International Journal of Electrical and Computer Engineering (IJECE)
Vol. 13, No. 3, June 2023, pp. 3244~3254
ISSN: 2088-8708, DOI: 10.11591/ijece.v13i3.pp3244-3254

Towards understanding the influence of personality and team behaviors on requirements engineering activities

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Article Info

Article history:

Received Jun 16, 2022
Revised Sep 27, 2022
Accepted Oct 1, 2022

Keywords:

Personality
Requirements engineers
Systematic review
Team behavior

ABSTRACT

Requirements engineers play an important role in the development of software products and services. The nature of requirements engineering (RE) is multifaceted and influences the quality, success, or failure of software products. In gathering software requirements, engineers commonly work in a team, particularly when dealing with the customers or modeling the requirements, hence the team behavior may influence the RE activities. The investigation of requirements engineers' personality and their team behavior associated with RE activities is still an open area in which research is still developing. This study aims to investigate the personality and team behavior of requirements engineers involved in RE activities using a systematic literature review approach. We included 64 primary studies that addressed the association between personality and team behavior of requirements engineers on the effectiveness of RE activities. The result shows that among personality dimensions, extraversion and conscientiousness were found to be the predominant personality traits that positively affect RE activities. Furthermore, team behavior of requirements engineers such as flexibility, collaboration, creativity, innovation, and norms were discovered as factors that influence the RE process, performance, and success. The findings of this study contribute to the body of knowledge and practice of RE by providing empirical evidence on the influence of requirements engineers' personality and team behavior on the effectiveness of RE activities.

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1. INTRODUCTION

Requirements engineering (RE) encompasses various activities, which together lead to the production of quality software products [1]. RE is defined as the branch of engineering, which focuses on the real-world goals functionality, and constraints of systems and their relationship to the system-specific behavior, evolution, and family of the related system [2]. In RE, a requirements engineer can be assigned to any of the following activities: i) requirements elicitation/discovery, ii) requirements analysis and reconciliation, iii) requirements representation/modeling, iv) requirements verification and validation, or v) requirements management [1], [2]. This means that a requirements engineer is expected to perform several roles in software engineering such as system analyst, business system analyst, requirements analyst, functional architect, and software engineer [2], [3]. Thus, the scope of this research considers the

requirements engineer to be information technology (IT) professionals who are described as either system analysts, requirements analysts, or software engineers.

During requirements elicitation, requirements engineers interact with customers and stakeholders to gather and collect raw requirements of the system under study. They use various combinations of elicitation techniques such as interviews, prototyping, and other well-defined approaches. In eliciting requirements, the engineers discover various types of requirements including non-functional requirements. Requirement analysis and reconciliation involve understanding the collected requirements and negotiating any faults or problems in the requirements with the stakeholders [2]. This is where the behavior and personality of the engineers can potentially affect the way the requirements are gathered and whether the requirements engineering tasks can be performed effectively or not. A software project team typically consists of a project manager, requirements engineer or analyst, developers, and quality assurance personal [4]. The RE team's coordination and interaction capabilities can be influenced by their personality traits [5]. Therefore, it is important to understand how these two variables (personality and team behavior) affect positively or negatively the RE process.

RE is a crucial activity in software engineering [2]. Research shows that one of the fundamental issues related to project failure originated from software requirements management due to lapses of technical expertise and human factors [6]. In this study, we have discovered that researchers have contributed to the area of personality traits and team behavior of different software engineering professionals such as software testers, programmers, and designers. Despite the importance of understanding the influence of requirements engineers' personality traits and team behavior on RE activities, there is no available work that reports the state of research on this topic. Hence, it is important to fill in the such gap to better inform software professionals on the kinds of personality traits and the types of team behaviors that are likely to determine the success in performing requirements tasks.

The research objective we are addressing in this study is to identify whether different personalities of requirements engineers and their social behavior in the team positively affect RE activities. To achieve this objective, we have conducted a systematic review and thoroughly searched the literature, and investigated relevant empirical studies on personality traits and team behavior of software engineers. This study specifically contributes to the synthesis of the empirical studies on the impact of requirements engineer's personality traits and team behavior on RE activities.

