The Effect of Software Engineers' Personality traits on Team Climate and Performance: a Systematic Literature Review

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Abstract

Context: Over the past 50 years numerous studies have investigated the possible effect that software engineers' personalities may have upon their individual tasks and teamwork. These have led to an improved understanding of that relationship; however, the analysis of personality traits and their impact on the software development process is still an area under investigation and debate. Further, other than personality traits, "team climate" is also another factor that has also been investigated given its relationship with software teams' performance.

Objective: The aim of this paper is to investigate how software professionals' personality is associated with team climate and team performance.

Method: In this paper we detail a Systematic Literature Review (SLR)[2] of the effect of software engineers' personality traits and team climate on software team performance.

Results: Our main findings include 35 primary studies that have addressed the relationship between personality and team performance without considering team climate. The findings showed that team climate comprises a wide range of factors that fall within the fields of management and behavioural sciences. Most of the studies used undergraduate students as subjects and as surrogates of software professionals.

Conclusions: The findings from this SLR would be beneficial for understanding the personality assessment of software development team members by revealing the traits of personality taxonomy, along with the measurement of the software development team working environment. The said

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[2] Abbreviations used in this paper:
SLR – Systematic Literature Review, FFM – Five Factor Model, MBTI – Myers-Briggs Type Indicator, TCI – Team Climate Inventory

measurements would be useful in examining the success and failure possibilities of software projects in development processes.

General Terms: Human Factors, Performance

Keywords: Software Team Climate, Personality and Software Engineering, Systematic Literature Review, Team Performance

1. Introduction

The impact of individuals' personality traits on task performance and team work has been a research focus in software engineering since 1960s [1–3]. Weinberg [4], in his book "The Psychology of Computer Programming", also emphasized the impact of programmers' personalities upon the successful completion of tasks: *"Because of the complex nature of the programming task, the programmer's personality – his individuality and identity – are far more important factors in his success than is usually recognized"* (p.158). Shneiderman [3] also provides additional support to the importance that personality traits play in software development when stating in his book that *"Personality variables play a critical role in determining interaction among programmers and in the work style of individual programmers"*.

Software engineering typically deals with software project teams. Generally, "project teams" are classified as a group, which can be defined as *"an arrangement between two or more people to work together so as to produce an identifiable good or service in such a manner that the group members are highly interdependent"* [5]. Software groups or teams, on the other hand, are considerably different from work groups in other domains as they differ in nature of resources required from a software engineer, their objectives, and the environment [6].

An additional definition of a team is given as "*a number of individuals brought together for a certain task, goal or objective, engaged in frequent face-to-face interaction to execute a task, while the individuals are mutually interdependent on each other with regard to the outcome of the task and its execution*" [7]. Katzenbach and Smith [7] observed that a team has three key elements*: i) common goals; ii) complementary skills and responsibilities;* and *iii) they give value to regular meetings among the team members to interchange their ideas*. These meetings also help to pursue a clearer common goal and develop a collaborative environment, strengthening the team climate cognition. The term team climate cognition or team cognition is defined by Açıkgöz et al. [8] as *"the capability to perform a learning process related to the rational acquisition, processing, and dissemination of information for the purpose of creating team-level intellectualness"* (p.149).

Every team possesses its own team climate which represents the concept of exchange of ideas and perceptions among team members in order to promote innovation in work processes. It has been considered as important for achieving team effectiveness. Loo [9] has enlightened the importance of team climate in the field of project management. In his study, he has adopted the TCI developed by Anderson & West [10] to assess the team climate of research project teams. The findings showed that TCI can be a useful tool to assist project managers and trainers in team building exercises as well as project management training and project evaluations.

Within the context of software engineering, "team climate" can be defined as a combination of its team members' interactions in order to share their perceptions of the team's work procedures and practices [11]. To date research has shown that there is a relationship between team personality composition and team performance and climate [12–14]. However, previous research has not yet identified what are the best personality compositions that lead to the highest team performance and climate. Therefore, understanding how personality affects or relates to software team's performance is an important investigation.

In this research we have conducted a Systematic Literature Review (SLR) on the effects of software engineers' personality traits on team climate and their relationship with team performance. The primary studies that were included in our SLR provided evidence relating to the impact of personality on team climate and the associated performance in software teams. Our results provide useful guidance for project managers and team members to better understand team climate and relate it to personality differences and performance. We have also identified several areas for promising future research in this area.

2. Related Work

There is no agreed upon definition of human personality although there are many theories that have been developed related to this area of study. Personality is nevertheless commonly referred to as *individual differences* [14]. In Personality Psychology, which is the branch of psychology, human behavior can be studied by the identification and classification of individual differences [15]. The commonly founded three features of personality are: *i) that each individual is unique*; *ii) the behavior of the individual remains steady in all situations and moments*; and *iii) every individual's personality is composed of some attributes that control this individual's behavior* [16]. The various theories about personality traits have formulated different models to characterize human behavior, to be detailed next.

One of the most widely accepted personality models is the Big Five model [17], also known as Five Factor Model (FFM) [18], and additionally also described as the OCEAN model that includes *Openness*, *Conscientiousness*, *Extroversion*, *Agreeableness* and *Neuroticism* [16]. This model has been used in many studies to understand the influence of the personality traits on team climate e.g. in an engineering team, "conscientiousness" was found among the team members to noticeably raise task performance, and those members who were found to be low in "extraversion" were found to be key in running product design processes [19]. In another study where 10 teams consisting 78 college students competing in a business simulation were observed it was found that the "emotional stability" (the alternate term for neuroticism [20]) predicted task performance, and "agreeableness" predicted consistency within the work team [21].

Besides the FFM, another psychometric questionnaire widely used, particularly in software engineering personality research, is the Myers-Briggs Type Indicator (MBTI). The MBTI uses the Jungian theory of psychological types in a way that can be easily understood and become more adaptive in people's lives [22]. It is based on four pairs of opposite personality factors, these pairs of choices or scales are also called dichotomies. The four scales are *extroversion* versus *introversion* (E/I), *intuition* verses *sensing* (I/S), *thinking* versus *feeling* (T/F) and *perceiving* versus *judging* [23].

The MBTI has been used by many researchers to identify the "best" personality type for a software engineer to possess. Yilmaz & O'Connor [23] developed a card game-based personality identification method and constructed a periodic table for sixteen personality types. The result of their research is that the software teams consisted of more extroverted individuals not only in the classroom settings but also in industry. For managers the authors suggested that they should consider this implication while configuring the effective team. Another study used MBTI to examine software engineers' personality type and their effect on software modelling activities [22]. Cunha et al. [22] argues that personality and project team members' cultural identity affect the software engineering process more than it is currently believed.

The Keirsey temperament sorter (KTS) is an instrument based on theory developed by a behavioural scientist called David Keirsey. He correlated his modern theory of temperament with the MBTI framework and classified sixteen personality types into four temperament types [24,25]. These four temperament types are namely *Artisan, Guardian, Idealist* and *Rational*. The KTS has been used by some researchers to measure the variance in the personalities of software engineers and their temperament when they are working as a team. Sfetsos et al. [27] have investigated developers' personalities and temperament and their effect on pair performance. In their research the KTS-test

has been used to interpret the subjects' personalities in the experiment. Their results showed the heterogeneous personalities working in pairs possess better communication, pair performance and pair collaboration than the homogeneous personalities in pairs. Pieterse et al. [28] also used Keirsey-Bates temperament sorter to measure a software team's diversity by focusing on each of the team member's individual personality and its impact upon the team's performance. They reported personality diversity had strong correlation with team success in the beginning of project development which grew weaker while projects reaching to the completion.

