Evaluating the Relationship of Personality and Teamwork Quality in the Context of Agile Software Development

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***Abstract*—The software industry is increasingly adopting agile software development (ASD). A characteristic of ASD is of focusing on people over processes. Given this, the literature presents models to evaluate teamwork quality for agile teams. Another perspective is to predict the team's behavior, given the members' personality. This study aims to evaluate the effect of the personality of a team on its teamwork quality. For this purpose, we executed an empirical study collecting data from 38 subjects from five software teams, using a psychometric and a teamwork quality instrument presented in the literature. We triangulated the data from both instruments to check their agreement through correlation analysis. As a result, the soft skills expected given the psychometric instrument were observed given the metrics presented in the teamwork quality instrument, evidencing the impact of the team's personality on its efficiency. Moreover, we observed that the personality of the project manager has a direct impact on the behavior of the team. The results presented herein show that personality instruments might be used to predict the team's behavior having several applications such as assisting in forming teams.**

Keywords: Agile team; Psychometric instruments; Personalities; Bayesian networks.

I. Introduction

Recently, Agile Software Development (ASD) has become the mainstream development method of choice [10]. It consists of a change-driven approach to developing software in the context of volatile requirements [11]. ASD relies highly on people factors, as evidenced in the Agile Manifesto: six out of the twelve principles are teamwork related factors such as collaboration, communication, and motivation.

The literature presents several studies exploring the relationship between personal characteristics and ASD. Misra et al. [16] explored success factors in adopting ASD and concluded that personal characteristics of the team members, including interpersonal and communication skills, collaborative attitude, and sense of responsibility, are a crucial success factor. Sheffield and Lemétayer [19] claim the empowerment of the team members is one of the factors that characterize agility. This claim leads to the importance of the team members having proper personal characteristics, as identified by Misra et al. [16]. These claims are confirmed by other studies such as Sahibuddin et al. [18] and Dhir et al. [4].

Researchers have also proposed models to assess ASD teamwork quality. For this purpose, Freire et al. [7] presented a Bayesian network, Lindsjørn et al. [14] applied the Structural Equation Modeling-based instrument, previously proposed by Hoegl and Gemuenden [12], to agile teams, and Moe et al. [17] proposed a Radar Plot. Each of these studies proposes a construct to assess teamwork quality based on expected personal characteristics such as communication, collaboration, and cohesion.

Another perspective is, instead of modeling the team's characteristics or expected behavior, predicting them given the team members' personality. Several researchers have explored this theme in software engineering, such as Kosti et al. [13], Yilmaz et al. [21], Capretz [2], Farhangian et al. [5], and Cruz et al. [3]. For instance, Kosti et al. [13] demonstrated that personality is a predictor for the individual's preference regarding software engineering tasks. Given this, we hypothesize the personality is also a predictor for the teamwork quality.

For this purpose, we executed an empirical study collecting data from 39 subjects from five software teams, using a psychometric and a teamwork quality instrument presented in the literature. We used the 16 Personality Factors questionnaire and the TeamWork Quality (TWQ) model proposed by Freire et al. [7]. We triangulated the data from both instruments to check their agreement through correlation analysis. This study synthesizes the findings of our empirical study focusing on the analysis of the level of agreement of the applied instruments and discussing its implications.

The remaining of this paper is organized as follows: Section II presents an overview of psychometric instruments and the TWQ model proposed by Freire et al. [7]. Section III describes the methodology adopted in this research. Section IV discusses our findings; Section V discusses the study's threats to validity. Finally, Section VI presents our conclusions and

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future works.

II. Background

This section presents an overview of psychometric instruments (Section II-A) and the teamwork quality (TWQ) model proposed by Freire et al. [7] (Section II-B).

A. Psychometric Instruments

One of the main views of personality psychology is the personality can be described by a set of characteristics, being a fixed set of patterns of how a person behaves, feels, and thinks[15]. These characteristics can be used to summarize, explain, or even predict how a person will act in different situations [6]. To determine these personality characteristics, analysts use to apply **psychometric instruments**. The psychometric instruments act as identifiers for personalities. Among them, the most used instruments by psychologists and coaches are the following:

