

A Comparative Analysis of Agile Teamwork Quality Instruments in Agile Software Development: A Qualitative Approach

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Abstract—[Context] Multiple models (or instruments) for measuring Teamwork Quality (TWQ) for Agile Software Development (ASD) have been created. Regardless, such models have different constructs and measures, with a limited understanding of how they are related with literature factors in ASD. [Objective] Our goal is to understand how specific instruments for ASD are related, considering the relation with ASD literature factors. [Method] We analyzed three specific teamwork instruments for ASD (ASD instruments), namely ATEM, aTWQ and TWQ-BN, comparing quantitatively factors and questions to identify which ones such instruments use most and patterns among ASD literature factors. Then, we compared them qualitatively with ASD factors, given that they are specific instruments in agile context considering the solid theories that support them. [Results] The results showed that the Team Orientation and Coordination themes were identified in the first and second positions, considering the frequencies of instrument questions and literature-based Thematic Network themes (factors). Qualitative concepts can be investigated considering the ASD factors from the knowledge of the identified parts of the agile instruments. [Conclusion] There is conceptually a correlation between the identified frequencies of the ASD factors with the ASD instruments factors. We argue to add other ASD instruments to be compared to solidify the results found in this study, so we advocate further studies on this topic.

Index Terms—teamwork, teamwork quality, teamwork effectiveness, Teamwork instrument, agile software development.

I. INTRODUCTION

The success of Agile Software Development (ASD) heavily relies on the competencies, interactions, and skills of its professionals [29, 33]. As software teams are the critical source of agility in ASD [34, 11], people are a crucial resource [26, 34, 3], and the quality of team interactions can significantly impact a project's outcome. Hence, teamwork quality (TWQ) is critical for agile projects' success [20, 7, 21]. The industry is rapidly adopting ASD [31], and the need for systematic team development [25] has compelled researchers to focus on teamwork aspects increasingly.

A team can be defined as a social system of two or more people which is embedded in an organization (context), whose members perceive themselves as such and are perceived as members by others (identity), collaborating on a common task (teamwork) [1, 14, 13]. The main focus of Teamwork Quality research is on the quality of interactions within teams rather than team members' (task) activities. Starting from the widespread fundamental proposition that the success of work conducted in teams depends (beyond the quantity and correctness of the task activities) on how well team members collaborate or interact,

the construct teamwork quality (TWQ) was proposed [16] as a comprehensive concept of the quality of interactions in teams. To capture the nature of team members working together, six facets of the collaborative team process integrate into the concept of TWQ: Communication, Coordination, Balance of Member Contribution, Mutual Support, Effort, and Cohesion. These facets capture both task-related and social interaction within teams. Research has shown that TWQ has a positive impact on team development [17]. Researchers argued about the importance of assessing TWQ to increase the chances of succeeding with ASD [17],[23][25].

In this context, researchers have proposed instruments for assessing teamwork quality in agile context, such as: (i) a Radar Plot [24] that considers five dimensions for assessing TWQ (Shared Leadership, Orientation, Redundancy, Learning, and Autonomy); (ii) a Structural Equation Model [20] (TWQ-SEM), based on a differentiated replication from [16], which considered that the teamwork construct is comprised of six variables: Communication, Coordination, Balance of Member Contribution, Mutual Support, Effort, and Cohesion.

All the instruments mentioned are generic (not using specific terms of ASD) and cannot represent specific situations in the agile context. Based on this finding, recently specific instruments for ASD have emerged: the aTWQ instrument [25] was developed based on the TWQ instrument [17], the ATEM instrument [32] was developed based on the Big Five theory [28], (iii) a Bayesian networks-based model (TWQ-BN) [8] was developed based on the TWQ instrument [17]. The TACT instrument [10] was developed based on the TCI instrument [2]. The STEM instrument [35] was developed considering that some specific factors in Scrum.

Silva et al. [30] performed a quantitatively comparative instruments study in ASD considering the instruments: TWQ-SEM [20] and TWQ-BN [8] instrument. However, the authors' study was conducted only from a quantitative perspective, neither investigating the instruments' questions nor providing a better understanding of how these instruments relate to each other at the question level.

Although the literature on TWQ of agile teams has evolved, there was no unified understanding of what factors influence teamwork in ASD. To better understand the factors associated with teamwork in the literature, Freire et. al. [9] developed a literature-based Thematic Network identifying the most frequent codes and themes (ASD factors) in agile teamwork literature in

ASD. Freire et al. [9] argued that the thematic network can support their decision-making process. Practitioners can use it as a reference for understanding the factors and dimensions that comprise ASD Teamwork. With this, they can, for example, define mechanisms to monitor such dimensions and use the collected data as a reference to drive actions towards improving the team's performance.

However, for this Freire et al. [9] thematic network to have a practical use, it is necessary to identify how these codes and themes are being considered in the instruments that measure the TWQ construct in agile context. It is important to understand how these factors are associated with the factors and questions of the Agile teamwork instruments, so that they can be used in practice by teamwork instruments.

To address the research gap, we investigated current Agile teamwork Quality instruments in ASD, named from now on only "teamwork instruments", using a quantitative and qualitative approach by comparing the ASD factors and the questions for each instrument. This paper presents our findings, which represent the comparison of the current instruments in this area of research. To our knowledge, this is the first work that compares three ASD Teamwork instruments quantitatively and qualitatively at question level.

This paper is organized as follows: Section II presented the general information of the ASD Teamwork instruments compared in this work. Section III describes the employed research method. Section IV presents the results, followed by a discussion in Section V. Section VI covers the study's limitations and threats to validity. Lastly, Section VII presents our final remarks, discussing potential future work.

II. BACKGROUND

In this section we presented the three ASD instruments compared in this work: ATEM, aTWQ e TWQ-BN.