Jia et al. [29] have performed a comparative research on FFM, MBTI and KTS to identify their suitability in SE domain. The comparison was carried upon the basis of: *i) content*, *ii) measurement method* and *iii) application*. The *content* based comparison further involved two more sub-categories *a) factors comparison* and *b) feature representation comparison*. In terms of *content*, FFM is reported to provide a more richer and comprehensive description of an individual personality In *measurement method comparison* the FFM based instruments had the advantage in terms of the time spent in answering the questionnaire. For the *application comparison* the results showed that all the three models have been researched in the context of academia and FFM reported as the dominant personality model. The importance of addressing personality in software development has been raised by many researchers (e.g. [22,23]). They claim that software project outcomes are very likely affected by the personality of the software engineers involved in the development process. This is because an engineer's or developer's personality influences the way they apply certain modelling methods or techniques, as these depend on several perspectives and abstractions that occur during the Software Development Life Cycle. In another study of Bedingfield & Thal [30] it is highlighted that personality of project managers is an important predictor for determining a project's success. In particular, their findings indicate that the personality traits Conscientiousness and Openness are positive predictors of Project Manager's success.

Gómez & Acuña [31] performed a quasi-experiment to analyse how the personality and team climate influence software development teams' performance. Their experiment used university students as subjects, and was conducted in an academic setting. Results revealed that there is a significant correlation between the extroversion personality factor and software quality and with respect to team climate they found out that the team's perception of high *participative safety* correlates with better quality software. *Participative safety* is one of the team climate factors that refers to the sense of safety (i.e. trust and support) that team members feel exist within the group [10].

The term *team climate* has been used in a number of studies (e.g. [32][33]) and it has been measured and examined by the Team Climate Inventory (TCI) by Anderson & West [10]. The Anderson & West [10] theory for team climate comprises of four factors: *i) vision, ii) participative safety, iii) task orientation,* and *iv) support for innovation*. Sudhakar et al. [34] in their secondary research reported TCI as the key instrument for measuring team climate among software professionals. Sudhakar et al. [34] classified the soft factors, which have been reported in their primary studies, as influential on software team performance. These soft factors include *team climate, team diversity, team innovation, team member competencies and characteristics, top management support* and *team leader behaviour*.

Cruz et al. [14] in their secondary study reviewed the literature covering personality in software engineering. They performed a SLR of peer reviewed studies published from 1970 to 2010. The main purpose of their work was to identify the methods used, topics addressed, personality tests applied, and reported the main findings produced in the research about personality in software engineering. They included studies that used undergraduate students as well as software professionals as subjects. One of their findings is that the number of studies that have focused on undergraduate student software teams and individuals as subjects is greater than the number of studies covering professional developers.

In a more recent study, Cruz et al. [35] have conducted a systematic mapping study of personality in software engineering covering forty years of research within the period from 1970 to 2010. Based on the 90 articles included in their review, their findings show that the majority of articles were published after year 2002 and mostly researched on education and pair-programming. They further

reported that MBTI was the most used personality test. They also discussed that the types of participants is not equally distributed as 60% of the studies used students as subject and 35% used professionals as subjects. They have classified the studies according to the research topics which include *pair programming, education, team effectiveness, software process allocation, software engineer personality characteristics, individual performance, team process, behaviour and preferences,* and *leadership performance*.

As one's individual personality is likely to have an impact on team interaction and performance, we were interested to determine the degree of research and findings to date in this area. To this end we designed and performed an SLR on software professionals' personalities and their impact on software team climate and team performance. While much relevant research has been conducted in this area, many studies vary greatly in methodology, personality assessment used, subjects population covered, or combinations of these. Most of the studies we found have focused on undergraduate software or computer student teams [14,31], where they have examined subjects as individuals or as a development team in an academic environment.

According to Sharma & Gupta [36], software development in an organization is often delimited by a number of factors; these factors include technical factors, non-technical factors along with organizational and environmental factors. Such results motivated us to perform a systematic literature review on software development teams in an industrial environment. In addition, to date the number of studies covering software professionals as subjects in industrial environments are very few (e.g. [PTC4][PTC5]).

The main contribution of this paper is therefore to identify and to understand how personality traits have been associated with team climate and team performance in the domain of software engineering among software professionals.

3. Research Methodology

The Systematic Literature Review (SLR) detailed herein was conducted to evaluate and synthesize existing research evidence about personality traits and software team climate in software development in teams. SLR is a form of secondary study and it is a well-defined methodology to determine, investigate and infer all available evidence related to a specific research question in a way that is unbiased and (to a degree) repeatable [37]. The SLR increases the likelihood of detecting real effects that individual smaller studies are unable to identify [37].

We followed Kitchenham & Charters' [37] procedure and Kitchenham & Brereton [38] guidelines for conducting this SLR. The search and data extraction was carried out by the first author under the close supervision of the second author, who is experienced in conducting SLRs in software engineering. To synthesize the findings of this SLR we performed qualitative metasummary [39,40] and narrative synthesis [41]. In qualitative metasummary the qualitative findings are combined in quantitative orientation. The main purpose is to distinguish the number of occurrences of each finding [39,40]. Narrative synthesis is another way to report the findings than statistical summary. It supports a general framework which helps researcher to report findings by using selected narrative descriptions and by giving order to primary evidence with comments [41].

3.1 Research Questions

First, a set of Research Questions (RQs) were formulated by following the elements suggested by Petticrew and Roberts [42]: the *intervention*, the *population*, *outcomes of interest*, and the *context* within which the intervention is delivered. This approach is described by Kitchenham & Charters [37] as PICOC (population, interventions, comparison, outcomes and context).

Table 1: PICOC for RQs

Population	Software Engineers/ Professionals
Intervention	Personality Traits and Software Team Climate
Comparison	N/A
Outcomes	Team Performance
Context	Software Houses/Software Industry

The Following are the RQs for our SLR formulated with the help of PICOC (see Table 1).

- RQ1. What, if any, are the key software engineer personality trait(s) that have a significant influence on software team climate and/or software team performance?
- RQ2. What are the key factors in team climate composition that have been addressed or investigated in software development team studies?
- RQ3. Which, if any, software team climate factor(s) has/have significant effect on software team's performance?
- RQ4. How has software team's performance been measured in these studies?

3.2 Identifying the relevant literature

In order to identify the relevant studies we used the search terms shown in Table 2 and Table 3.

3.2.1 Search Strategy for Primary Studies

i. We selected major key search terms from our PICOC (see Table 1 and Table 2). The key terms were related to the intervention and outcomes aspects.

ii. Some new terms were also explored during the search process and included in the list of alternate search terms (see Table 3).

iii. The execution of search string has been done on eight (8) online databases and one (1) search engines listed in Table 5 and Table 6.

iv. In construction of final search string the alternate terms were selected by referring the work of Cruz et al. [35](see Table 3).

v. The final search string (see Figure 1) which is used to locate primary studies from databases was constructed by using Boolean operators. The OR operator was used to concatenate the synonyms and AND to concatenate the major key terms from Table 2 and Table 3 (see Table 4 and Figure 1).

vi. Search Tips, including stemming and wildcards, as specified by different digital library help pages, were used during search process.