- The **Myers-Briggs Type Indicator (MBTI)**, based on Jungian theory and, to the best of our knowledge, it is the most used psychometric instrument. The MBTI has four dimensions: (i) Extroversion vs. Introversion, (ii) Sensing vs. Intuition, (iii) Thinking vs. Feeling, and (iv) Judging vs. Perceiving [8]. Based on 93 forced-choice items (only two options of which one has to be chosen), a licensed MBTI assessor can identify the type of a person based on the largest score for each bipolar dimension. In theory, each of the 16 different personality types measured by MBTI can be viewed as collections of packaged traits [21].
- The **Big Five Inventory (BFI)** is a structure that considers five factors (i.e., Openness, Consciousness, Extroversion, Kindness, and Neuroticism) which are essential for classifying individual differences in terms of personality characteristics [9]. Based on five comprehensive dimensions (i.e., the personality characteristic), this model suggests a personality visualization. It is worthy to mention that this instrument is one of the most reorganized by personality researchers [13]
- **The 16 Personality Factors (16PF)** questionnaire is a psychometric instrument, from the same family as the BFI, that presents a reliable measure of 16 personality characteristics, describing and predicting a person's behavior in several contexts. It is used to select, develop, and motivate people to make organizations thrive. With over 50 years of research, the insights selected by the 16PF instrument are authenticated by more than 2,700 independent research articles, reviewed by experts, displaying a highly reliable and accurate indicator of future behavior and presumably success [5].

These psychometric instruments, in addition to revealing the personality of the individual, also establish the soft skills determined for each personality type [6]. Although the software industry has become a vital force in society, attracting people of all psychological types, specific characteristics are more represented than others in the software engineering field [20]. For instance, according to Barroso et al. [1], the software field is dominated by introverts, who typically have difficulty communicating with the software end-users.

Since in this study we use the 16PF questionnaire, we describe it in more detail in what follows. We discuss the reasoning for choosing this psychometric instrument in Section III-A. The 16PF generates 16 types of personalities, formed by acronyms generated from the dichotomies emitted by the psychometric instrument [2]. The acronyms are generated from the combination of the initial letters of the ten psychological preferences [3]. For instance, INTJ is obtained from a combination of **IN**tuitive, **T**hinking and **J**udgment. Likewise, ISTP is obtained from **I**ntrover**S**ion, **T**hinking and **P**erception. In the following is presented five dichotomies used in the psychometric instrument applied in the present study:

- Mind: Extroversion; Introversion.
- Energy: Intuitive; Sensitive.
- Nature: Thinking; Feeling.
- Tactic: Judgement; Perception.
- Identify: Assertive; Cautious.

According to combination of aforementioned characteristic, the personalities are organized in the following four groups:

- **Analyst personalities**: INTJ-A/ INTJ-T; INTP-A / INTP-T; ENTJ-A / ENTJ-T; ENTP-A / ENTP-T.
- **Diplomat personalities**: INFJ-A / INFJ-T; INFP-A / INFP-T; ENFJ-A / ENFJ-T; ENFP-A / ENFP-T.
- **Sentinel personalities**: ISTJ-A / ISTJ-T; ISFJ-A / ISFJ-T; ESTJ-A / ESTJ-T; ESFJ-A / ESFJ-T.
- **Explorer personalities**: ISTP-A / ISTP-T; ISFP-A / ISFP-T; ESTP-A / ESTP-T; ESFP-A / ESFP-T.

B. Bayesian Networks for Teamwork Quality Estimation

Freire et al. [7] proposed a Bayesian Network (BN) that models the causal relationships between the key factors that influence TWQ. A Bayesian Network is a probabilistic graphical model that exposes conditional dependency or causality, representing random variables by nodes and conditional dependence by edges in a Directed Acyclic Graph (DAG).

The model outputs a probability distribution that represents the current TWQ and can assist in its process of continuous improvement. Each node in the network represents a key factor of the TWQ, and an edge between two nodes represents a causal relationship (i.e., influence). Also, each key factor has possible states, and each has an associated probability [7]. Figure 1 presents the main variables that make up the model.

To feed the model, the user inserts data related to each input node, according to the observations made by the team during the software development time-frame (e.g., sprint in ASD context). Then, the outputs must be calculated using a Bayesian inference tool, such as AgenaRisk[7]. The calculated results represent probabilities for each node state regarding the quality level of each factor in the current state of the project.

