complex problems			Y	Y			
Preparing proposals for replacement/modified systems	Y		Y	Y			
Working on projects feasibility reports	Y		Y				
Working with developers and users for acceptable system development	Y	Y					
Fully supervising the implementation of a new proposed system		Y			Y		
Planning and executing deadline-oriented development work				Y	Y		
Total Frequency	**5**	**4**	**6**	**4**	**2**	**0**	**0**

B. Design Stage: The "software designer" (also known as "software architect") is the designated role for performing different tasks during design stage of the software development lifecycle. The job descriptions posted by different software companies for post of software designer were analyzed in [3, 14]. The list of requirements for this designation is shown in table-IV.

Table-IV: Software Designer Job Requirements & Soft Skills Requirements [3, 14]

Job Requirements	Soft Skills Requirements						
	S1	S2	S3	S4	S5	S6	S7
Ability to craft storyboards, scenarios, features and interfaces	Y		Y		Y		
Evaluate alternative designs and solution ideas from co-workers	Y	Y			Y	Y	
Preparing prototypes for user experience and alternative designs ideas	Y		Y				
Guiding technical solutions by considering business domain of product	Y		Y				
Proposing architectural design for HW, SW and data available	Y		Y		Y		
Ensure that the system design meets the user expectations	Y	Y					
Formalizes system design procedures and documentation	Y		Y		Y		
Ensures the system integration by participating in system testing		Y				Y	
Determines software, hardware and network requirements of system			Y				
Total Frequency	**7**	**3**	**6**	**0**	**4**	**2**	**0**

C. Development Stage: The "software programmer" (also known as "software developer") is the designated role for performing different tasks during development stage of the software development lifecycle. The job descriptions posted by different software companies for post of software programmer were analyzed in [3, 14]. The list of requirements for this role is shown in table-V.

Table-V: Software Programmer Job Requirements And Soft Skills Requirements [3, 14]

Job Requirements	Soft Skills Requirements						
	S1	S2	S3	S4	S5	S6	S7
Contributes in development efforts and documentations	Y					Y	
Prepares detailed programming constructs for proposed system	Y		Y	Y	Y		
Prepares test scenarios/cases to test applications in development			Y	Y	Y		
Analyses specifications and builds programs accordingly	Y		Y		Y		
Coordinates team members in programming tasks and running projects	Y					Y	
Determines procedures and forms for installation and maintenance guide			Y		Y		
Translates system design flow charts into program coded machines	Y		Y		Y		Y
Selects and integrates appropriate available system programs			Y		Y		
Total Frequency	**5**	**0**	**6**	**2**	**6**	**2**	**1**

D. Testing Stage: The "software tester" is the designated role for performing different tasks during testing stage of the software development lifecycle. The job descriptions posted by different software companies for post of software tester were analyzed in [3, 14]. The list of requirements for this designation is shown in table-VI.

Table-VI: Software Tester Job Requirements & Soft Skills Requirements [3, 14]

Job Requirements	Soft Skills Requirements						
	S1	S2	S3	S4	S5	S6	S7
Finalizes test scenarios and prepares test specifications for product	Y		Y		Y		Y
Executes manual testing scenarios, evaluates results and log the results		Y	Y		Y		Y
Able to demonstrate ability to run medium to large scale test scenarios	Y		Y		Y		
Identifies bugs, fixes them and logs defects		Y	Y		Y		
Ensures that test processes and tools are applied appropriately	Y	Y	Y		Y		
Maintains databases of relevant test results	Y		Y		Y		Y
Negotiates testing budget, timelines, staffingand scope with managers	Y	Y	Y		Y		
Total Frequency	**5**	**4**	**7**	**0**	**7**	**0**	**3**

E. Maintenance Stage: The "software maintainer" (also known as "maintenance engineer") is the designated role for performing different tasks during maintenance stage of the software development lifecycle. The job descriptions for this designation are shown in table-VII [3, 14].