Table 2: Major Search Terms

Intervention	Personality Traits and Software Team Climate
Outcomes	Software Team Performance

Table 3: The Alternate Search Terms

Basic Search Terms	**Alternate Search Terms**
Personality	Personality traits, Personality type
Software engineer	Software professional, Software developer
Software team	IS team, Programming team, Project team, Pair programming
Software team climate	Team climate, Group climate, Work climate

Table 4: Construction of search strings with OR

1	Personality OR Personality traits OR Personality type
2	Software engineer OR Software professional OR Software developer
3	Software team OR IS team OR Programming team OR Project team OR Pair programming
4	Software team climate OR Team climate OR Group climate OR Work climate

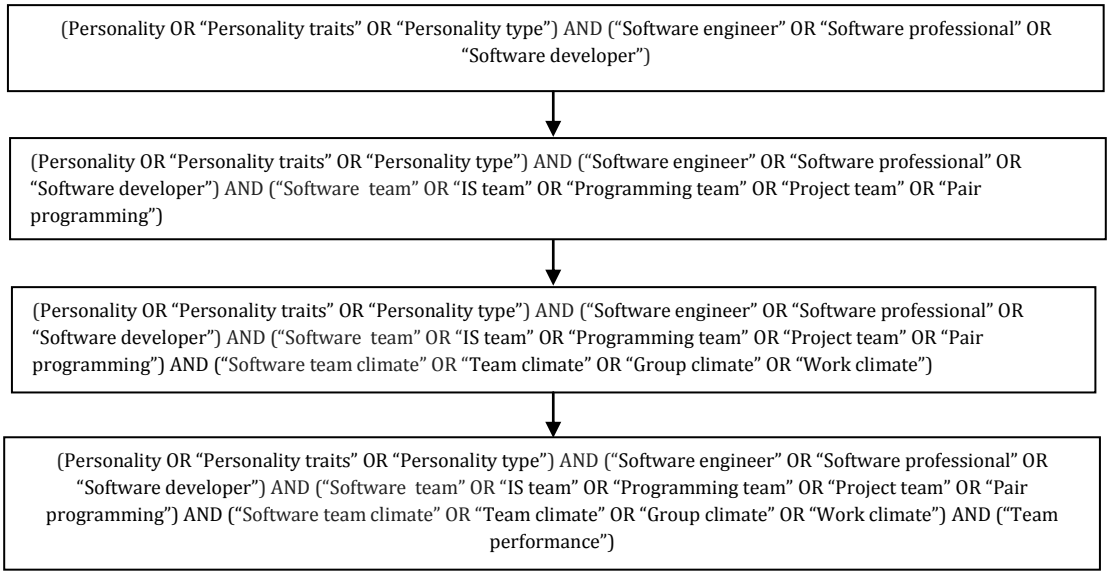

Figure 1: Formulation of Search String

3.2.2 Primary Search Process

The primary search phase for the relevant studies was performed on eight (8) online databases and one (1) search engine. We chose these databases as they are the standard databases and the search engine typically used in Computer Science and Software Engineering SLR studies and have also been suggested by Kitchenham & Charters [37] . The search string was successfully executed on all databases except for IEEEXplore, Emerald Insight and Google Scholar because they did not support the lengthy search string. Since our goal is to achieve a higher sensitivity and to get more specific and relevant results from these search engines, hence the main search string was split into four (4) sub-strings as shown in Figure 2.

Main Search String	
(Personality OR "Personality traits" OR "Personality type") AND ("Software engineer" OR "Software professional" OR "Software developer") AND ("Software team" OR "IS team" OR "Programming team" OR "Project team" OR "Pair programming") AND ("Software team climate" OR "Team climate" OR "Group climate" OR "Work climate") AND ("Team performance")	
Sub-Strings(SS)	
SS 1	(Personality OR "Personality traits" OR "Personality type") AND ("Software engineer" OR "Software professional" OR "Software developer") AND ("Software team" OR "IS team" OR "Programming team" OR "Project team" OR "Pair programming")
SS 2	(Personality OR "Personality traits" OR "Personality type") AND ("Software engineer" OR "Software professional" OR "Software developer") AND ("Software team climate" OR "Team climate" OR "Group climate" OR "Work climate") AND ("Team Performance")
SS3	(Personality OR "Personality traits" OR "Personality type") AND ("Software team climate" OR "Team climate" OR "Group climate" OR "Work climate") AND ("Team performance")
SS4	(Personality OR "Personality traits" OR "Personality type") AND ("Software team" OR "IS team" OR "Programming team" OR "Project team" OR "Pair programming") AND ("Team performance")

Figure 2: Sub strings

These sub strings were executed on IEEEXplore, Emerald Insight and Google Scholar (see Table 6). In the case of Google Scholar the number of studies retrieved was not practically manageable,

therefore we only looked at the studies displayed over the initial 10 pages. All studies were scrutinized on the basis of title and abstract. Table 5 shows the results from using the final search string (see Figure 1) execution on each online database.

Table 5: Literature Resources

Resource Name	No. of Studies
ACM Digital Library	83
SCOPUS	13
Springer Link	5
Science Direct	6
Wiley online library	6
ProQuest	10

Table 6: Results by Sub-Strings

Databases	SS1	SS2	SS3	SS4	Total
IEEE Xplore	2	2	2	40	46
Emerald Insight	21	1	4	39	65
Google Scholar	1370	90	2580	5870	9910

3.2.3 Strategy for Secondary Search Process

The secondary search phase included a screening of all studies listed in the references section of the retrieved primary studies. These helped us in tracing other relevant studies required for our study as suggested by Achimugu et al. [43]. We have found additional 18 studies during the secondary search process (see Table 7).

Table 7: Selected Primary Studies

Search Phases	No. Of Primary Studies
Primary Search	13
Secondary Search	18
Recommended Papers[3]	4
Total	**35**

3.3 Selection Criteria

During the search process, the time period for the studies selected was not limited. The selection of studies was conducted by applying a set of inclusion and exclusion criteria. The inclusion criteria were:

- Domain – the main domain must be software engineering, and the study focus on personality aspects and/or team climate.
- Method - studies can be quantitative, qualitative, mixed, case studies or experimental.
- Type – the type of study could be an article, conference paper, magazine article, and book chapter.
- Subjects – the study subjects should be affiliated with software industry.
- Team size – studies need to be on teams of two ("dyads") or more members, not individuals

The exclusion criterion was set on the basis of the following:

- Studies including non-professional subjects or students working on projects in academic settings.

[3] **Science Direct has feature to recommend article relevant to search*

- Non empirical studies that include the authors' assumptions or personal views without supporting data.
- Studies that focused on tool development.
- Secondary or review studies
- Studies appear as work-in-progress, posters, or short papers containing less than 6 pages
- Studies written in other than English language.

Initially, each retrieved paper was selected by reading the title, abstract and keywords and irrelevant studies were removed based on the inclusion/exclusion criteria. When the paper's title and abstract did not provide sufficient information to decide, its full text was referred to and the decision was made based on the inclusion/exclusion criteria.

3.4 Quality checklist and procedures

As stated by Kitchenham & Charters [37], there is no agreed upon definition for the "quality of study". However, the CRD Guidelines [44] and the Cochrane Reviewers' Handbook [45] both elaborate the quality of a study in terms of "less biased" and being higher in its internal and external validity. Less biased refers to the production of true results or absence of systematic error. Internal validity is associated with the error- free design and conduct of the study. External validity relates to the extent that the study findings could be generalized.

3.4.1 Study Quality Checklist

Our SLR followed the quality checklist suggested by Kitchenham & Charters [37], and Kitchenham & Bereretton [38]. This focuses on biasing and validity issues related with the various phases of empirical studies. The phases along with the relevant six (6) questions are:

- Design
  - Are the aims clearly stated?
  - Are the variables used in the study adequately measured (i.e. are the variables likely to be valid and reliable)?
  - 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? For example, SE experience, type (student, practitioner, consultant), nationality, task experience and other relevant variables
- Conclusions
  - Are all study questions answered?

For each question above we set scores according to the recommendations from Kitchenham and Brereton [38]. The scores are as follows: Yes = 1 point, No = 0 point, and Partially = 0.5 point. These weightings were accumulated and helped us in assessing the quality of each included study. Based on this scoring, the maximum quality score for a primary study is 6.

3.5 Data Extraction Strategy

The data extraction process was performed by the first and second author, entitled "extractor" and "data checker". This was done to avoid bias in the data gathered from the primary studies [37]. A data extraction form was designed by considering the Research Questions as well as the Study Quality Criteria. An identity code was formulated and assigned to each selected study e.g. PTC(n) is an identity code serial number assigned to every individual study with fixed prefix PTC assumed as Personality Team Climate and a unique number *'n'* as postfix. Other attributes of our data extraction

form were set according to the guidelines provided by Kitchenham & Charters [37] and an example from Salleh et al. [46]. The list of attributes extracted from primary studies is available in Appendix B.