III. Methodology

In this section we present our approach, Personality-based Teamwork Skills (PTS), which uses psychometric instruments to identify the personalities of team members. Based on this classification, we estimate some teamwork skills interesting for

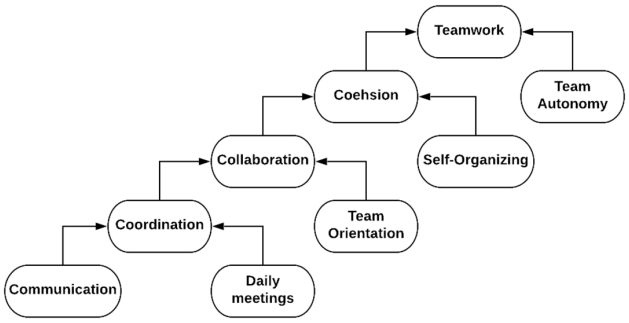

Fig. 1. Key factors that influence agile teamwork

the software development process, comparing our results with the ones found through the Bayesian Network model proposed by Freire et al [7]. Next, we describe our methodology, as well as the environment in which we obtained the data and how we performed the validation.

A. Methods

Among the psychometric instruments presented in the previous session, the 16 Personality Factors (16PF) Questionnaire was chosen to be applied in this study. This choice occurred due to several factors as (i) its free availability on the internet, (ii) its ease of use, and its data analysis to have a vocabulary that is easy to understand [5], (iii) It is one of the most used instruments in the field of psychology [6]. This instrument generates a descriptive analysis of the personality and the soft skills, associated with the one obtained, according to the responses collected and inserted in the instrument, for each individual that composes the work team.

The 16PF is available on the internet and it has about 60 questions. With an application time average about 15 minutes, each one has a scale of markup variation, composed of seven marking circles, which vary from: "Agree"; "Neutral" and "Disagree". The choice of marking directly influences the results obtained. With this, the questionnaire was adapted/transcribed in the text editor and a short header was added, which asked the individual to identify the sex and function performed in the project. Then, printed and applied in loco, with the work teams, of five ongoing projects in the company, formed by a project manager, scrum master; test developers and analysts, totaling 39 subjects (6 women and 33 men) with ages ranging from 23 to 35 years with working experience.

After applying the psychometric instrument, the answers obtained from the printed questionnaires were inserted, one by one, in the same online questionnaire available on the 16PF website, after inserting the questionnaires, descriptive reports of the personalities were generated and saved in a digital folder (i.e., in .pdf format). Then, it aims to perform the analysis of the personalities described in the reports generated by the 16PF, the percentages of the dichotomies issued were generated. These data were correlated with the percentage of nodes and states of the Bayesian network generated from the same agile teams of the applied projects of this research.

B. Environment

We apply the psychometric instrument in a Brazilian software company that works with Scrum-based projects, centralizing its workforce mainly in the development of Web Systems. The company focuses on executing RD projects, in cooperation with other Information Technology and Communication companies, demanding temporary efforts with predefined objectives to create new products, services, or processes. Nowadays, the company executes more than 40 projects together with multinational partners. The projects follow agile methods and each team has 5 to 10 members, depending on the project requirements. Each person spends about 15 minutes - on average - to complete the questionnaire, which was estimated by the 16PF psychometric instrument itself. The questionnaire was applied at the same time to all members, where each answered his own. One of the authors organized this activity and received support from two other authors for coordinating and controlling this activity.

C. Validation

Our validation was performed by analyzing the data generated in the reports issued by the 16PF psychometric instrument. Then, we correlated the aforementioned data with other ones generated from the Bayesian network (See figure 1). In addition to the information described the individual's personalities, the 16PF issues five dichotomies (each one with two partitions that help to describe the personality): mind, energy, nature, tactics and, identity. As seen in Table I.

For each dichotomy, a graph is generated with values, in percentages, based on the factorial analysis, these values are generated from the variations of the responses of the markup variation scale: "I agree"; "Neutral" and "Disagree", contained in the 16PF questionnaire. This instrument uses the matrix of inter-correlations between these variables as a starting point, in an attempt to discover the underlying traits of human personality.

IV. Results and Discussion

After the application of the psychometric instrument, the obtained data were entered into the 16PF web platform. Then, after the individual generation of the personalities report of each team member, the data were inserted into an electronic spreadsheet aiming at organizing them. According to that, it was possible to analyze which were the most predominant personalities of the agile teams by members as well as by function.

The personalities of the agile team members were organized by function, then we made a comparative analysis with the Bayesian model applied to the same projects. From the accomplishment of the previous task, this allowed us to make the correlation of the personalities with the Bayesian model under study.