ATEM - Agile teamwork effectiveness model [32]: Teamwork is crucial in software development, particularly in agile development teams which are cross-functional and where team members work intensively together to develop a cohesive software solution. Effective teamwork is not easy; prior studies indicate challenges with communication, learning, prioritization, and leadership. Nevertheless, there is much advice available for teams, from agile methods, practitioner literature, and general studies on teamwork to a growing body of empirical studies on teamwork in the specific context of ASD. The ATEM [32] model is based on evidence from focus groups, case studies, and multi-vocal literature and is a revision of a general Big Five [28] team effectiveness model. The ATEM [32] model is comprised of shared leadership, team mentoring, redundancy, adaptability, and peer feedback. Coordination mechanisms are needed to facilitate these components. Coordination mechanisms are shared mental models, communication and mutual trust. ATEM instrument has 31 questions.

aTWQ - Agile Team Work Quality [25]: Based on Hoegl and Gemuenden's study [17] and a systematic literature review about challenges and success factors for large-scale agile transformations performed by Paasivaara et al. [6]. Poth et al. [25] derived the aTWQ at initial team-level approach covering the following six factors: communication, coordination, balance of contribution, mutual support, effort, and cohesion. These six quality aspects lead to team performance [20], legitimating economically the effort for measurement and further TWQ improvement. They combined these aspects with those of TCI [2]

and defined 19 related questions to come up with a holistic team evaluation questionnaire for aTWQ [25].

TWQ-BN - Teamwork Quality Bayesian networks [8] - According to the agile principles and values, as well as recent research articles, teamwork factors are critical to achieving success in agile projects. However, teamwork does not automatically arise. There are some existing instruments with the purpose of assessing the teamwork quality based on Structural Equation Modeling (i.e., empirically derived) and Radar Plot [24], but they may not be useful in a concrete situation because these techniques are not advised for prediction and diagnosis purposes. TWQ-BN instrument has 17 factors, one factor for each question.

III. RESEARCH DESIGN

This study aims to examine, compare and synthesize the three specific instruments that measure Teamwork in ASD: ATEM [32], aTWQ [25] and TWQ-BN [8]. We used the literature-based Thematic Network codes and themes identified by Freire et. al. [9] as a basis of comparison, comparing them with three ASD Teamwork instruments factors and questions. Next, we present the study design.

A. Research questions

We aimed to perform a quantitative and qualitative comparison between literature-based Agile Teamwork factors found by Freire et al. [9] and new Teamwork instruments factors in ASD and identify trends in this comparison by focusing on the following research questions (RQs):

- **RQ1.** How are literature-based Agile Teamwork factors (codes and themes) and ATEM, aTWQ, and TWQ-BN Agile Teamwork instruments factors and questions are quantitatively related?
- **RQ2.** How are literature-based Agile Teamwork factors (codes and themes) and ATEM, aTWQ, and TWQ-BN Agile Teamwork instruments factors and questions are qualitatively related?
- **RQ3.** How literature-based Agile Teamwork factors (codes and themes) can be investigated by researchers and practitioners with support of the instruments ATEM, aTWQ and TWQ-BN?

B. Choosing the Agile Teamwork instruments in ASD

We chose comparing the instruments ATEM [32], aTWQ [25] and TWQ-BN [8] because they are specific to the agile context. Instruments like TWQ [17] and TCI [2] are considered generic, therefore, they are outside our analysis. We did not include STEM [35] instrument in the comparison due to it being specific to Scrum nor TACT [10] because is an instrument to assess the organizational climate of agile teams, not focusing specifically in teamwork quality construct.

C. Literature-based Codes considered for the comparison with Agile Teamwork Instruments Factors and Questions

Freire et. al. [9] presented a literature-based Thematic Network identifying the following Teamwork ASD Themes and ASD codes in Table I. For example, for ASD Theme "Coordination" there are the following ASD codes: Coordination, Performance Monitoring, Task Novelty and Familiarity, and so on for the other ASD themes. In Table II are presented the factors of the ATEM, aTWQ and TWQ-BN instruments compared in this work, for each factor, there are several associated questions.

To see all Freire et.al. [9] ASD factors, questions of these instruments, and analysis, is available in the supplementary material¹.

For each Teamwork ASD code identified by Freire et al. [9], we performed a string search having the ASD code as a string word on the following ASD Instruments questions: ATEM instrument [32], aTWQ instrument [25] and TWQ-BN instrument [8]. For each Teamwork ASD code matched, we stored the question. Next, we measured the frequency of occurrence and compared the questions of these instruments aiming to give directions about how the factors (ASD code) have been used in ATEM, aTWQ and TWQ-BN instruments.

TABLE I: ASD Themes and ASD Codes in ASD identified in Freire et. al. [9] work

ASD Theme	ASD Code
Communication	Communication
Coordination	Coordination Performance Monitoring Task Novelty Familiarity
Organization Culture	Culture Structure Team Size Organization Support
Members Personality	Individual Differences Heterogeneity Personality
Management Mechanisms	Management Planning Discussion Implementation Evaluation Information Radiators Decision-Making
Team Orientation	Team Orientation Value Diversity Goals Roles Holistic Team Involvement Team Experience in the Organization Trust Motivation Norms
Expertise	Tools knowledge Collective Knowledge Adequate Skills Redundancy Team Experience with Work
Collaboration	Interdependence Collaboration
Shared Leadership	Shared Leadership Formal Leadership
Team Autonomy	Team Autonomy Task Control
Feedback	Awareness Acceptance Feedback
Team Learning	Team Learning
Communication	Communication
Cohesion	Cohesion

IV. RESULTS

This section presents the results of this study. We compared quantitatively and qualitatively the instruments ATEM, aTWQ and TWQ-BN with the ASD codes of Freire et.al. study [9]. All the definitions of codes and themes presented in Section IV are in Freire et.al. [9] study and in the supplementary material of this work.