3.5.1 Data Extraction Process

Total retrieved studies as listed in Table 5 were saved into different folders, and the folders were named after the source database/search engine from where the study was downloaded. A list of all studies, their authors and publication year were specified. Each of the primary studies included was assigned a unique identification number for reference on the data extraction form (i.e. data item ID). A separate soft copy of the data extraction form was created in Microsoft Word for each of the relevant studies. The file was stored with the name holding the ID as prefix, then the First Author name, followed by year of publication. In case of multiple publications in same year a sequence number was added as a suffix to the file name. After completing the data extraction process by the first author, a meeting with the second author was held to perform cross-checking of the extracted data.

4. DATA SYNTHESIS AND FINDINGS

The selection of primary studies was based on the set of inclusion and exclusion criteria. The extracted data from these primary studies include both qualitative data (e.g. team climate factors or personality traits associated with software team performance) and quantitative data (e.g. number of subjects covered). Data was presented via descriptive statistical tools (e.g. tables, pivot chart, simple bar chart, multiple bar chart and pie chart).

4.1 Studies' Overview

A total of 35 primary studies were included in this SLR, as per our selection criteria (see list of studies in Appendix A). All the three variables of this research, personality traits, software team climate and software team performance, are rarely found together in any of these studies. However, the relationship between personality traits and team performance is often covered.

The 35 selected studies include 15 journal articles, 15 conference papers, 2 workshop papers, 2 book chapters and 1 magazine article. Most of the studies (30 out of 35) are journal articles and conference papers (see Figure 3). The oldest study is from 1993 [PTC13] and the latest ones from 2015 [PTC25] [PTC33][PTC34]. The list of relevant studies can be seen in Appendix A and a bar chart detailing the number of primary studies published by year is shown in Figure 4. In general, the bar chart suggests a trend towards an increasing number of studies published more recently.

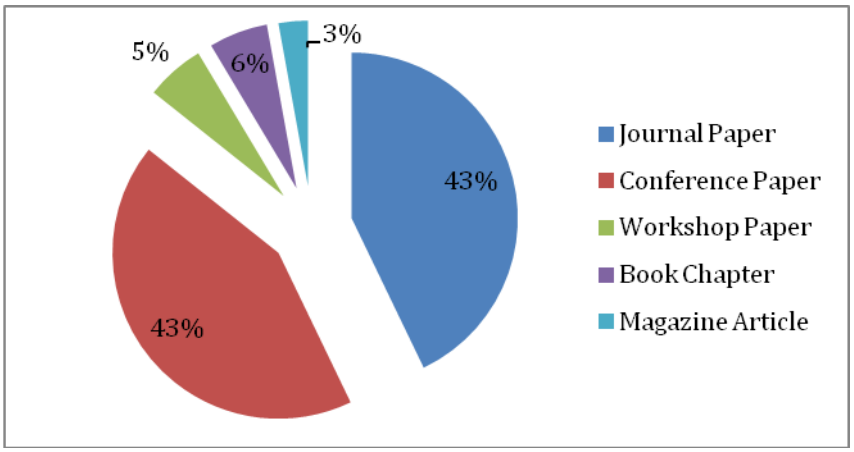

Figure 3: Proportions of studies according to publication type

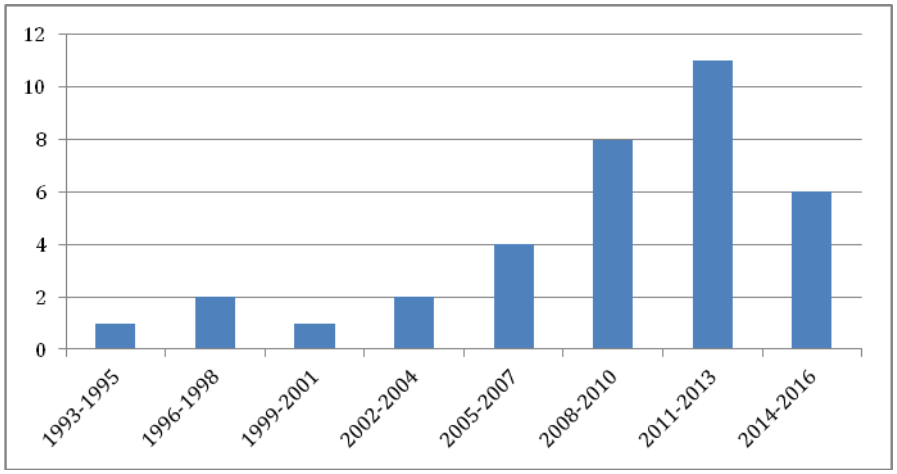

Figure 4: Number of primary studies by Years

The selected studies were assessed based on the quality criteria detailed in section 3.4.1. Table 8 shows the distribution of studies possessing different quality scores within the range 0 (poor) to 6 (very good). The quality score 3 is considered as borderline as it denotes 50 percent of total quality score. Therefore studies below quality score 3 were not included in SLR. Based on the quality assessment, in general we found that most of the studies (27 out of 35) are of "very good" quality and there was no study having quality score below 3.

Table 8: Studies distribution as per Quality Score Range

Quality Score Range(QSR)[4]	**Quality Level**	**No. of Studies**
QSR<2	Poor	0
QSR>=2 and QSR<=3	Borderline	0
QSR>3 and QSR<4	Fair	6
QSR>=4 and QSR<5	Good	2
QSR>=5 and QSR<=6	Very Good	27
Total		35

4.2 Answering the Research Questions

While answering our study's research questions the data extracted in data extraction forms were used. Table 9 shows the list of relevant studies for each of the RQ.

Table 9: List of relevant studies for each RQ

RQ#	**Study ID#**	**#Studies**
RQ1	PTC1, PTC2, PTC3, PTC4, PTC6, PTC8, PTC9, PTC12, PTC15, PTC16, PTC21, PTC35	12
RQ2	PTC2, PTC3, PTC5, PTC7, PTC9, PTC10, PTC11, PTC13, PTC14, PTC17, PTC18, PTC19, PTC33	13
RQ3	PTC2, PTC3, PTC5, PTC7, PTC9, PTC10, PTC11, PTC13, PTC17, PTC18, PTC32, PTC34	12
RQ4	PTC4, PTC7, PTC13, PTC14, PTC17, PTC18, PTC19, PTC20, PTC22, PTC28, PTC32, PTC34, PTC35	13

4.2.1 *What, if any, are the key software engineer personality trait(s) that have a significant influence on software team climate and/or software team performance? (RQ1)*

This research question focuses on the effects of software engineers' personality trait(s) on software team climate and/or software team performance. None of the studies showed any association between personality and team climate. In total, 12 out of the 35 primary studies included in this SLR have provided data on personality factors out of which nine (9) studies reported personality model/instruments that were used to measure personality and three (3) studies [PTC9], [PTC15] and

[4] The total Quality Score is 6.

[PTC16] have not reported any specific personality measure. Table 10 shows the personality models/instruments that have been used in the primary studies. We found that MBTI has been used in five studies (PTC2, PTC3, PTC6, PTC8, PTC35) whereas the remaining studies have utilized various instruments based on FFM.

Table 10: Personality model/instruments used in primary studies

S#	Study ID	Personality Model/Instrument
1	PTC1	FFM[5]
2	PTC2	MBTI
3	PTC3	MBTI
4	PTC4	FFM(BFFM100)
5	PTC6	MBTI
6	PTC8	MBTI
7	PTC12	IPIP (FFM)
8	PTC21	NEO-FFI (FFM)
9	PTC35	MBTI

Extraversion is one of the personality factors in the FFM and studies reported that present a positive influence on software professionals' performance. In three of the included studies [PTC3], [PTC4] and [PTC12] it was reported that software team members with an *extroverted nature* are good in interpersonal skills, social activities and they feel comfortable to work together as a team. This supports the factors discussed in [PTC15] *communication, comfortable, confidence* and *compromise*, which define the extraverted personalities. [PTC15] reported that professionals who possess these attributes build a successful software development team.