Figure 2 shows how the types of personalities of the agile teams found in the project 1 (P1) were organized, being composed by the personalities of the project manager (PM) and the work team. During the analysis, we noticed in the same team there were several types of personalities, being

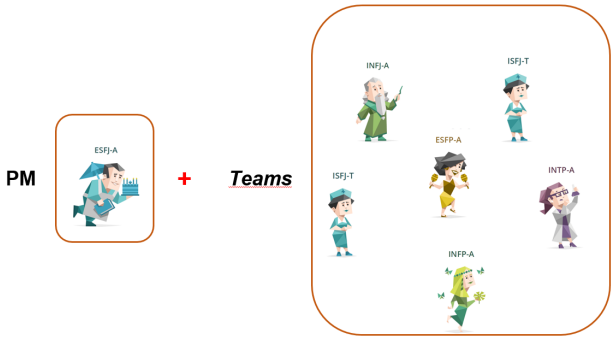

Fig. 2. Types of personalities from the agile project 1 team

able to contemplate the four personality groups presented in section II, named by the instrument under study.

After identifying the personalities of the team, the average of the percentages of the dichotomies obtained from each member was calculated and consolidated in a single graph containing all percentages of the 10 psychological preferences, attributed by the 16PF. The result of the aforementioned task can be seen in Table I below.

TABLE I
DICHOTOMIES OF THE FIVE AGILE PROJECTS (P)

DICHOTOMIES		P1	P2	P3	P4	P5
MIND	EXTROVERTED (%)	40.6	75.5	46	71.7	60
	INTROVERT (%)	52.4	24.5	51	28.3	40
ENERGY	INTUITIVE (%)	45	28.5	42.7	48.9	52.2
	OBSERVER (%)	55	71.5	57.3	51.1	47.8
NATURE	THINKING (%)	41.6	32	34.3	30.3	39.5
	FEELING (%)	58.4	68	65.7	69.7	60.5
TACTIC	JUDGER (%)	63.6	79	71.9	58.6	53.5
	EXPLORER (%)	36.4	21	28.1	41.4	46.5
IDENTITY	ASSERTIVE (%)	69.3	63	57.9	56.6	55.3
	CAUTIOUS (%)	30.7	37	42.1	43.4	44.7

Through the percentages used for each psychological dichotomy, it was possible to identify which were the predominant psychological users in the agile teams for each project. We performed the same analysis for each evaluated project, taking into account the data obtained from the dichotomies of each one. Next, the analysis of the dichotomies prevalent in each project will be shown, according to the data provided in Table I. In what follows, we described the analysis of the predominant dichotomies of software projects:

- **Mind:** The psychological preference *Introvert* - which covers the team members who have the following characteristics: Receptors, Contained, Reflexive and Quiet - had a *slightly higher percentage in projects 1 and 3*. On the other hand, the psychological preference *Extroverted* - which concerns the team members who have characteristics such as Initiatives, Expressive, Active and enthusiastic - was predominant in the *projects 2, 4 and 5*.
- **Energy:** The psychological preference *Observer* - which covers the team members who have the following characteristics: Concrete; Realistic, Practical and Traditional - had a *slightly higher percentage in projects 1, 2, 3 and 4*. Additionally, the psychological preference *Intuitive* - which concerns the team members who have characteristics such as Imaginative, Conceptual, Theoretical and Original - obtained *greater occurrence in project 5*.
- **Nature:** The psychological preference *Feeling* - which covers the team members who have the following characteristics: Empathic, Sensitive and Receptive - achieving a *high occurrence in all evaluated projects*. On the other hand, the psychological preference *Thinking* - which concerns the team members who have characteristics such as: Logical, Questioners, Reviews and Reasonable - obtained *greater occurrence in project 1 and 5*.
- **Tactic:** The psychological preference *Judger* - which covers the team members who have the following characteristics: Systematic, Planned, Anticipated and Methodical - had a *higher percentage in projects 2 and 3* whereas the psychological preference *Explorer* - which concerns the team members who have characteristics such as Informal, Open, Situational and driven by pressure - obtained *greater occurrence in projects 4 and 5*.
- **Identify:** The psychological preference *Assertive* - which covers the team members who have characteristics such as Objectives and Direct - achieving *higher percentage in all evaluated projects*. In addition, the psychological preference *Cautious* - which concerns the team members who have the following characteristics: Weighted, Moderates and Cautions - obtained *greater occurrence in projects 4 and 5*.