¹Supplementary Material: <https://figshare.com/s/13662df26088a629abf3>

TABLE II: ATEM, aTWQ and TWQ-BN Instrument Factors

ATEM factor	aTWQ factor	TWQ-BN factor
TCM - Shared Mental Models	Participative safety	Teamwork
TCM - Mutual trust	Support for Innovation	Team Autonomy
TCM - Communication	Vision	Cohesion
TC - Shared leadership	Task orientation	Collaboration
TC - Peer feedback	Coordination	Self-Organizing
TC - Redundancy		Coordination
TC - Adaptability		Team Orientation
TC - Team Orientation		Communication
		Daily Meetings
		Team Distribution
		Means of Commun.
		Monitoring
		All Members Present
		Personal Attributes
		Expertise
		Shared Leadership
		Team Learning

A. Quantitative Comparison between ASD factors (Codes and Themes) and ASD Instrument Factors and Questions

The quantitative analysis was based on frequency analysis, where each word of a ASD code contained in a question of the ASD instrument was computed. In Table III, it presented the themes and codes associated with agile teamwork literature identified by Freire et.al. [9]. The ASD Theme is associated with “ASD Theme” that correspond to the general concept. In the second column, there is the column “ASD Code” that correspond to the specific ASD concept. Since all the code is associated with a theme, the notation used to ASD code that will presented in this work will be: ASD Theme - ASD code. For example, in Table III the name “Team Autonomy - Task Control” represent a ASD code where the theme is “Team Autonomy” and the code is “Task Control”.

Next, we analyze the matches of the ASD codes and questions in ASD instruments shown in Table III. The notation used to instrument’s question that will presented in this work will be: [Number of Question]-Model-Factor-Question. For example, the question: [17]-aTWQ-Task orientation- “Do your team colleagues provide useful ideas and practical help to enable you to do the job to the best of your abilities?” The “aTWQ” correspond to the ASD instrument; the name “Task orientation” correspond to the instrument factor and the rest correspond to the instrument question.

Note that in Table III there are codes frequencies that have more than one theme. As an example, there are the codes Personality - Individual differences (4 matches) and Personality - Trust (4 matches) identified, resulting in 8 matches in Theme “Personality” since the two referred codes belong to the Personality Team, then these frequency matches were added. We did the same process for all ASD Codes in Table III. In Table IV is presented the result of the match frequency of the previous process.

In Table III, for each instrument, we identified the following ASD code frequencies: Team Autonomy - Task Control (14 matches), Coordination - Coordination (14 matches), Shared Leadership - Shared Leadership (9 matches), Communication - Communication (6 matches), Feedback - Feedback (4 matches), Personality - Trust (4 matches), Team Orientation - Team Orientation (4 matches), Team Orientation - Goals (4 matches), Team Orientation - Planning (3 matches), Coordination - Performance Monitoring (3 matches), Team Orientation - Information Radiators (3 matches), Team Orientation - Redundancy (3

TABLE III: ASD Code Frequencies in ASD instruments

ASD Code	Instrum.	#Freq	Tot.
Team Autonomy - Task Control	A TEM	4	15
	aTWQ	7	
	TWQ-BN	4	
Coordination - Coordination	A TEM	12	14
	aTWQ	1	
	TWQ-BN	1	
Shared Leadership - Shared Leadership	A TEM	8	9
	aTWQ	0	
	TWQ-BN	1	
Communication - Communication	A TEM	3	6
	aTWQ	1	
	TWQ-BN	2	
Feedback -Feedback	A TEM	4	4
	aTWQ	0	
	TWQ-BN	0	
Personality - Trust	A TEM	3	4
	aTWQ	0	
	TWQ-BN	1	
Team Orientation - Team Orientation	A TEM	3	4
	aTWQ	0	
	TWQ-BN	1	
Team Orientation - Goals	A TEM	0	3
	aTWQ	1	
	TWQ-BN	2	
Team Orientation - Planning	A TEM	1	3
	aTWQ	2	
	TWQ-BN	0	
Coordination - Performance Monitoring	A TEM	1	3
	aTWQ	1	
	TWQ-BN	1	
Team Orientation - Information Radiators	A TEM	2	3
	aTWQ	1	
	TWQ-BN	0	
Team Orientation - Redundancy	A TEM	3	3
	aTWQ	0	
	TWQ-BN	0	
Personality - Individual differences	A TEM	2	3
	aTWQ	1	
	TWQ-BN	0	
Team Orientation - Decision-Making	A TEM	0	1
	aTWQ	0	
	TWQ-BN	1	
Expertise - Tools knowledge	A TEM	1	1
	aTWQ	0	
	TWQ-BN	0	
Expertise - Adequate Skills	A TEM	1	1
	aTWQ	0	
	TWQ-BN	0	
Expertise - Task Novelty	A TEM	0	1
	aTWQ	1	
	TWQ-BN	0	
Expertise - Structure	A TEM	0	1
	aTWQ	1	
	TWQ-BN	0	
Expertise - Roles	A TEM	1	1
	aTWQ	0	
	TWQ-BN	0	
Expertise - Motivation	A TEM	0	1
	aTWQ	1	
	TWQ-BN	0	
Collaboration - Interdependence	A TEM	0	1
	aTWQ	0	
	TWQ-BN	1	
Team Learning - Team Learning	A TEM	0	1
	aTWQ	0	
	TWQ-BN	1	

matches), Personality - Individual differences (3 matches), Team Orientation - Decision-Making (1 match), Expertise - Tools knowledge (1 match), Expertise - Adequate Skills (1 match), Expertise - Task Novelty (1 match), Expertise - Structure (1 match), Expertise - Roles (1 match), Expertise - Motivation (1 match), Collaboration - Interdependence (1 match), and Team Learning - Team Learning (1 match).