2. RELATED WORK

This section describes the existing secondary studies or reviews related to personality traits and team behavior of software professionals. Soomro *et al.* [7] conducted a review that includes 35 primary studies that empirically addressed the personality traits, team climate, and team performance of software engineering projects. The authors intended to find the effect of the software team personality traits and climate on team performance. They discovered that majority of the studies used Myers-Briggs type indicator (MBTI) and five-factor model (FFM) to measure the personality traits of the software professionals. They further found that characteristics of the project team had a significant effect on software team performance and that no single study in their review addressed personality disorders concerning the success or failure of a software development project.

In another review study, Cruz *et al.* [8] performed a systematic mapping study reporting forty years of research on personality in software engineering (SE). The findings indicated nine research topics that have been investigated concerning how they are influenced by personality. The topics include education, pair programming, team effectiveness, software process allocation, individual performance, behavior and preference, project manager effectiveness, personality test application, and job retention. Leadership performance, team process, behavior, and preferences were the topics that have been less researched. They concluded that research collaboration with other disciplines such as psychology is necessary since research on personality in software engineering is regarded as multidisciplinary. In relation to the personality test, although MBTI mainly dominates the studies, they reported that personality tests based on FFM, particularly NEO personality inventory (NEO-PI), are becoming more popular.

In software engineering (SE), research on personality is gaining more attention compared to the last decade [8]. The need for research on personality in SE arose when researchers discovered that the major problems of SE are not confined to the technical aspect alone but extend to various human social concerns [9]. This discovery argues that SE, in which RE is one of the activities is equally a social endeavor [10]. Thus, there was a widespread call to investigate the idiosyncrasies of software developers for the improvement of technical skills [11]. A more recent review on the effects of human aspects on the RE process has been reported in [5]. The authors highlighted that many studies focused on the effects of communication on the RE process while other human aspects such as personality, motivation, and gender are also significant. Interestingly, human aspects were found to affect the RE process both positively and

negatively. Hence, more investigation is needed to identify the most influential human aspects of RE activities [5]. The study reported herein aims to address such a research gap by focusing on the personality and team behavior of requirements engineers. Due to the critical emphasis on team-oriented development, there are additional demands on the social and interpersonal skills of the developers [12]. However, little is known about how the two variables (personality and team behavior) both or concurrently influence the performance of the development team in delivering RE tasks.

3. METHOD

In this study, we used the systematic literature review (SLR) as our research method, following established guidelines reported in [13]. The main objectives are to search for evidence related to empirical studies on the personality and team behavior of requirements engineers and to evaluate and synthesize evidence from those studies. This study aims to answer the following questions:

- RQ1: Does the personality of requirements engineers impact the effectiveness of requirements engineering activities?
- RQ2: Does the team behavior of requirements engineers influence the effectiveness of requirements engineering activities?

Based on the formulated research questions, alternative search terms for personality, team, requirements engineer, and requirements engineering are grouped to enable wide coverage of the relevant studies as shown in Table 1. For instance, personality traits and types are search terms used for the personality basic search term. The requirements engineer and requirements engineering basic terms equally used related search terms in this study.

Table 1. Related search terms

Basic Search Terms	Related Search Terms
Personality	Personality Traits, Personality Types [5], [14]–[16]
Team Behavior	Team Climate, Team Dynamics [17]–[20]
Requirements Engineer	Requirements Engineer, Requirements Analyst, System Analyst, Architect [6]
Requirements Engineering	Requirements Engineering, Requirements [6], [21], [22]

3.1. Inclusion and exclusion criteria

The criteria for including and excluding primary studies are defined as the following: i) studies that focus on the impact or influence of personality traits and team behavior such as team climate, dynamics, or culture on the requirements of engineering activities; ii) studies that address personality aspects within the scope of RE. The exclusion criteria of this SLR include the following: i) papers not published in the English language; ii) secondary studies or studies that present a review of literature; iii) short papers published with fewer details (e.g., posters, abstracts, keynotes); iv) papers that lack empirical evidence; v) papers that are not fully accessible; and vi) gray literature such as theses, and dissertations. Thus, with these criteria, the authors are guided in the appropriate selection of the relevant papers in the study.