[PTC16] identified the attributes of a good programming team member as having *interpersonal skills*, and expanding his/her knowledge to others can lead towards the development of successful teams. Meanwhile, in another study [PTC6] it is reported that the *introversion personalities* decreases the effectiveness of software development teams due to lacking in interpersonal communication skills. In [PTC6], the study tested subjects' personality using the MBTI. In [PTC4] an experiment on software programmers was performed and it is reported that *Extraversion* is the strongest personality trait for the software team aggregation; other personality factors were *agreeableness, conscientiousness, emotional stability* and *openness*. Besides personality traits, the study also included some other human characteristics, including *gender, expertise, attitudes, preferences, ethnicity, generation* and e*xpertise* of software engineers as being interrelated with the performance of software development teams [PTC4].

[PTC35] is another study with MBTI and it proposed a model having influential factors related to the team performance. The authors have not mentioned any specific personality factor in association to the team performance rather they used the term *personality type heterogeneity*. The *personality type heterogeneity* refers to the individuals with mixed personality types in an IS team, such teams considered more effective than the teams possessing homogenous personalities [PTC35].

In [PTC9] the high level of *self-efficacy* has been related to performance. The author mentioned that *self efficacy* has the motivational effects on individuals [PTC9]. In this study, *self-efficacy* refers to the way people think and feel to motivate themselves. According to Bandura [47] *"people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives"*.

In [PTC2] some other personality factors with general negative impact on teams' stability are highlighted: *self-esteem, locus of control, introversion/extroversion, authoritarianism, dogmatism* and *dependability.* Without any elaboration for any of these factors the author mentioned them as personality differences. According to the author these personality differences may cause conflict

[5] *No particular tool or instrument was mentioned.*

among the group members which can lead to the decrement in team stability. However any prescribed high or low level for *self-esteem* and *dependability* was not reported in [PTC2]. Table 11 shows the personality factors addressed in the primary studies included in our SLR.

Table 11: Significant Personality Factors Affecting Software Team Performance

Study ID	Personality Factors	
	Positive Impact	**Negative Impact**
[PTC3][PTC4][PTC12] [PTC21]	Extraversion	N/A
[PTC15][PTC16]	Interpersonal Communication	N/A
[PTC9]	Self efficacy	N/A
[PTC15]	Comfortable and Compromise	N/A
[PTC4]	Mental Ability and Expertise	N/A
[PTC2]	N/A	Self-esteem, locus of control, introversion/extroversion, authoritarianism, dogmatism and dependability

4.2.2 *What are the key factors in team climate composition that have been addressed or investigated in software development teams/projects*? (RQ2)

Team Climate is referred to as the exchange of ideas and perceptions among team members favourably promoting innovation in work processes [11]. Anderson & West [10] used two approaches to define team climate known as "*the cognitive schema approach*" and "*the shared perception*". The cognitive schema approach refers to an individual's constructive representation of their work environments and the second approach represents the shared perceptions of organizational policies, procedures and practices.

In our study it has been discovered that some studies included the terms "organizational climate" [PTC11], "group cohesion" [PTC13][PTC14][PTC17] and "collaboration" [PTC2][PTC3] as alternative terms for team climate. The term "organizational climate" included the factors *high standards of work tasks, effective supervision, intrinsic fulfilment* and *role clarity* [PTC11]. In [PTC13] the cohesive groups are characterized by high levels of member attraction to the group, mutual liking, cooperation, and positive feelings about carrying out the group's tasks [48–50]. [PTC17] presented the term "group cohesion" as "*an individual's sense of belonging to a particular group and his or her feelings of morale associated with membership in the group*" (pg. 58) [51]. [PTC13] reported that highly cohesive software development groups have positive influence on their performance.

[PTC3] has reported the term "collaboration" as one of the factors of social behaviour. Collaboration along with other factors of social behaviour including *aggression, cooperation, and individuals' affiliation with other individuals* must be managed among software engineers to improve team performance. In [PTC5] the term "team climate" includes two characteristics or elements: *i) Uncertainty*: i.e. the type of team climate considered as "efficient", "excitation", "neutral", and it may be "negative", and *ii) Performance*: i.e. the type of team climate that has an important impact on team performance. It is further stated that the "team climate factors" are responsible to form the "scene". Every single team climate factor in the "scene" is considered as the condition to bring the type of "team climate" or the condition to increase the impact on team performance [PTC5].

In [PTC5] the major team climate factors are called as "triggering factors". These factors are *play advantages and abilities, job importance, clear work requirements, teamwork and support, commit to doing high quality work,* and *recognize or praise* [PTC5]. These six triggering factors have been analyzed individually by conducting survey among project managers, and it is reported that the team climate influences the team members' enthusiasm and this consequently results into positive inclination in software teams' performance. [PTC7] and [PTC10] reported that team climate has direct impact on software development team productivity and can lead to higher performance.

Another term known as "input-throughput-output" [52] [PTC19], where the intermediary term "throughput" is composed *of interaction among team members, exchanging of information, decision-*

making participation pattern and *social support*. [PTC9] studied the "agile team environment" composition factors that include *whole team involvement, agile values* (trust, openness and respect during team interactions), *culture of action & change* (in terms of bringing progress and improvement in team activities) and *collective thinking* (see Table 12). In [PTC18] project team composition is defined in two terms: *i) project team member composition* and *ii) project task*. It was reported that they are significantly correlated with project performance. In [PTC33] the term "IT team climate" is explored with the influence of Confucian work ethic. The authors defined team climate as companies norms reflected by employees' behaviour [53] .

Table 12: Team Climate Compositions

Term	**Factors of Composition**	**Study ID#**
Team climate	Vision, participative safety, task orientation and support for innovation	[PTC7][PTC10]
Organizational climate	High standards of work tasks, effective supervision, intrinsic fulfilment and role clarity	[PTC11]
Group cohesion	Members' affiliation with the group, mutual liking, cooperation, and task responsibility	[PTC13][PTC14][PTC17]
Collaboration	Aggression, cooperation, and individuals' affiliation with other individuals	[PTC2][PTC3]
Triggering factors	Play advantages and abilities, job importance, clear work requirements, teamwork and support, commit to doing high quality work, and recognize or praise	[PTC5]
Agile team environment	Whole team involvement, agile values, culture of action and change, and collective thinking	[PTC9]
Through-put	Team members' interaction, exchanging of information, decision-making participation pattern and social support	[PTC19]
Team Processes	Communication, conflict and cohesion	[PTC14]
IT Team climate	N/A	[PTC33]

4.2.3 *Which software team climate factor(s) has effects on software team performance*? (RQ3)

In total, 12 out of 35 studies were found relevant to answering our RQ3. Although the term software team climate is not used directly in many studies, alternate terms have been used in some studies. As reported in nine (9) studies, c*ollaboration, cooperation, coordination, collective thinking* and *cohesion* were considered as alternate terms to each other and has potential to improve the efficiency and performance of software teams [PTC2], [PTC3], [PTC5], [PTC7], [PTC9], [PTC10], [PTC13], [PTC17], [PTC18] (see Table 13).

Role allocation to a team member in a software development team is the second most focused factor of team climate that was reported as affecting software teams' performance [PTC2][PTC5][PTC11]. Role allocation is defined as "*assigning responsibilities to each team member according to their capabilities"* [PTC2]. [PTC9] focused on agile team methodologies and reported that the *whole team awareness* and *constant feedback* on delivery of working software to the individual team member is reported as the binding force and source of motivation in cohesive teams.