TABLE IV: Frequencies between ASD themes and Agile instrument questions

ASD Theme	Instrument	#Freq	Total
Team Orientation	A TEM	9	17
	aTWQ	4	
	TWQ-BN	4	
Coordination	A TEM	13	17
	aTWQ	2	
	TWQ-BN	2	
Team Autonomy	A TEM	4	15
	aTWQ	7	
	TWQ-BN	4	
Shared Leadership	A TEM	8	9
	aTWQ	0	
	TWQ-BN	1	
Personality	A TEM	5	7
	aTWQ	1	
	TWQ-BN	1	
Communication	A TEM	3	6
	aTWQ	1	
	TWQ-BN	2	
Expertise	A TEM	3	6
	aTWQ	3	
	TWQ-BN	0	
Feedback	A TEM	4	4
	aTWQ	0	
	TWQ-BN	0	
Collaboration	A TEM	0	1
	aTWQ	0	
	TWQ-BN	1	
Team Learning	A TEM	0	1
	aTWQ	0	
	TWQ-BN	1	
Cohesion	A TEM	0	1
	aTWQ	0	
	TWQ-BN	1	

It was identified the following ASD theme frequencies: Team Orientation (17 matches), Coordination (17 matches), Team Autonomy (14 matches), Shared Leadership (9 matches), Personality (7 matches), Communication (6 matches), Expertise (6 matches), Feedback (4 matches), Collaboration (1 match), Team Learning (1 match), and Cohesion (1 match) - as summarized in Table IV. Comparing the ASD theme frequencies in Freire et.al. [9] in Table V and the results of the Frequency Themes in the Instruments questions in Table IV, it was found that Freire's ASD Themes Team Orientation (the highest frequency with 22 matches) and Coordination (the second highest frequency with 16 matches) are the same ranking position found in this work: Team Orientation with 17 matches and Coordination with 17 matches. This result shows that the same codes identified in Freire et.al. [9] have been used in the ASD instruments (considering the number of matches).

B. Qualitative Comparison between ASD factors (Codes and Themes) and ASD Instrument Factors and Questions

For a more in-depth comparison, we compared all questions that have ASD code names in their content as showed in Table III. The purpose of this comparison is to understand how the ASD codes of Freire et.al. study [9] are addressed in the ASD instruments.

Team Autonomy - Task Control: Task Control refers to the “degree of control or authority that a team has over its internal work processes”[22]. The code Team Autonomy - Task Control has 14 matches with Instrument factors questions. The ATEM instrument has four matches in the following questions: [3]-ATEM-TCM-Shared Mental Models- “Common understanding of tasks”, [10]-ATEM-TCM-Communication- “The team follows up on the progress of tasks”, [25]-ATEM-TC-Redundancy-

TABLE V: ASD Theme frequencies in Freire et al. work

ASD Theme	ASD Code	#Freq	Total
Team Orientation	Orientation	7	22
	Value Diversity	1	
	Goals	2	
	Roles	2	
	Holistic Team Involvement	1	
	Experience in the Organi.	1	
	Trust	5	
	Motivation	1	
	Norms	2	
Coordination	Coordination	5	16
	Performance Monitoring	9	
	Task Novelty	1	
	Familiarity	1	
Expertise	Tools Knowledge	2	15
	Collective Knowledge	4	
	Adequate Skills	1	
	Redundancy	7	
	Experience with Work	1	
Management Mechanisms	Management	4	10
	Planning	1	
	Discussion	1	
	Implementation	1	
	Evaluation	1	
	Information Radiators	1	
	Decision Making	1	
Shared Leadership	Shared Leadership	8	9
	Formal Leadership	1	
Communication	Communication	9	9
Organization Culture	Culture	4	8
	Structure	1	
	Team Size	2	
	Organization Support	1	
Collaboration	Interdependence	1	8
	Collaboration	7	
Learning	Learning	8	8
Members Personality	Individual Differences	1	5
	Heterogeneity	1	
	Personality	3	
Team Autonomy	Autonomy	4	5
	Task Control	1	
Feedback	Awareness	1	5
	Acceptance	1	
	Feedback	3	
Cohesion	Cohesion	3	3

“Completion of the whole task or parts of tasks by other team members”, [29]-ATEM-TC-Team orientation- “Increased task involvement, information sharing, strategizing, and participatory goal setting”. The aTWQ instrument has seven matches in the following questions: [1]-aTWQ-Participative safety- “Do we have a “we are in it together” attitude driven by the ability and willingness to help and support each other in carrying out their tasks?”, [12]-aTWQ-Support for Innovation- “Do team members provide practical support for new ideas and their application by prioritizing the teams’ task over other obligations?”, [17]-aTWQ-Task orientation- “Do your team colleagues provide useful ideas and practical help to enable you to do the job to the best of your abilities?”, [18]-aTWQ-Task orientation- “Are team members prepared to question the basis of what the team is doing?”, [19]-aTWQ-Task orientation- “Does the team critically appraise potential weaknesses in what it is doing in order to achieve the best possible outcome?”, [20]-aTWQ-Task orientation- “Do members of the team build on one another’s ideas in order to achieve the highest possible standards of performance?”, [21]-aTWQ-Coordination- “Is there a common understanding when working on parallel subtasks, and agreement on common work breakdown structures, schedules, budgets, and deliverables?”. In the TWQ-BN instrument, has four matches: [2]-TWQ-BN-Team Autonomy- “There is

no external agent interfering on how the team executes its tasks. The external agent collaborates with them to define what will be”, [6]-TWQ-BN-Coordination- “The team executes its tasks in a synchronous and integrated manner”, [12]-TWQ-BN-Monitoring- “The team members expose their obstacles and progress regarding their tasks in a clear and objective way” and [15]-TWQ-BN-Expertise- “The team members have the necessary knowledge for developing the tasks with redundancy.” Analyzing these questions matches, it is possible to say that all, in general, are associated with the team autonomy, therefore, one can envision a conceptualization joining the Task Control factors with those identified in the questions of the instruments: ATEM-TCM-Shared Mental Models, ATEM-TCM-Communication, ATEM-TC-Team orientation, aTWQ-Participative safety, aTWQ-Support for Innovation, aTWQ-Task orientation, aTWQ-Coordination, TWQ-BN-Team Autonomy, TWQ-BN-Coordination, TWQ-BN-Monitoring and TWQ-BN-Expertise. Analyzing the matches, it is suggested that a team that has autonomy in its tasks and work processes, probably, has a shared mental models, a team orientation, a participative safety, a support for innovation, a task orientation, a coordination, a team autonomy, a monitoring and a expertise.