3.2. Search strategy

We used a peculiar searching strategy to retrieve virtually relevant primary studies on personality traits and team behavior of requirements engineers. We defined eight (8) search strings (SS) on four primary online databases: Scopus, IEEE Xplore, ScienceDirect, and Springer for the purpose to identify the most optimum search string that retrieves a considerably large number of studies with fewer false positives. The SS are: i) SS1: (“requirements engineer” OR “requirements analyst” OR “system analyst” OR “architect”) AND (“personality”); ii) SS2: (“requirements engineer” OR “requirements analyst” OR “system analyst”) AND (“personality”); iii) SS3: (“requirements engineer” OR “requirements analyst”) AND (“personality”); iv) SS4: (“requirements engineer” OR “system analyst”) AND (“personality”); v) SS5: (“requirements engineer” OR “requirements engineering”) AND (“personality”); vi) SS6: (“team behavior” OR “team behavior” OR “team climate”) AND (“personality”); vii) SS7: (“team climate”) AND (“personality”) AND (“requirements”); viii) SS8: (“team climate” OR “team dynamics”) AND (“personality traits” OR “personality types”) AND (requirements).

The search of the primary studies retrieved studies published up until 2020. Two rows, SS1 and SS6, are highlighted in Table 2 because they yielded the top two highest numbers of studies. To achieve the goal of covering as many relevant studies as possible, we used the aftermaths of all search strings where duplications of the studies were identified and removed. This reduced the total number of the search outcome to 348 papers as presented in Table 3.

Based on the screening of studies according to the inclusion and exclusion criteria, we included a total number of 64 relevant studies through the following two sources: i) online databases search, a total of 49 relevant studies were selected and ii) snowballing we applied a backward snowballing method to complement the online database search [23]. This is achieved by referring to the list of references of the selected primary studies and manually searching for more relevant studies that were perhaps missed in the previous searching phase. A total of 15 studies were additionally found and selected.

The selection process of the primary studies included in this SLR is divided into two parts, as depicted in Figure 1. For Figure 1, we adopted the PRISMA 2020 guideline for reporting systematic reviews [24]. As a result, we have a total of 64 included studies. As listed in Table 4, majority of the studies (29 out of 64) were retrieved from Scopus.

Table 2. Search results

String	Scopus	IEEE	Science Direct	Springer	Total
SS1	50	10	7	3	*70*
SS2	18	9	5	16	*48*
SS3	5	7	1	15	*28*
SS4	0	0	0	0	*0*
SS5	0	0	0	0	*0*
SS6	57	3	12	13	*85*
SS7	20	0	8	10	*38*
SS8	8	1	11	0	*20*
Total	*225*	*35*	*47*	*57*	*364*

Table 3. Summary of the searched papers

Total Number of Papers Retrieved from Online Databases	364
Number of Duplicated Papers	16
Number of Papers Without Duplication	348
Number of Papers Screened Based on Title and Abstract	155