Participatory safety, which is one of the inventories of team climate [10] is also reported as a significant factor affecting software teams' performance [PTC7][PTC10]. West [54] defined participative safety as *"Participativeness and safety are characterized as a single psychological construct in which the contingencies are such that involvement in decision-making is motivated and reinforced while occurring in an environment which is perceived as interpersonally non-threatening"* (pg. 311).

[PTC5] identified 20 team climate factors out of which 6 major factors namely were *play advantages and abilities, job importance, clear work requirements, teamwork and support, commit to doing high quality work,* and *recognition or praise*. In [PTC5], the potential impact of these six triggering factors

has been analysed individually by conducting survey among project managers, and it is reported that there is a significant relationship between team climate factors and team performance. The team climate influences the team members' enthusiasm and this consequently results into positive inclination in software teams' performance.

In one study [PTC17] reported that cohesion is not related with software teams' performance, however *user representativeness* and *team members' involvement in system design* can affect software teams' performance.

The study [PTC18] included project team characteristics namely *team member composition* and *project task*. Project team member composition includes *member familiarity, background diversity, or gender diversity, flexibility in job assignment* and *age*. The project task characteristics have three dimensions: *task variety, task importance,* and *task identity*. It is reported in [PTC18] that project team characteristics have a very high impact on software teams' performance.

The primary studies [PTC32] and [PTC34] focused on *communication*. It is reported that facilitating good communication can produce a good *atmosphere*. The term *atmosphere* has been used to represent the soft environmental factors which have direct association with the performance [55,56]. Sudhakar et al. [34] listed soft factors in their research which are *team climate, team diversity, team innovation, team member competencies and characteristics, top management support* and *team leader behaviour*.

Table 13: Significant Team climate factors affecting Team Performance

Studies	Significant	Not Significant
[PTC3][PTC9][PTC13]	Collaboration, cooperation, coordination	N/A
[PTC5]	Play advantages and abilities, job importance, clear work requirements, teamwork and support, commit to doing high quality work, and recognize or praise	N/A
[PTC7]	Commitment, trust, and coordination	N/A
[PTC9]	Agile values(trust, openness and respect) and collective thinking	N/A
[PTC2][PTC11]	Role allocation	N/A
[PTC7] [PTC10]	Participatory safety	N/A
[PTC18]	Composition and project task	N/A
[PTC17]	User representativeness and team members' involvement in system design	Cohesion
[PTC32][PTC34]	Communication	N/A

4.2.4 How software teams' performance is measured? (RQ4)

A total of twelve (13) studies, out of 35 studies, provided evidence to answer RQ4. These studies document various factors that have been used to measure team performance. Table 14 shows the instruments used to measure performance of a software team.

In [PTC4] the measures for team performance are mentioned as *Correctness, Duration, Methodology, Extensibility, Cost effectiveness, Redesign* and *Regression grade*. The *time* or *time duration*, *on-time*, *timeliness* or *schedule* have been commonly used in four (4) studies [PTC4], [PTC7], [PTC14], [PTC18] to measure team performance.

Table 14: Measures used for Team Performance

Study ID#	Measures
PTC4	Correctness, Duration, Methodology, Extensibility, Cost Effectiveness, Redesign, Regression grade
PTC7	Hoegl and Gemuenden (2001)
PTC13	Group Characteristics(Group Cohesiveness, Group Experience and Group Capability)
PTC14	Cost, Time and Scope
PTC19	Quantity, Quality, Speed, Customer Satisfaction Degree
PTC17, PTC18, PTC20	Henderson & Lee (1992)
PTC28	Jiang et al. (1997)
PTC35	Effective leadership, Intra-team communication, Group cohesion and Personality heterogeneity

[PTC7] used Hoegl & Gemuenden [57] to assess team performance based on two factors: *effectiveness* (the degree to which project goals were achieved) and *efficiency* (the degree to which the project was on-time and on-budget). Hoegl & Gemuenden [57] presented a comprehensive concept of collaboration in teams and named it Teamwork Quality (TWQ). The TWQ construct has six measures: *i) communication, ii) co-ordination, iii) balance of member contributions, iv) mutual support, v) effort* and *vi) cohesion.*

Henderson & Lee [58] instrument is based on *subjective* measures and reported in three (3) primary studies [PTC17], [PTC18] and [PTC20]. They have measured the performance by taking non-team stake-holders as a subject. Stakeholders are defined as *"individuals who were not formal members of the project but were directly affected by the output of the team or could directly affect the team's performance"* [PTC17][PTC18][PTC20].

The [PTC20] used the Henderson & Lee [58] instrument and perceptual measures for team performance. The [PTC20] measures included: *i) the quality of the software, ii) the ability of the team to work together effectively, iii) the efficiency of the team* and *iv) satisfaction with the resulting product*. In [PTC17], the authors report the dimensions of team performance as *efficiency, effectiveness* and *timeliness*. These three variables were also measured by items based on scales developed by Henderson & Lee [58].

Cost incurred is also considered as an important factor to measure performance in [PTC4], [PTC7], [PTC14] and [PTC18]. In [PTC4] Cost effectiveness is defined as *simplicity* and *reusability* of the software code and in [PTC20], cost variance is one of the objective measures of software team performance. Efficiency in [PTC7] has been defined in two terms: *i) the degree to which the project was on-time*, and *ii) on-budget*.

Another study [PTC13] presented three variables *group cohesiveness, group experience* and *group capability* that can help in measuring software team's performance. These three variables were defined as three main characteristics of software development groups. It is reported [PTC13] that *cohesiveness* had largest influence on team performance after which the capability variable has shown influence and the third variable experience had weakest influence on group performance.

[PTC14] specifically stated three factors that can be used to measure performance: *i) cost, ii) time,* and *iii) scope*. [PTC19] recommended implementing the team compensation to evaluate team performance. They referred many definitions for individual and team performance but did not mention any particular measurement tool or instrument. [PTC22] carried out research on student teams practically involved in large-scale software development projects from industry. In [PTC22] past and current academic grades given by clients and managers were used to measure the individual performance. [PTC35] carried out case research on two IS teams' performance. In [PTC35] four factors namely *effective leadership*, *intra-team communication*, *group cohesion* and *personality*

heterogeneity were used to measure the team performance. The result of this study showed that the personality types are an important factor for successful teams.

[PTC28] used Jiang et al. [59] six measures to measure the team performance. These measures are amount of work, quality of work, efficiency of team operations, user interaction effectiveness, adherence to budgets, and adherence to schedule. [PTC32] and [PTC34] reported 33 major categories of performance factors. The authors presented these factors in a theoretical structure that explains how the subjects experience software team performance [55,56]. They concluded that the practitioners perceive performance in many ways varying from individuals and teams to organisations, markets, and customers.

5. Discussion

This SLR reported 35 studies relating to personality and team climate research conducted on software professionals in the software industry context. The quality of each selected primary study was assessed on the basis of quality criteria and in general most of the studies were found as of more or less very good quality. In this section we discussed about the implications of our SLR findings (Section 5.1), recommendations (Section 5.2) and threats to the validity of our findings (Section 5.3).

5.1 Implications

Software development teams are, like the other technical teams, made up of capable skilled professionals. Cromar [61] suggests that *"-- the programmers are optimistic*" - they are nevertheless also humans with individuality and possess diverse personalities. This SLR focused on better understanding of software professionals' personality and team climate factors that influence the software team members to perform efficiently together as a team.

In terms of personality measurement MBTI and FFM were mostly adopted in primary studies. Dysfunctionality of personality was not discussed at all in any primary study. Dysfunctional traits are personality disorders or dysfunctional interpersonal dispositions that (a) coexist with talent, ambition, and good social skills, and (b) prevent people from completing the essential task of leadership that is building a team [62]. Hogan & Hogan [63] have developed an inventory that consists of 11 key dimensions which deals with personality disorder and was intended to predict managerial failure. In relation to this aspect, future research regarding personality disposition in software development teams might be an area of interest to be investigated.