Coordination - Coordination: Coordination refers to team members executing their activities in a timely and integrated manner. It implies that the performance of some team members influences the performance of others. This may involve an exchange of information that subsequently influences another member’s performance [23]. The degree of common understanding regarding the interrelatedness and status of individual contributions [16]; It refers to team members executing their activities in a timely and integrated manner and it is linked to the performance of teams [12]. The code Coordination has 14 matches with Instrument Factors questions. In ATEM instrument, there are Team Coordination Mechanisms (TCM) and Teamwork Components (TC). The TCM are composed by: Shared Mental Models, Mutual Trust, and Communication, showing how important the Coordination Mechanisms are to Agile Teamwork Effectiveness. The TC are composed by: Shared leadership, Redundancy, Peer feedback, Adaptability, and Team Orientation. The questions in ATEM-TCM are general, such as: [2]-ATEM-TCM-Shared Mental Models- “Common understanding of goals”, [3]-ATEM-TCM-Shared Mental Models- “Common understanding of tasks”, [7]-ATEM-TCM-Mutual trust- “Information sharing”. In the aTWQ instrument, there is only one question referred to “Coordination”: [21]-aTWQ-Coordination-“Is there a common understanding when working on parallel subtasks, and agreement on common work breakdown structures, schedules, budgets and deliverables?”. Note that in this question, the aTWQ instrument aggregates several characteristics of coordination factors into a single question. In the TWQ-BN instrument, there is only one question too: [6]-TWQ-BN-Coordination- “The team executes its tasks in a synchronous and integrated manner.” Note that in this question, the TWQ-BN instrument brings a more generic concept of coordination. Analyzing these matches, it is possible to say that all, in general, are associated with Coordination that following mechanisms that TCM and TC in ATEM instrument. These factors represent a large number of factors, including: Shared Mental Models, Mutual Trust, and Communication, showing how important the Coordination Mechanisms are to Agile Teamwork Effectiveness. It is suggested by the high frequency that

Coordination is one of the most important factors in Teamwork quality. The ATEM instrument defines the Coordination factor with a greater completeness while the aTWQ and TWQ-BN instruments are more generic. As recommendation, for more in-depth analysis, we recommend using the ATEM instrument when analyzing the Team Coordination.

Shared Leadership - Shared Leadership: Leadership is rotated to the person with key knowledge, there is jointly shared decision authority [27]. The code Shared Leadership has nine matches with Instrument Factors questions: [13]-ATEM-TC-Shared leadership- “The agile team facilitates team problem-solving”, [14]-ATEM-TC-Shared leadership- “The agile team determines performance expectations and acceptable interaction patterns”, [15]-ATEM-TC-Shared leadership- “The agile team synchronizes and combines individual team member contributions using agile practices combined with automated tools”, [16]-ATEM-TC-Shared leadership- “The agile team seeks and evaluates information that affects team functioning”, [17]-ATEM-TC-Shared leadership- “Agile values and methodologies determine team member roles”, [18]-ATEM-TC-Shared leadership- “Agile values and methodologies determine the frequency and type of preparatory meetings and feedback sessions”, [19]-ATEM-TC-Shared leadership- “A servant leader facilitates a boundary-spanning function”, [20]-ATEM-TC-Shared leadership- “Agile team practices provide a planning function”. In aTWQ there is no specific question related to “Shared Leadership”, in TWQ-BN instrument there is one question: “[16]-TWQ-BN-Shared Leadership- “The decision authority and leadership is shared.” Shared Leadership code has a great importance in ATEM instrument with eight matches and is one of the most important factors for Teamwork Quality in Agile Context. In TWQ-BN instrument there is one generic question. The ATEM instrument has a greater completeness in Shared Leadership code.

Communication - Communication: Communication provides a means for the exchange of information among team members [16]. The fundamental component of teamwork is communication. It provides a means to exchange information, share ideas among team members, coordinate efforts and provide feedback [36]. The code Communication has six matches with Instrument Factors questions. In the ATEM instrument, we found more generic questions, for example: [10]-ATEM-TCM-Communication- “The team follows up on the progress of tasks”, [11]-ATEM-TCM-Communication- “Visualize project information” and [12]-ATEM-TCM-Communication- “Facilitate informal communication”. In aTWQ instrument, there is not explicitly a communication factor, but in question [4]-aTWQ-Participative safety- “Do people keep each other informed about work-related issues in the team supported by a frequent communication?”. In TWQ-BN instrument, two questions are related to “Communication”: [8]-TWQ-BN-Communication- “The communication is effective” and [11]-TWQ-BN-Means of Communication- “The team members communicate face-to-face whenever possible”. Communication factor have a great importance in the three instruments: in ATEM, the questions are associated with informal communication and visualization of project information. In aTWQ instrument, it is considered that for a team to stay informed about work matters, good communication is necessary. In TWQ-BN instrument, highlights the importance of effective, face-to-face communication whenever possible. For a team to coordinate the tasks, it must communicate. Since agile

is based on tacit knowledge sharing [4], Communication is a must factor to assess agile teams [8] [18], Furthermore, in agile context, daily meetings play an important role on synchronizing the team members’ tasks, as well as removing impediments and mitigating risks.