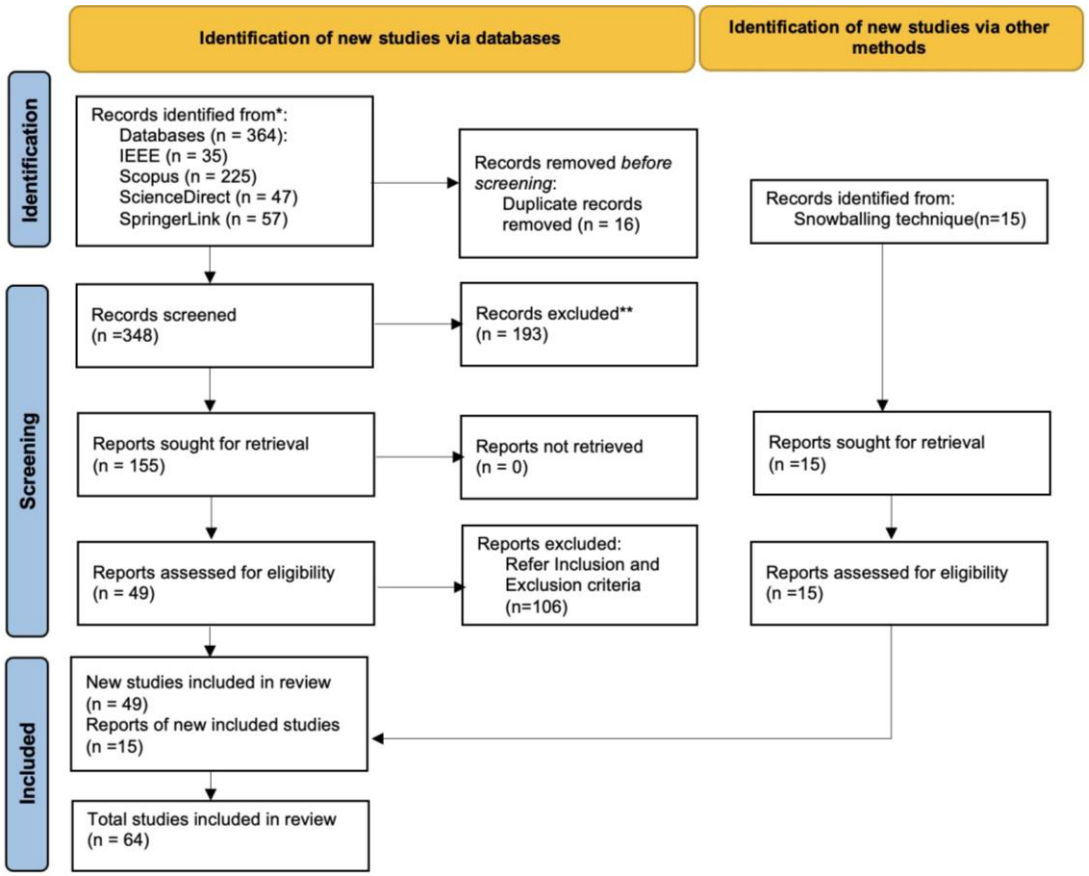

Figure 1. Study selection process

Table 4. Sources of the primary studies

Sources	No. of Study
IEEE	5
Scopus	29
Science Direct	9
SpringerLink	6
Snowballing	15
Total	64

3.3. Quality checklist and procedures

To assess the quality of the selected primary studies in this SLR, we intended to answer the following questions based on the design, conduct, analysis, and conclusion as listed based on the studies as suggested in [13]. Design: i) are the aims clearly stated? ii) are the variables used in the study adequately measured? iii) are the measures used in the study fully defined? Conduct: are the data collection methods adequately described? Analysis: are the study participants or observational units adequately described? Conclusion: are all study questions answered? Having posed the six aforementioned questions, we set three scores for each question. The scores are (1) Yes=1; (2) No=0; and (3) Partially=0.5. Thus, on aggregate each study has a total of 6 scores for quality assessment.

4. RESULTS

In total 64 studies were included in our SLR. In terms of study context, we found that about 70% (45 out of 64) of the studies were conducted in industry settings; 19% in academic settings; and 5 studies representing 8% were conducted in both academic and industry settings. In terms of research approaches, we found that a vast majority of the studies (32 out 64) used survey methods such as questionnaires and interviews; followed by experiments (12 studies) and case studies (10 studies). Based on the quality assessment, most of the studies (78.1%) scored 3 out of 6 points, which indicates an overall good quality score. Figure 2 shows the distribution of publications by year. The highest number of publications was found in 2014 and 2015 respectively. The publication numbers however decreased starting from 2018.