Figure 3 shows the following current TWQ of the agile project team 1. The Bayesian networks have the following key factors: *Cohesion; Teamwork; Self-Management; Collaboration; Team orientation; Coordination; Daily Meetings and Communication*. Each factor is composed of the states: *(i) Very low; (ii)Low; (iii) Medium; (iv) High and (v) Very high*. Each one of these factors contains the corresponding percentages of occurrence. These data were acquired by the answers raised by the questionnaire applied to the members of the agile team. The input nodes assigned to their states in project 1 by the author [7] were: Team Autonomy; Team Learning; Team leadership; Expertise; Personal Attributes; Presence of all members; Monitoring; Team Communication and Distribution. For each node, how their state's probabilities are identified and represent the level and quality of each factor in the current state of the project.

Observing the Figure 3, we can conclude the *team members belonging to project 1 had a good performance*, despite the team's autonomy having negatively influenced the teamwork, the other factors were assessed as high quality, which contributed to a high value of TWQ.

From that, it was possible to make a direct correlation between (i) the influence of the predominant psychological preference - using the percentages obtained utilizing the psychometric instrument 16PF - in contrast to (ii) the percentages shown for each state with their respective key factors, associated with the input nodes of the model shown in Figure 3.

after analyzing the project 1, we perform the same analyses for other projects (i.e, projects 2, 3, 4 and 5). For doing

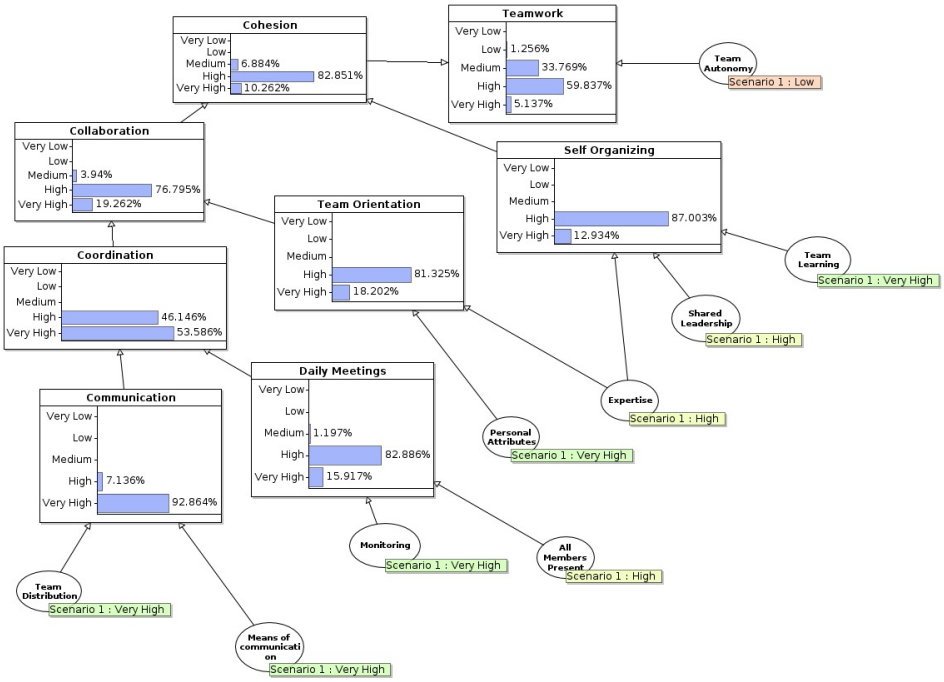

Fig. 3. Bayesian Network Diagram Project 1

so, Bayesian networks were generated with the same input nodes, main factors and states, according to Bayesian Network generated from project 1 (See Figure 3). Due to space limitations, further details of these empirical activities can be accessed through the supplementary material available at https://bit.ly/39rMTQI .

It was possible to correlate the input node "Team autonomy" in contrast to the dichotomy "mind". According to previous results, the team members of project 1 has a 'Receptive' profile because there was a greater prevalence in the psychological preference 'Introvert'. Additionally, we do not realize a negative impact on the team's performance. it occurs due to the (i) 'extrovert' psychological preference had a minimal difference in the percentage obtained and (ii) the profile of the project manager also has this same psychological preference. Therefore, we conclude the psychological preference of the project manager has a direct influence on the performance of the team. The projects 2, 3, 4 and 5 had similar results to those ones obtained by project 1. Even though the nodes had an impact factor very low or medium, the team's results were good. Similarly, the project manager personality had a direct influence on the results.