Feedback - Feedback: Feedback involves the giving, seeking, and receiving of information among team members. Giving feedback refers to providing information regarding other members’ performance. Seeking feedback refers to requesting input or guidance regarding performance and to accepting positive and negative information regarding performance, e.g. * responding to other members’ requests for information about their performance * accepting time-saving suggestions offered by other team members” [23]. “It involves providing information regarding other members’ performance, requesting input or guidance regarding performance of self and to accept positive and negative information regarding performance” [12]. “High performance teams also get constant feedback on their productivity and effectiveness both internally and from external resources, and use this feedback to make improvements to the group work” [11]. The code Feedback has four matches with Instrument Factors questions. [8]-ATEM-TCM-Mutual trust- “Willingness to admit mistakes and accept feedback”; [18]-ATEM-TC-Shared leadership- “Agile values and methodologies determine the frequency and type of preparatory meetings and feedback sessions”; [21]-ATEM-TC-Peer feedback- “Identifying mistakes and lapses in other team members’ actions”; [22]-ATEM-TC-Peer feedback- “Regular feedback regarding team member actions to facilitate self-correction”. Analyzing the frequencies, the ATEM instrument is the only instrument that talks about the importance of feedback associating this code with the factors: ATEM-TCM-Mutual trust, ATEM-TC-Shared leadership and ATEM-TC-Peer feedback.

Personality - Trust: Without sufficient trust, team members will extend time and energy protecting, checking and inspecting each other as opposed to collaborating to provide value-added ideas [19]. They understand that agility depends on trusting individuals to apply their competency in effective ways [5]. The code Personality - Trust has four matches with Instrument Factors questions: [7]-ATEM-TCM-Mutual trust- “Information sharing”; [8]-ATEM-TCM-Mutual trust- “Willingness to admit mistakes and accept feedback”; [9]-ATEM-TCM-Mutual trust- “Supportive team social climate”; [7]-TWQ-BN-Team Orientation- “The team members trust each other and feel motivated to work together for achieving the team goals.” Analyzing the frequencies, the ATEM instrument has a specific factor related to the Trust code called “ATEM-TCM-Mutual trust” and the TWQ-BN instrument has a factor called “TWQ-BN-Team Orientation”. The ATEM instrument associated trust code with “Information sharing”, “Willingness to admit mistakes and accept feedback” and the TWQ-BN instrument has a more general question. So, if the company needs more detailed information for the purposes of diagnosing the situation of the teams about the trust of team members, it is more recommended to apply the ATEM instrument.

Team Orientation - Team Orientation: Team orientation refers to the team tasks and the attitudes that team members have towards one another. It reflects an acceptance of team norms, the level of group cohesiveness, and the importance of team membership, e.g.-assigning high priority to team goals and participating willingly in all relevant aspects of the team [23].

Refers to belief of team members in the importance of team goals over individual member goals, propensity to take other's behavior into account during group interaction. It reflects an acceptance of team norms, the level of group cohesiveness and the importance of team membership" [12]. The ability to take other team member's behavior into account and set team goals over individual goals [15]. The code Team Orientation has three matches with ATEM Instrument Factors questions and one match with TWQ-BN instrument factor: [28]-ATEM-TC-Team orientation- "Increased task involvement, information sharing, strategising, and participatory goal setting"; [30]-ATEM-TC-Team orientation - "Increased task involvement, information sharing, strategising, and participatory goal setting"; [31]-ATEM-TC-Team orientation- "The team sticks together and remains united"; [7]-TWQ-BN-Team Orientation- "The team members trust each other and feel motivated to work together for achieving the team goals." Analyzing the frequencies, the code Team Orientation, this is a factor in ATEM with 3 questions and a factor in TWQ-BN with one question. The Team Orientation is related with control mechanisms in ATEM what is associated with achieve the goals.

Team Orientation - Goals: That members are clear about team goals is the single most important part of high performing teams [11]. The code Team Orientation-Goals has one match in [6]-aTWQ-Participative safety- "Do we keep in touch with one another as a team by accepting that team goals are more important than individual goals? It is suggestive a relationship between Team Orientation - Goals code and Participative safety, considering that the "team goals are more important than individual goals".

Team Orientation - Planning: "The best teams spend time planning how they will solve problems and make decisions [11]". The code Team Orientation-Planning has one match in ATEM instrument: [20]-ATEM-TC-Shared leadership- "Agile team practices provide a planning function" and two matches in aTWQ instrument: [5]-aTWQ-Participative safety- "Is there a lot of give and take by the team members' motivation to maintain the team? - Innovation and Planning Iteration-IV"; [10]-aTWQ- "Support for Innovation - Do people in this team always search for fresh, new ways of looking at problems- Innovation and Planning Iteration-IV?" It is suggestive that Team Orientation - Planning code is associated with ATEM-TC-Shared leadership when say "Agile team practices provide a planning function".

Team Orientation - Performance Monitoring: "It is the ability to develop a common understanding of the team environment through observing the activities of other team members and apply appropriate task strategies to accurately monitor teammate performance to recognize when a team member performs correctly [12]. The code Team Orientation - Performance Monitoring has three matches with Instrument Factors questions: [14]-ATEM-TC-Shared leadership- "The agile team determines performance expectations and acceptable interaction patterns"; [20]-aTWQ-Task orientation- "Do members of the team build on one another's ideas in order to achieve the highest possible standards of performance?"; [12]- TWQ-BN- Monitoring- "The team members expose their obstacles and progress regarding their tasks in a clear and objective way." Analyzing the frequencies, the code Team Orientation - Performance Monitoring are found in three instruments evidencing the importance for teamwork quality.

Team Orientation - Information Radiators: "Information radiators, such as burn charts, allow teams to clearly visualize current project status and what is required to complete goals. Such information radiators were discussed as being invaluable sources of motivation, excitement, and team cohesion" [37]. The code Team Orientation - Information Radiators has three matches: two matches with ATEM Instrument and one match with aTWQ instrument: [16]-ATEM-TC-Shared leadership- "The agile team seeks and evaluates information that affects team functioning"; [28]-ATEM-TC-Team orientation- "Increased task involvement, information sharing, strategising, and participatory goal setting"; [4]-aTWQ- "Participative safety - Are there real attempts to share information throughout the team driven by openness of the information exchange?" Analyzing the frequencies, the code Team Orientation - Information Radiators, it's suggestive the information is important for team functioning.