Cruz et al. [14] have conducted an SLR on personality in software engineering to identify the research topics, methods used, personality tests applied and the effects of personality on tasks and process of software engineering. In their recent study in which they have covered forty years of literature, they have classified the primary studies into number of categories representing major research topics such as pair programming, personality in Education, team effectiveness, and software process allocation among others [35]. The term "team climate", however was not highlighted in their study and this might indicate that the association between personality and team climate has not been investigated in any of the included studies.

The association of team performance and the nature of team had also been discussed in the past research within organizational behaviour domain. To get a clear understanding about the nature of team or group, different points-of-views were presented by researchers, e.g. socio-technical theories [64,65], self-leadership theories [66] and participative management theories [67,68]. These theories also explained team effectiveness of teams in work settings [69]. The understanding regarding the nature of groups gave the idea of *group dynamics* or *team dynamics* which was initially conceived by Kurt Lewin [70]. Later, Cartwright & Zander [71] provide a formal definition of group dynamics as *"field of inquiry dedicated to advancing knowledge about the nature of groups, the laws of their development, and their interrelations with individuals, other groups, and larger institutions"* (pg. 7).

The concept of "group dynamics" has been through evolutionary stages which added more knowledge from other behavioural sciences [72]. The additional information in the concept of group dynamics has defined a set of group tasks in psychological perspective. For instance, Vugt & Kameda [73] have proposed six (6) adaptive group tasks: *i) coordination, ii) social exchange, iii) status, iv) group cohesion, v) collective decision making, and vi) intergroup relations*. These group tasks can be helpful to construct an evolutionary framework to understand the group processes in the domain of software engineering [72].

This SLR has provided an insight into group tasks associated with the term group dynamics as can be seen in Table 13. The term group dynamics can be perceived in a broader perspective, while the term team climate is following only the two set of theories belongs to the area of group dynamics*; i) self-leadership theories* [66] and *ii) participative management theories* [67–69].

Driskell et al. [74] relate the specific personality traits with the group dynamics or teamwork dimension in order to define effective team performance. They have developed a model by defining personality facets most relevant to team performance and relate them with teamwork dimensions. Such a model can be useful for SE community for recruiting and training of team members to enhance team performance.

Based on our SLR's findings, we identified that almost all studies adopted the general term "team climate" and the measurement instrument that has been commonly employed was TCI [10]. The used of TCI in software engineering domain triggers the idea that researchers were comfortable to adopt this general inventory without considering the specific differences between the team climate for software groups and the work groups in other domains. We also observed that the diverse team climate compositions found in primary studies are related to the domain of organizational behaviour and social sciences. In future research the results of this SLR would be helpful to design a specific team climate model for software groups and team climate inventory to measure it.

We found from our SLR that performance measures comprise of objective and subjective measures [75]. Objective measures include *function points, complexity metrics, cost variance, schedule variance,* and *resource consumption*. Subjective or perceptual measures include *user satisfaction, teamwork satisfaction* and *perceived output quality* [75]. While answering the review question addressing the team performance measures we have been through the studies which referenced many definitions from different authors with various sets of measures for team performance. This affirms the statement mentioned by Sawyer [75] that *"Software development team performance demands multiple measures as no single metric can capture a total picture of the effort"*. Based on the approaches given by Sawyer [75] it has been observed that the subjective or perceptual measures were more preferred than the objective measures. As it can be seen in Table 14, Henderson & Lee [58] instrument has been used in three primary studies ([PTC17][PTC18][PTC20]) and it is based upon subjective measures.

5.2 Threats to Validity

The results of this SLR might have been affected by some limitations such as bias in the selection of primary studies, inaccuracy in performing data extraction, and assessing quality of the studies. We addressed the issue of bias in study selection through comprehensive searching from search databases commonly used in existing SLRs (e.g. [35], [41], [44]) and also based on Kitchenham & Charters [37] that help to minimise the possibility of missing evidence. The searching phase of this research faced some limitations due to limited and un-availability of suitable search options in the search engine and online databases. For example, the IEEEXplore, Emerald Insight and Google scholar search engine do not support the lengthy search string. In case of IEEEXplore it is clearly mentioned that the maximum number of search terms is 15. Hence, to overcome this issue, we created several sub-strings, which were executed separately and the results from each execution was recorded and then accumulated.

To minimise the bias in data extraction and study quality assessment, the first author extracted the data under the guidance of the second author. Beside this the second author selected about 20% of the primary studies and filled in the data extraction form. The evaluation of quality level of primary studies was considerably subjective. For instance, some studies did not explicitly define the variables or measures used in their research design. We had a meeting to discuss any discrepancies we found during the extraction process until a consensus is met.

5.3 Recommendation

Software engineering mainly relies on working in teams [5]. In comparison to work teams or work groups in other domains, software development teams are different in terms of nature of their tasks or activity [5]. This suggests that the team climate for software engineering teams may possibly differ than for other teams. There was only one (1) primary study found in our SLR which has used the specific term "IT team climate" [PTC33] in which they have determined the impact of IT co-workers on individual deviance behavior in organizations. This indicates that more research should be carried out to investigate team climate in the domain of software engineering.

While conducting this SLR which mainly focused on personality, team climate and performance, we have noticed that one of the known aspects related to the personality: "personality disorders" or the "dark side of personality" was not found in the primary studies. Thus, future research would address the missing areas related to the personality or other dimensions associated with the software team, team climate and team performance.

As discussed in section 5.2 regarding the threats faced during the conduct of this SLR, we observed that there is a need to improve the searching techniques as well as search interfaces in some of the online databases in favor to increase their search reliability. In relation to this, we would recommend that the SE community should establish a link (or a one-stop portal/database) that indexes studies related to the SE area in order to support evidence-based research in SE. It is also important to apply a common set of interfaces in online databases in order to enable a consistency of literature search.

6. CONCLUSIONS

The number of primary studies included in the SLR was 35, with no significant work found on personality and team climate, which indicate that quite a limited research has been done to date on team climate and personality in the domain of software engineering, and using software professionals as subjects. We found that the publication years of these studies ranging from 1993 to 2015.

This research is meant to reveal the effect of software engineer's personality on team climate and team performance. The first review questions helped in identifying whether there is any association between the personality trait(s), team climate and team performance. Almost all studies reported about the relationship between the personality and team performance without noticeably mentioning the term "team climate".

In terms of the personality measurement models, we found from our SLR that MBTI and FFM were widely used by researchers. Another clear gap is that FFM as a theoretical framework has not so far being used in many studies involving software industry professionals as subjects in relation with team climate and team performance.

The findings from our SLR showed that there is no single agreed upon team climate composition defined in the domain of software engineering. It has been observed while answering the second review question that primary studies included diverse team climate compositions which are related to the domain of organizational behaviour and social sciences. Instead of using the term "team climate" many studies used the alternate terms as mentioned in Table 12. There is also no evidence available on personality disorders in software teams because none of the study included measurement of the dysfunctional traits.

The third review question helped in identifying the significant team climate factor and its effect on team performance. The results showed that project team characteristics have a significant impact on software team performance. The fourth review question focused on identifying different ways of measuring team performance. We found that three (3) primary studies have used the instrument based on Henderson & Lee [58] team performance measures and a single study with the instrument based on team performance measures by Hoegl & Gemuenden [57]. Both set of measures belong to organizational sciences and generally adaptable in many domains.

The findings from this SLR would be beneficial for understanding the personality assessment of software development team members by revealing the traits of personality taxonomy, along with the measurement of the software development team working environment. The said measurements would be useful in examining the success and failure possibilities of software projects in development processes.