It was possible correlating the input nodes "Team learning and Shared Leadership" in contrast to the dichotomies "Mind and identity" because the agile team of the project 1, proved to be individuals with characteristics such as "assertive, active and initiative". The aforementioned relationship favored the key factor of "Self Management" to reach a state of 96.57% 'High'. The other projects 2, 3, 4 and 5 had results consistent with those of project 1. According to this, we conclude these two dichotomies (i.e. "Mind and identity') directly influenced the results.

It was possible to correlate the input nodes "Expertise and Personal Attributes" in contrast to the dichotomies "Identity and Tactics", since the agile team of the project 1 proved to be individuals with characteristics such as "assertive, planned, anticipated". The aforementioned relationship favored the key factors "Self Management and Team Orientation" to reach their respective percentages of '96, 57% High 'and '81, 33% High'. The projects 2, 3, 4 and 5 had results consistent with those of project 1.

It was possible to correlate the input nodes "Presence of all members and Monitoring" in contrast to the dichotomy "Tactic", since the agile team of the project 1, proved to be individuals with the following characteristics: planned, methodical, anticipated and systematic. This relationship favored the key factor "Meeting Diaries" to reach the status of '87, 54% High'.The projects 2, 3, 4 and 5 had results consistent with those ones obtained by project 1. We can conclude the dichotomy influenced the results obtained.

It was possible to correlate the input nodes "Means of Communication and Team Distribution" in contrast to the dichotomies "Mind' and 'Tactics", since the agile team of the project 1, proved to be individuals with characteristics such as extroverted, initiators, expressive, planned and anticipated. The aforementioned relationship favored the key factor "Communication" to reach the status of '97, 86% Very High '.The projects 2, 3, 4 and 5 had similar results compared to those ones obtained by project 1. According to this, we conclude these two dichotomies directly influenced the obtained results.

The 16PF psychometric instrument applied in the team members who working on the five analyzed projects supporting us to obtain The main following soft skills: Leader; Nice; Organized; Encouraging; Controller; Responsible; Re-

spectful; Perceptible; Reserved; Adaptable; Altruistic; Generous; Perfectionist; Accurate; Noticeable; Dreamer; Enthusiastic; Dedicated; Friendly; Shy; Realist; Charitable; Opnious; Sensitive; Egalitarian; Stressed; Impatient; Insecure; Joyful; Spontaneous; Energetic; Sociable; Curious; Idealistic; Positive; Honesty; Intuitive; Optimistic; Kind, and Communicative.

After analyzing all the projects, we realized the states of the Bayesian Networks met the expectations of the soft skills of the agile teams. We can highlight the state of the key factor "Communication" exceeded this estimation. Even the team members having low levels of soft skills related to communication performance, the fact of having a project manager with a high level of this soft skill favored the high communication performance of the team members under analysis.

V. Threats to Validity

We identified a few threats in our work, which follow from the instruments selected, researcher bias, and data being collected from only one company. The 16PF psychometric was the only means for identifying personalities, which can be considered a threat because there are other instruments to accomplish this task. Further, we only used one instrument to measure the TWQ. Even though there is a risk of bias in the measurement processes, both instruments have been evaluated with industry projects.

In addition, the data generated by the psychometric instrument was analyzed only by the authors of this research, with no contribution from any psychology professional, which leads to the risk of researcher bias. To mitigate this threat, the first author held training sessions with specialists aims to use the psychometric instrument correctly.

Finally, we collect data from a single company. this makes it difficult to generalize our conclusions. Therefore, we cannot generalize the study findings to the entire agile context. Unfortunately, collecting real-world data in the field of Software Engineering is not a trivial task because most software development companies are not likely to contribute to academic research.

VI. Conclusions and future works

In this paper, we evaluated the level of agreement of the 16PF psychometric instrument and the Teamwork Quality (TWQ) model proposed by Freire et al. [7], which is based on a Bayesian network. The correlational analysis was based on the data obtained from the dichotomies generated from the 16PF, compared with the data obtained from the input nodes, states, and key factors of the generated Bayesian networks.

As a result, the soft skills expected given the psychometric instrument were observed given the metrics presented in the TWQ instrument, evidencing the impact of the team's personality on its efficiency. Moreover, we observed the personality of the project manager has a direct impact on the behavior of the team. The results presented herein show that personality instruments might be used to predict the team's behavior having several applications such as assisting in forming teams.

For future work, we seek to carry out new empirical studies on the types of personalities of the work teams and their correlation with the individual performance of each team member. Besides, we also seek to carry out new studies aims to confirm the main findings of this research.

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