Team Orientation - Redundancy: Redundancy is associated with members that have multiple skills so that they can perform (parts of) each others' tasks [27]. It was found three matches: [23]-ATEM-TC-Redundancy- "Recognition by potential backup providers that there is a workload distribution problem in their team". [24]-ATEM-TC-Redundancy- Shifting of work responsibilities to underutilized team members", [25]-ATEM-TC-Redundancy- "Completion of the whole task or parts of tasks by other team members". Analyzing the frequencies, the only instrument that matches with Team Orientation - Redundancy was ATEM that has one specific factor for this. So, the Redundancy is associated with "Recognition by potential backup providers that there is a workload distribution problem in their team" and "Shifting of work responsibilities to underutilized team members" and "Completion of the whole task or parts of tasks by other team members" [32].

Personality - Individual Differences: Successful teams also accept differences in people as long as their behavior helps task accomplishment [11]. The code Personality - Individual Differences has three matches with Instrument Factors questions: [6]-ATEM-TCM-Shared Mental Models- "Common understanding of individual skills and expertise"; [15]-ATEM-TC-Shared leadership- "The agile team synchronizes and combines individual team member contributions using agile practices combined with automated tools"; [6]-aTWQ-Participative-safety- "Do we keep in touch with one another as a team by accepting that team goals are more important than individual goals?"; Analyzing the frequencies, the Individual Differences are more associated with Participative safety considering that team accepting that team goals are more important than individual goals.

Team Orientation - Decision-Making: It does not matter if the decision-making strategy is consensus or majority, etc., it is only important that the rules of engagement are defined beforehand [11]. Analyzing the frequencies, the only instrument that matched was [16]-TWQ-BN- Shared Leadership- "The decision authority and leadership is shared.". It was suggestive a relationship between Decision-Making and Shared leadership. The literature consider that the agile team needs a Shared Leadership [32] [35].

Expertise - Tools knowledge: There was one match in Expertise - Tools knowledge: [15]-ATEM-TC-Shared leadership- "The agile team synchronizes and combines individual team member contributions using agile practices combined with automated tools". It is suggestive and proven in the literature that agile practices with automated tools is a important factor for

teamwork quality in agile context [32], [35].

Expertise - Adequate Skills: “Refers to the required skills that the software development team must possess to execute their tasks. It is measured through the team member’s perspective about the adequacy of the team competencies” [22]. There is one match in ATEM instrument: [6]-ATEM-TCM-Shared Mental Models- “Common understanding of individual skills and expertise”. It is suggested that a common understanding of individual skills and expertise influenced positively the teamwork quality [32].

Expertise - Task Novelty: If the task novelty is low, it is likely that the teams have developed sufficient meta knowledge to adequately assign tasks to team members [22]. It has one match in the question: [8]-aTWQ-Support for Innovation- “Is this team always moving towards the development of new answers?”. We consider a team that is looking for new answers as well as one that has knowledge of new tasks. So, it suggestive that task novelty is associated with teamwork quality.

Expertise - Structure: “The structure of the team is important. The team members must all contribute, and therefore, a successful team only consists of the smallest number of members necessary to reach the group goal. The group must also allow subgroups to form to work on smaller chores. These subgroups are not seen as a threat to the group, but as necessary and valued for their contribution to the team [11]”. There is one match in aTWQ instrument: [21]-aTWQ-Coordination- “Is there a common understanding when working on parallel sub-tasks, and agreement on common work breakdown structures, schedules, budgets and deliverables?”. This match did not have a semantic correspondence.

Expertise - Roles: “After the goal is defined the group can get organized and decide what needs to be done and who does what. The most important thing is that each member really knows what their role is, independently of if they volunteered for the role or not, i.e., both the expectations and the process need to be clear [11].” There is one match with “[17]-ATEM-TC-Shared leadership- “Agile values and methodologies determine team member roles”. It is possible to say that roles in agile teams are determined by agile values and methodologies [32].

Expertise - Motivation: “There seems to be value, therefore, in frequent signs of progress towards collective goals. Such indicators were seen to strongly support individual motivation to contribute to team efforts [37]. There is one match in aTWQ instrument: [5]-aTWQ-Participative safety- “Is there a lot of give and take by the team members’ motivation to maintain the team?”. Motivation was associated with the quality of a team’s work [17].

Collaboration - Interdependence: “In high performance teams, the tasks demand that members work together as a unit or in subgroups to reach the goal [11].” There is one match in TWQ-instrument: [4]-TWQ-BN-Collaboration- “There is a high degree of collaboration in the team for achieving success on the project development.” Is suggestive that the existence of high degree of collaboration is associated with success on the project development [8].

Team Learning - Team Learning: “It involves the ability to identify the changes in the team environment and adjust the strategies as needed” [12]. The instrument TWQ-BN has one match: [17]-TWQ-BN-Team Learning- “The team adapts itself to changes in the team environment and adjust the strategies as needed.”. The instruments aTWQ and STEM don’t explicitly

talk about team learning, but has the “Team Learning” in other factors.

Cohesion - Cohesion: Team cohesion refers to the degree to which team members desire to remain on the team [16]. The TWQ-BN instrument has one match: [3]-TWQ-BN-Cohesion- “The team works cohesively and synchronously, prioritizing the team goals, and self-organize efficiently.” Cohesion is one important factor in [17].

C. Responses to research questions

This section introduces a discussion on research questions, trends observed, attributes, and data collection mechanisms.

RQ1. How are literature-based Agile Teamwork factors (codes and themes) and ATEM, aTWQ, and TWQ-BN Agile Teamwork instruments factors and questions are quantitatively related?

We mapped the factors of the three instruments (ATEM, aTWQ, and TWQ-BN), then we compared them with ASD codes and themes found by Freire et al. [9]. The objective is to understand how the ASD factors (codes and themes) and instrument factors and questions are related. Then, we intended to identify trends in these factors. We noted that the codes with more Teamwork instrument questions are Team Autonomy - Task Control (14 questions matched), Coordination - Coordination (14 questions matched), and Shared Leadership - Shared Leadership (9 matches). Considering the Themes analysis in Section IV-A, the result of this work confirmed Freire et.al. [9] results in which the first two frequencies of these studies are in the same order: Team Orientation and Coordination.