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Appendix A: List of studies included in the SLR

PTC1. Asil, A., Asil, H., & Asil, M. (2012). The Effect of Programmers on Software Project Management Based Upon Personality Five Traits Theory. *International Journal of Emerging Technology and Advanced Engineering*, *2*(11), 796–798. Retrieved from http://www.ijetae.com/files/Volume2Issue11/IJETAE_1112_125.pdf

PTC2. Dafoulas, G. A., Street, S., & Macaulay, L. A. (2001). Facilitating Group Formation and Role Allocation in Software Engineering Groups. In *Computer Systems and Applications, ACS/IEEE International Conference* (pp. 352–359).

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PTC6. Karn, J., Court, R., & Cowling, T. (2006). A Follow up Study of the Effect of Personality on the Performance of Software Engineering Teams. In *ACM/IEEE international symposium on Empirical software engineering* (pp. 232–241).

PTC7. Sumner, M., & Molka-Danielsen, J. (2010). Global IT teams and project success. *Proceedings of the 2010 Special Interest …*, 34–42. Retrieved from http://dl.acm.org/citation.cfm?id=1796920

PTC8. Cunha, A. B., Canen, A. G., & Capretz, M. A. M. (2009). Personalities , Cultures and Software Modeling : Questions , Scenarios and Research Directions. In *Proceedings of the 2009 ICSE Workshop on Cooperative and Human Aspects on Software Engineering. IEEE Computer Society* (pp. 23–31).

PTC9. Whitworth, E. (2008). Experience Report: The Social Nature of Agile Teams. In *Agile 2008 Conference* (pp. 429–435). IEEE. doi:10.1109/Agile.2008.53

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PTC12. Feldt, R., Angelis, L., Torkar, R., & Samuelsson, M. (2010). Links between the personalities, views and attitudes of software engineers. *Information and Software …*, *52*(6), 611–624. doi:10.1016/j.infsof.2010.01.001

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PTC14. Da Silva, F. Q. B., França, a. C. C., Suassuna, M., de Sousa Mariz, L. M. R., Rossiley, I., de Miranda, R. C. G., … Espindola, E. (2013). Team building criteria in software projects: A mix-method replicated study. *Information and Software Technology*, *55*(7), 1316–1340. doi:10.1016/j.infsof.2012.11.006

PTC15. Dick, A. J., & Zarnett, B. (2002). Paired Programming & Personality Traits. In *International Conference on eXtreme Programming and Agile Processes in Software Engineering* (pp.82–85). Retrieved from http://cf.agilealliance.org/articles/system/article/file/916/file.pdf

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PTC19. Liu Liwei; Zhao Erdong, "Team Performance and Individual Performance: Example from Engineering Consultancy Company in China," *Management and Service Science (MASS), 2011 International Conference on* , vol., no., pp.1,4, 12-14 Aug. 2011

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PTC24. Walle, T., & Hannay, J. E. (2009, October). Personality and the nature of collaboration in pair programming. In Empirical Software Engineering and Measurement, 2009. ESEM 2009. 3rd International Symposium on (pp. 203-213). IEEE.

PTC25. Li, P. L., Ko, A. J., & Zhu, J. (2015, May). What makes a great software engineer?. In Proceedings of the 37th International Conference on Software Engineering-Volume 1 (pp. 700-710). IEEE Press.

PTC26. Ahmed, F., & Capretz, L. F. (2010). Why do we need personality diversity in software engineering. ACM SIGSOFT Software Engineering Notes, 32(2), 1-11.

PTC27. Varona, D., Capretz, L. F., & Piñero, Y. (2011). Personality types of cuban software developers. Global Journal of Engineering Education, 13(2), 77-81.

PTC28. Gorla, N., & Lam, Y. W. (2004). Who should work with whom?: building effective software project teams. Communications of the ACM, 47(6), 79-82.

PTC29. Sodiya, A. S., Longe, H. O. D., Onashoga, S. A., Awodele, O., & Omotosho, L. O. (2007). An improved assessment of personality traits in software engineering. Interdisciplinary Journal of Information, Knowledge, and Management, 2, 163-177.

PTC30. Ferreira, V., Natasha, N., & Langerman, J. J. (2014, August). The correlation between personality type and individual

performance on an ICT Project. InComputer Science & Education (ICCSE), 2014 9th International Conference on(pp. 425-430). IEEE.

PTC31. Yilmaz, M., O'Connor, R. V., & Clarke, P. (2014). An exploration of individual personality types in software development. In Systems, Software and Services Process Improvement (pp. 111-122). Springer Berlin Heidelberg.

PTC32. Fagerholm, F., Ikonen, M., Kettunen, P., Münch, J., Roto, V., & Abrahamsson, P. (2014, May). How do software developers experience team performance in lean and agile environments?. In Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering (p. 7). ACM.

PTC33. Zhang, H., Luo, X. R., Liao, Q., & Peng, L. (2015). Does IT team climate matter? An empirical study of the impact of co-workers and the Confucian work ethic on deviance behavior. Information & Management, 52(6), 658-667.

PTC34. Fagerholm, F., Ikonen, M., Kettunen, P., Münch, J., Roto, V., & Abrahamsson, P. (2015). Performance Alignment Work: How software developers experience the continuous adaptation of team performance in Lean and Agile environments. Information and Software Technology, 64, 132-147.

PTC35. J. H. Bradley and F. J. Hebert, "The effect of personality type on team performance," J. Manag. Dev., vol. 16, no. 5, pp. 337–353, 1997.

Appendix B: Data Extraction Form fields

1. Primary Study ID
2. Title of Study
3. Author(s) Names
4. Year of Publication
5. Type of Study: Journal Publication/ Conference Paper/ Conceptual Paper
6. Source of Study: Name Of Online Database/ Digital Library/ Journal
7. Source Type: Online Database/ Digital Library/ Manual Search
8. Name of Journal/Conference in which study has been published
9. Keyword(s): Major keywords used in the study, which were also helpful in scrutinizing of the relevant study.
10. Aims/Objectives/Goals of study
11. Hypothesis formulated in the study
12. Research Question(s) of the study
13. Subject covered in the study e.g. IT or IS professionals (software engineers, software developers, software team leaders), Telecommunication personnel, Technicians, end users, under-graduate students.
14. Population/Sample size
15. Independent Variable(s)
16. Dependent Variable(s)
17. Other Variable(s): Which addresses any other control variables discussed in the study
18. Research Method used in the study, which could be qualitative, quantitative, correlation/regression, quasi-experimental, experimental or meta-analysis
19. Instrument(s) used in the study, it refers to those tools or techniques which were used by the researchers for data collection either directly developed by the researcher or pre-developed and merely adopted by the researcher in the study.
20. Team Climate Elements Composition Addressed; this addresses the first research question of the study and focuses on key elements or factors which compose the phenomena of software team climate.
21. Effects of Software Engineer Personality Traits on Software Team Climate in terms of Software Team Performance; this is the second research question of the study.
22. Software Team Climate factor(s) associated with software team performance; it is covering the third research question of the study, specifically intends to find the major software team climate factor(s) helpful in software team performance
23. Software Team Performance metrics; another important research question which keenly associated to locate the major measures of software team performance.
24. Results of the study
25. Study Quality; it has been discussed earlier in quality check list and procedure part and hence included in data extraction form.
    a. Design
        i. Are the aims clearly stated?
        ii. Are the variables used in the study adequately measured (i.e. are the variables likely to be valid and reliable)?
        iii. Are the measures used in the study fully defined?
    b. Conduct
        i. Are the data collection methods adequately described?
        ii. Analysis
        iii. Are the study participants or observational units adequately described? For example, SE experience, type (student, practitioner, consultant), nationality, task experience and other relevant variables
    c. Conclusions
        i. Are all study questions answered?
26. Total quality score; the score which is given according to the scale defined above and helps in rating the primary study relevancy and comprehensiveness