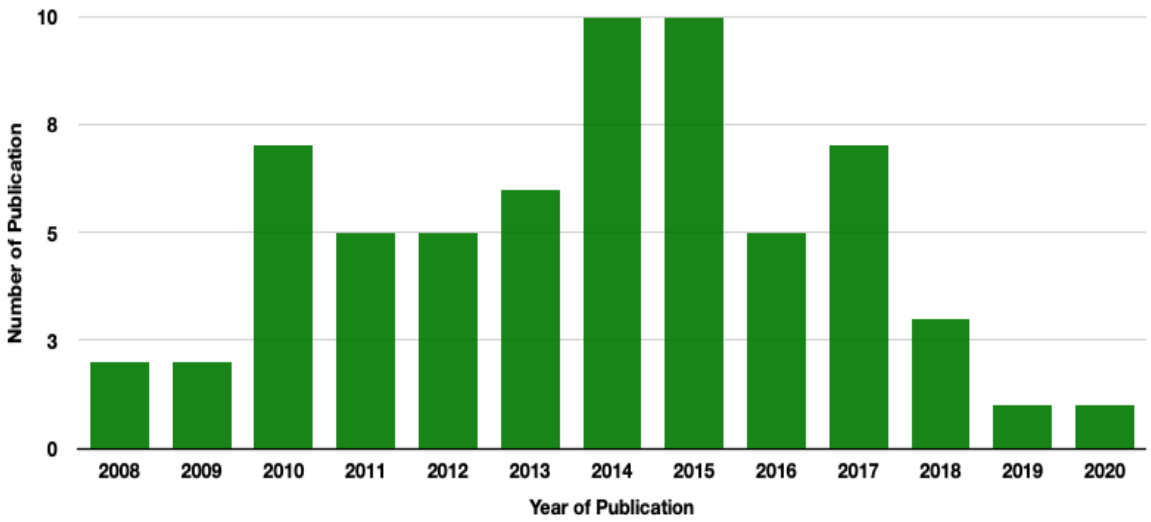

Figure 2. Distribution of publication year

4.1. Does the personality of requirements engineers influence requirements engineering activities (RQ1)?

This research question is intended to investigate the influence of the personality of requirements engineers on the effectiveness of RE activities. We found that the most frequently used personality models are the five FFM and MBTI employed by 19 and 8 studies respectively. Other personality test techniques include the critical incident technique, emotional assessment, and Cattell's 16 personality factors model each used in one study as listed in Table 5.

Table 5. List of personality tests/models used

Personality Test/Model	References	#Study
MBTI	[9], [12], [21], [25]–[29]	8
FFM	[9], [11], [14], [30]–[45]	19
Critical Incident Technique (CIT)	[15]	1
Emotional Assessment (EA)	[16]	1
Cattell's 16 Personality Factors Model	[17]	1

We found that extraversion personality dimension of requirements engineers played significant role towards influencing RE effectiveness [9], [11], [31], [37], [45]. For instance, Kosti *et al.* [11] focused on measuring the emotional intelligence and self-compassion of software engineers and found that requirements engineers fall into a group they informally referred to "intense group", which scored the highest in extraversion. Their results showed that extraversion was associated with a preference to work in a team as shown in Figure 3. In [31], a similar result was found based on the results from their cluster analysis. The result reported in [9] complemented that requirements engineers should possess extraversion and agreeableness as part of their personality traits. This is because those requirements engineers are responsible to interact with customers, to obtain and analyzing requirements. Hence these personalities are suitable for the requirements engineers' jobs. Murukannaiah *et al.* [34] used two multiple regression models for personality traits and creative potentials of workers in terms of novelty and usefulness. Their findings showed that agreeableness was found the highest in influencing workers' usefulness of ideas, followed by conscientiousness. However, they found that extraversion has a substantial negative impact on the usefulness of the worker's knowledge. In [37], requirements engineers with a high level of extraversion showed a significant relationship with team performance. Similarly, Martínez *et al.* [45] found that extraversion was one of the factors that scored a high degree, indicating the job suitability of analysts, i.e., having a good rapport with people and targeting to achieve their goals and objectives.

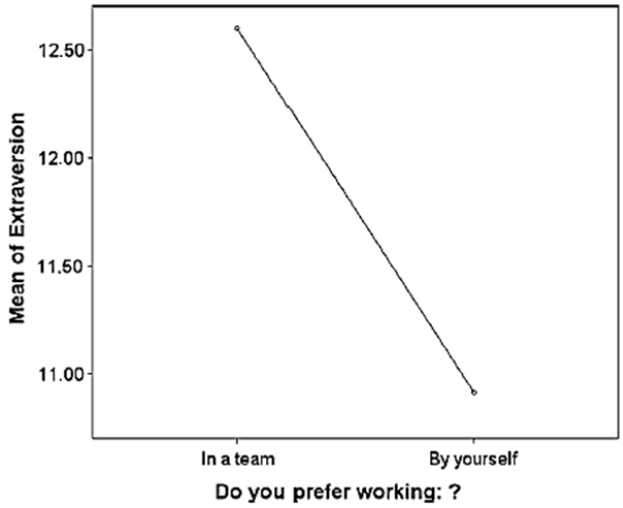

Figure 3. Mean of extraversion Vs team [10]

In software engineering, task preference influences the quality and productivity of software [25]. In line with that, Capretz *et al.* [25] investigated possible patterns related to the personality of requirements engineers to role preferences. They found that the role of system analyst was the most preferred and the majority are extroverts. This fact is supported by the findings in [11], where extraversion was associated with a preference to work in a team and be responsible for the entire software development project. In [9], both FFM and MBTI were used and the result indicated that requirements engineers should possess extraversion and agreeableness as part of their personality traits. Mazni *et al.* [12] who used MBTI corroborated with existing findings that extroverted software engineers influence software quality and project success.