RQ2. How are literature-based Agile Teamwork factors (codes and themes) and ATEM, aTWQ, and TWQ-BN Agile Teamwork instruments factors and questions are qualitatively related? From the Section IV-B it’s possible to say that the instruments ATEM, aTWQ and TWQ-BN brought in these instruments questions new concepts directly associated with the agile context, among them: agile practices, daily sprints, retrospective meetings, etc. Thus, the present work demonstrated this conceptual evolution of the ASD terms in Freire et.al. [9] work. As examples: [15]-ATEM-TC-Shared leadership- “The agile team synchronizes and combines individual team member contributions using agile practices combined with automated tools”; [18]-ATEM-TC-Shared leadership- “Agile values and methodologies determine the frequency and type of preparatory meetings and feedback sessions”; It can be understood by the behaviours markers that consider agile practices[32].

RQ3. How literature-based Agile Teamwork factors (codes and themes) can be investigated by researchers and practitioners with support of the instruments ATEM, aTWQ and TWQ-BN?

The researchers can investigate whether high or lower frequencies are in fact more or less important for the teamwork quality. In this way, researchers will already have prior knowledge of which parts of the instruments to use. From the results from RQ2, it was found the frequency of appearance of each factor related to the teamwork quality and the number of corresponding questions for each instrument. With this knowledge, this work can support other works that need to use a ASD teamwork instrument for a specific purpose. As example, if a researcher needs to investigate the relationship between Feedback and Team Autonomy in a company, he can choose specific parts of ASD instruments identified in this work.

Qualitative concepts can be investigated in future works that aim to investigate the ASD factors from the knowledge of the identified parts of the agile instruments.

V. DISCUSSION

In Section IV, we compared ASD codes found in Freire et.al. [9] with all the questions of the ASD instruments, addressing the RQs in section III-A. In Section V-B, we discuss implications for research and practice.

A. Comparison of Literature-based Teamwork Factors (codes and themes) and Teamwork Instrument Factors and Questions

We used the literature-based Thematic Network codes identified by Freire et al. [9] as a comparison base because it is the most current work that analyzed the most recurrent factors in agile teamwork works in the literature, providing evidence that these factors are important for the teamwork quality. We observed that, considering the four themes with more matches as showed in Section IV: Task Orientation (17 matches), Coordination (17 matches), Team Autonomy (14 matches), and Shared Leadership (9 matches). From the result of the analysis of the frequencies of the instruments, it is suggestive to say that: “Agile times that have task orientation, coordination, time autonomy and shared leadership are more likely to have a high teamwork quality.”

B. Summary of findings

This work can support other works that need to use a ASD Teamwork Instrument for a specific purpose. As example, if a researcher needs to investigate the relationship between Feedback and Team Autonomy, he can choose what parts of instruments use. For Feedback code, there are four questions in ATEM instrument. For Team Autonomy, there are four questions in ATEM instrument, six questions in aTWQ instrument, and four questions in TWQ-BN instrument. This work highlights that the ASD literature themes: Team Orientation (14 matches), Coordination (17 matches), Team Autonomy (14 matches), and Shared Leadership (9 matches) are the most used in ASD Teamwork Instruments. We observed that, considering the four themes with more matches as showed in Section IV, we have a pattern considered that in Freire et.al. [9], the two ASD themes with more frequency were Team Orientation, and Coordination. This is an important result, as it confirms that the factors identified by Freire et. al. [9] are, in fact, those that are being used more frequently in specific ASD teamwork instruments, which were developed based on strong literature theories and empirical studies. Additionally, we compared the referred questions in the ATEM, aTWQ and TWQ-BN instruments. We noted that finding a standard terminology for ASD Teamwork factors remains challenging, and there is a need for further investigation into this area. Finally, practitioners can benefit from the study’s findings by better understanding the recent Agile Teamwork instruments in ASD.

VI. LIMITATIONS AND THREATS TO VALIDITY

The results of this study may have been impacted by the frequency analysis methods based only on syntactic aspects and incompleteness of the ASD Teamwork instrument.

Quantitative analysis based only on syntactic aspects. The quantitative analysis was based on frequency analysis, where each word of a ASD code contained in a question of the ASD instrument will be computed without considering

semantic aspects. This can lead to some problems, such as incorrect semantic counts, but in order for the study to have a more reproducible method, we preferred to adopt this choice. As future work, we intend to consider semantic aspects in quantitative analysis.

Incompleteness of the ASD Teamwork instruments. Three instruments were chosen for the agile context, possibly the results could be different if more instruments were added. For reasons of time and complexity of the work, at the moment, only three instruments were considered. As future works, we intend to compare more ASD instruments.

VII. CONCLUSIONS

Our study makes several contributions to the teamwork quality literature aiming to give directions for an understanding of how ASD literature-based codes and themes identified by Freire et al. [9] and Agile Instruments factors and questions in ASD are related. We identified and compared three instruments specific for ASD, showing the frequency of the matches. Further, we identified ASD Instruments questions related to ASD literature-based codes that can support other works that investigate the relationship between ASD factors by providing knowledge of specific parts of ASD instruments. In this way, researchers will be able to have greater coverage in their investigations. This study can support other studies that can increase the body of knowledge by allowing an update of the literature-based Thematic Network developed by Freire et. al. [9].

Our findings show that many factors have been used by researchers to measure teamwork quality in ASD. Also, the analyzed instruments have similar questions with different names, pointing to the need for terminology standardization. Our results can support a unified Teamwork instrument in ASD, considering the most frequent questions of each instrument.

This paper presents a comprehensive view of comparing teamwork instruments qualitatively in ASD. This study has identified new trends that should be taken into account for further research in the field. Furthermore, more investigation is still needed into comparing teamwork instruments qualitatively.

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