Table-VII: Software Maintainer Job Requirements & Soft Skills Requirements [3, 14]

Job Requirements	Soft Skills Requirements						
	S1	S2	S3	S4	S5	S6	S7
Maintains updated systems documentations to align applications				Y			Y
Assists development teams to upgrade system to meet desired quality		Y				Y	
Coordinates system users and analysts to meet business needs	Y	Y		Y	Y		
Assists teams in process improvement tasks and initiatives				Y		Y	
Supports the maintenance of user systems developed fully in-house		Y	Y				
Contributes positively in process/procedural improvements				Y	Y		
Coordinates effectively in integration and user acceptance testing	Y	Y	Y				
Open mind to consider different alternatives to solve technical problems			Y	Y			
Total Frequency	**2**	**4**	**3**	**5**	**2**	**2**	**1**

V. MAPPING OF SOFT SKILLS TO THE BIG-FIVE TRAITS

In this section, the soft skills of software engineers working for different stages of software development lifecycle have been mapped to their related personality characteristics and personality traits. For example, the soft skill *"*Communication Skill*"* stresses that a person can have good communication skills if he is talkative and sociable otherwise his communication skills would be poor [7, 15]. Hence, the "Communication Skills" is closely related with personality characteristics of being *"talkative"* and *"sociable"*. Now if we look at the table-I, which shows the prominent characteristics of each personality trait of the big-five model, we found that individuals having personality characteristics of being talkative and sociable belong to extraversion trait [7, 15]. Similarly, by considering analysis in [7, 15], the remaining required soft skills have been mapped with personality characteristics and personality traits as shown in table-VIII.

Table-VIII: Relating Soft Skills with Big-Five Traits [7, 15]

Major Soft Skills Required For SDLC Stages	Related Personality Characteristics	Related Big-Five Trait
S1: Communication Skill	Talkative, Sociable	Extraversion
S2: Interpersonal Skills	Talkative, Sociable	Extraversion
S3: Analytical & Problem-Solving Skills	Analytical, Solution Oriented	Openness
S4: Open and Adaptable to Changes	Curious, Willing to Learn	Openness
S5: Organizational Skills	Responsible, Organized	Conscientiousness
S6: Team Player	Cooperative, Helpful	Agreeableness
S7: Ability to Work Independently	Analytical, Imaginative	Openness

VI. IDENTIFYING BIG-FIVE PERSONALITY TRAITS VII. FOR SOFTWARE ENGINEERS

In order to identify the personality trait of each software engineering role, the soft skills (e.g. S1, S2, S3, S4, S5, S6 and S7) and their corresponding personality traits of each software engineering role have been placed in table-VIII in descending order from left to right as shown in table-VIII. For example, based on table-III, we found that soft skill S3 is the most needed to fulfill the job requirements, i.e. S3 = 6, S1 has the next lowest frequency of use i.e. S1 = 5, S2 & S4 has the next lowest frequencies of use i.e. S2 = S4 = 4 and S5 has the next lowest frequency of use i.e. S5 = 2.

Table-VIII: Relating Soft Skills with Big-Five Traits [7, 15]

In table-IX, the frequency distribution of soft skills for the system analyst is shown as S3 (and its related personality trait *"openness"*) on left most side of table and S5 (and its related personality trait *"conscientiousness"*) on right most side of table and vice versa. Similarly, the soft skills and their related personality traits for software designer, software programmer, software tester and software maintainer have been placed in table-VIII according to their frequency distributions of use.

Table-IX: Frequency Distribution of Soft Skills and Their Related Personality Traits

SE Role	Frequency Distribution of Soft Skills & Their Personality Traits				
System Analyst	S3=6	S1=5	S2=4, S4=4	S5=2	
	O	E	E, O	C	-
Software Designer	S1=7	S3=6	S5=4	S2=3	S6=2
	E	O	C	E	A
Software Programmer	S3=6, S5=6	S1=5	S4=2, S6=2	S2=1, S7=1	
	O, C	E	O, A	E, O	-
Software Tester	S5=7, S3=7	S1=5	S2=4	S7=3	
	C, O	E	E	O	-
Software Maintainer	S4=5	S2=4	S3=3	S6=2, S5=2	S1=1, S7=1
	O	E	O	A, C	E, O

In order to calculate the total frequency of use for each personality trait (from its relevant soft skill frequency of use) for given job requirements for each software engineering role, the frequency union has been taken to accumulate their total usage count as shown in table-X. For example, if we consider the role of system analyst, the frequency of usage of extraversion trait appears due to soft skills S1 = 5 and S2 = 4. Now if we look at table-III and take union of frequencies of use of S1 and S2, it becomes as S1US2 = 6. There are 10 job requirements/tasks concerning the system analyst as shown in table-III.