In the case of conscientiousness, it was revealed in [11] that a high level of conscientiousness indicates a preference to prioritize specific tasks and involve in long software projects from beginning to end. This personality can therefore be linked with the nature of the RE lifecycle. In [15], conscientiousness was associated with driving project to result and working systematically competencies factors of requirements

engineers. This influences RE activities as conscientiousness personality describes qualities of requirements engineers, which include organized manner, carefulness, self-discipline, and sense of responsibility [15]. In terms of requirements engineer's idea, Murukannaiah *et al.* [34] found that conscientiousness was positively associated with the novelty and usefulness of the analyst's ideas. In [44], it was found that a higher level of conscientiousness was correlated to the attitudes of software engineers towards working style and adoption to change. Such nature of personality could help in promoting RE activities.

Several studies report the influence of agreeableness personality on RE activities. For instance, Kosti *et al.* [11] found that a high level of agreeableness in software engineers indicates preference of the engineers to work in a team rather than by themselves. The findings of [36] showed that in automated crowd RE, characteristics of requirements managers especially agreeableness positively affect RE processes. Practically, RE activity particularly requirements validation demands the collaboration of analysts, thus a team of analysts drives and executes the task towards quality and perfection [18]. The open personality was associated with one of the critical competencies of requirements analysts, which is gathering information [15]. A high level of openness also indicates the preference of requirements analysts to take responsibility for the whole project rather than just working on some parts [31]. In the case of neuroticism, software analyst with higher emotional stability (low neuroticism) prefers to prioritize their tasks during software project and take responsibility for the entire development without being assigned a manager [11]. It can be observed from the above-mentioned findings that the most prevailing personality that influences RE activities is extraversion. Conscientiousness is the second trait that has a positive impact on RE activities. Neuroticism was found to have less influence on the role played by requirements engineers. In fact, research has shown that neuroticism has negative but no significant relationship with team performance [37].

4.2. Does team behavior of requirements engineers influence the requirements engineering activities (RQ2)?

Besides personality aspects, we have also discovered several team assessment methods used to measure team behavior and performance. Only four studies described the team assessment methods they used to empirically analyze software teams as shown in Table 6. Team Selection Inventory (TSI) and Team Climate Inventory (TCI) are psychometric inventories designed for assessing team climate preferences and team climate perceptions respectively [19]. Both inventories are used to measure four factors (participative safety, support for innovation, team vision, and task orientation) considered important for effective team predisposition for innovation [19]. Team Social Score (TSS) is defined as the cumulative capability score of the relationships between every team member within the team [20]. Another team assessment technique is the global teaming model (GTM), which defines a set of guidelines together with motivational factors for coordinating global SE teams [22]. Lastly, Team Self-assessment is an instrument that measures team capability profile from which different performance attributes are captured, combined, and translated to the capabilities of the team [46].

Table 6. List of team assessment methods

Team Assessment	Study
Team Selection Inventory (TSI), Team Climate Inventory (TCI)	[19]
Team Social Score (TSS)	[20]
Global Teaming Model (GTM)	[22]
Team Self-assessment	[46]

To answer RQ2, we focused on studies that reported the impact of team behavior in software development particularly in RE activities. Furthermore, we discovered that the team behavior of requirements engineers influences two areas: i) RE process and ii) team performance and success. For the RE process, five studies [6], [16], [47]–[49] reported the impact of team behavior of requirements engineers on the RE process. For instance, Browne *et al.* [47] investigated a type of illusion in requirements determination called the Abilene paradox, which was found to significantly affect requirements elicitation and determination based on team agreement. Human social factors such as flexibility, collective knowledge, and transactive memory are essential elements in RE collaborative teamwork [6]. This means that adaptability and utilization of experiences among RE team members lead to well-heeled RE activities. The concept of collaboration in RE was also supported and elaborated in [48], [49]. While the former [48] focuses on creativity in RE as an indispensable factor for influencing the RE process, the latter [49] emphasized requirements engineer's collaboration improves requirements elicitation.

Team behavior of requirements engineers can also affect team performance and success [50]. Certain acquired behaviors, such as analytical and problem solving, team player, and communication skills remarkably improve team performance [50]. Table 7 lists the soft skill requirements of requirements engineers, which indicates that communication skills play important role in RE activities. To achieve high performance in software teams, [46] proposed a team capability analysis approach, which gauges the proficiency of each team member while improving performance with respect to the goal of the software organization. The capabilities include agile, lean, business excellence, operational excellence, growth, and innovativeness.

Table 7. Soft skills requirements for requirements engineer job [50]

No.	Soft Skills	Percentage (%) of requirements
1	Communication	92
2	Analytical and problem-solving skills	69
3	Team player	66
4	Organizational skills	37
5	Ability to work independently	27
6	Interpersonal	26
7	Open and adaptable to changes	20
8	Innovative and creative	9
9	Fast learner	6

One of the key factors that makes software products successful is quality [51]. The motivation of software engineers is key to the quality of the software they developed [22]. Beecham [22] argued that to produce quality software, the needs of the software teams such as task identification and purpose, feedback, trust, appreciation, rewards, a career path, and sustainable working hours should be satisfied. The dynamics of software engineers are among the central attributes of team performance and project success [12]. Another factor that leads to team performance is team collaboration. This factor was advocated in [52], where the authors proposed a team assessment approach, implemented it in several cases, and obtained positive and promising results on how team collaboration improves the team performance of software engineers. In summary, we found that many requirements for engineers' behavior such as collaboration, good emotion, communication skills, innovation, flexibility, and creativity among others have a positive impact on RE activities. Albeit, we have discovered other behaviors such as team climate [19], [37], [40], team dynamics [53], [54], team structure [38], [54], team learning [55], [56], and team composition [26], [57] where these aspects of behavior were focused on the role of software developers.

5. DISCUSSION

Contrary to the findings in [8], we found that majority of the included studies of this SLR used FFM. This implies that researchers in this field are becoming more familiar and receptive to the FFM personality test. Nonetheless, 45% (29 out of 64) of the studies neither use a personality model nor team assessment methods in their approaches. We found only one study [9] that mixed both FFM and MBTI in their approach.

Requirements engineers with extraversion personalities demonstrated good communication skills to gather the requirements [5]. On this note, it is essential for requirements engineers to equip themselves with good communication skills if they naturally lack extraversion personality. Requirements analysts with high conscientiousness levels are capable to improve RE activities as they are described with several qualities such as systematized action, carefulness, self-discipline, and a sense of responsibility [15]. Few studies analyzed and reported the impact of neuroticism on RE, which indicates that neuroticism has a virtually negative impact on RE. This is because analysts with Neuroticism personalities are described with a preference to work alone with less interaction and supervision. However, RE activities entail interaction and communication with individuals and teams. Those with a certain level of Neuroticism are likely dissatisfied with their job and consequently affect team performance (e.g. [11], [31]).

Team climate is one of the team behaviors that influence software teams, which covers some aspects like vision, innovation, communication patterns, participation safety, norms, cohesion, and task style [58]. We were unable to locate any studies on team climate specifically for requirements engineers. Few studies, however, have focused on other aspects of team behaviors including flexibility, collaboration, creativity, innovation, and norms. It was discovered that each of the aforementioned behaviors had a positive impact on RE activities. For example, collaboration across RE teams has a positive impact on RE activities. Collaboration among team members improves RE performance, particularly requirements elicitation, since they become more flexible to challenging circumstances and could also gain more knowledge.

6. CONCLUSION

The purpose of this research was to investigate the relationships between personality and team behavior of requirements engineers against RE effectiveness. Out of the 64 primary studies included in this review, we found that several studies tried to answer the question by employing different personality test models among which FFM and MBTI were the most prevalent. Several personality dimensions such as extraversion, openness, agreeableness, and conscientiousness were found in association with RE effectiveness. The result reveals that extraversion and conscientiousness personality dimensions were the most noticeable personality traits that positively affect RE activities.

In terms of the relationship between team behavior of requirements engineers and the effectiveness of RE activities, we discovered that the existing studies used several teams' assessment methods such as team climate inventory, and team social score. Furthermore, we found that the team behavior of requirements engineers affects: i) the RE process; and ii) team performance and success. Team behavior of requirements engineers such as flexibility, collaboration, creativity, innovation, and norms were found to positively affect RE activities. The findings of this SLR would contribute to the body of knowledge and practice, in particular, to better inform IT professionals in the industry on the influence of personalities and team behaviors in RE-related activities. The impact of these variables on RE activities could improve performance and success in RE teams. This benefit could extend to the improvement of quality and attainment of success in the whole software engineering process.

ACKNOWLEDGEMENTS

This work is funded by the Ministry of Higher Education of Malaysia FRGS/1/2019/ICT01/UIAM/03/1.

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