Table-X: Accumulated Frequency Based Ranking of Personality Traits

SE Role	Highest Trait			Lowest Trait
System Analyst	E (6/10)	O (6/10)	C (2/10)	-
Software Designer	E (8/9)	O (6/9)	C (4/9)	A (2/9)
Software Programmer	O (6/8)	C (6/8)	E (5/8)	A (2/8)
Software Tester	C (7/7)	O (7/7)	E (7/7)	-
Software Maintainer	O (7/8)	E (4/8)	C (2/8)	A (2/8)

The personality trait of extraversion (associated with S1 and S2) has an accumulated frequency of use in 6 out of 10 and written as E (6/10). This means that six job requirements/tasks of system analyst require Extraversion personality trait out of 10 required tasks. Similarly accumulated frequencies of use for other traits have also been calculated and appeared to be openness O (6/10) and conscientiousness C (2/10) tasks and are placed in table in descending order from left to right as shown. Similarly, the calculations have been made for the roles of software designer, software programmer, software tester and software maintainer and are shown in table-X accordingly.

If we consider the top two personality traits of software engineering roles from table-X (i.e. as depicted by grey colored columns) then it can be observed that the *Extraversion* and *Openness* personality traits are the most relevant traits for "System Analyst", *Extraversion* and *Openness* are the most relevant personality traits for "Software Designer", *Openness* and *Conscientiousness* are the most relevant personality traits for "Software Programmer", *Conscientiousness* and *Openness* are the most relevant personality traits for "Software Tester" and *Openness* and *Extraversion* are the most relevant personality traits for "Software maintainer". Figure-3 shows the data in a form of a graph.

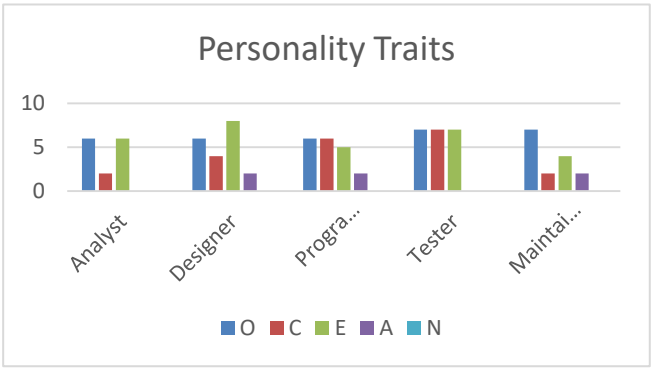

Fig-3. Graph for Frequency of Use Ranking of Personality Traits

VIII. DISCUSSION

This article identifies the relevant personality traits for different roles involved in software development lifecycle activities based on their required job tasks announced by industry during their hiring. The personality traits have been recognized by mapping job requirements/tasks on suitable soft skills required to accomplish the associated tasks and then remapping the soft skills on the appropriate personality traits by considering the characteristics of each trait. It has been observed from the findings that the roles of system analyst, software designer, software programmer, software tester and software maintainer are strongly associated with personality traits of "extraversion", "openness" and "conscientiousness" while weakly associated with personality trait of "agreeableness". It has also been observed that personality characteristics related to the Neuroticism did not appear in any of the SE roles. This is because personality characteristic related to Neuroticism did not appear in any of the soft skills or advertised job requirements, despite their importance. The findings of this investigation are closely matched with the findings in [3, 15] except the arguments about personality trait agreeableness. The authors in [3, 15] suggested that agreeableness is closely related with roles of software development lifecycle activities. This variation might be occurred because this article has considered all major job tasks associated with each role and predicted the personality trait based on the usage frequency of each trait in their tasks.

In contrast, the studies [3, 15] have predicted the personality trait by considering the few selected job tasks for each role and finding the appropriate personality trait without looking at their usage frequency. In terms of implication for research, further empirical studies are needed to confirm the findings of this study.

IX. CONCLUSION

The software development lifecycle defines a systematic way to develop good quality software to meet customer expectations within the defined boundaries of project constraints. The different stages of this lifecycle require different kind of tasks and hence require a different set of hard and soft skills. The soft skills of software engineers are inheritably dependent on their personality traits and play a vital role to fulfill specific tasks of different stages of development lifecycle. This article examined the personality traits of software engineers by correlating them with their soft skills required to work in different phases of software development lifecycle. The soft skills were chosen according to different job descriptions found in different job advertisements in software industry [14]. The findings of this article show that a different set of personality traits are required by system analyst, software designer, software developer, software tester and software maintainer to effectively perform their assigned tasks. The effectiveness of different development activities of software development lifecycle can be improved if the industry chooses the right personality with right personality traits for any specific job.

X. FUTURE WORK

As our future work, we aim to perform a more comprehensive personality traits analysis of different roles of software development activities by enlarging the spectrum of data analysis about real needs of these roles in software industry. In next studies, more comprehensive need analysis for different job posts of software development activities will be performed to identify the tasks and responsibilities of different roles of software engineering.

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