Preliminary Results of Mapping Capabilities for Agile Software Team Formation

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ABSTRACT

Context: Team formation is critical in agile software development, directly affecting project effectiveness and performance. Ensuring teams possess the necessary capabilities is vital for success. However, the specific capabilities used in practice for team composition remain unclear. **Aims**: Our objective is to understand the evolution, relevance, and practical application of capabilities used in agile team formation and gain real-world insights. **Method**: We conducted a comparative analysis, contrasting the software engineers' capabilities identified in a prior review with those used in agile team formation based on recent studies. To gain insights into real-world practices, we interviewed a key practitioner from a software organization through a semi-structured interview. **Results**: The study highlights the most impactful capabilities for agile team formation, providing valuable guidance for practitioners and researchers to enhance software engineering practices. **Conclusions**: This research advances the understanding of essential attributes for successful agile team formation and offers valuable implications on underlying aspects and challenges faced in the practical application of these capabilities.

CCS CONCEPTS

• **Software and its engineering → Software development process management**; • ;

KEYWORDS

Team Formation, individual capability, agile teams, agile software development.

1 INTRODUCTION

Skilled professionals are fundamental assets in Agile Software Development (ASD)[44], and the capabilities of software engineers are vital for team composition[47] and influence their outcomes [9]. However, allocating human resources without understanding capabilities is challenging. Therefore, comprehending the most suitable capabilities for ASD can enhance teams' achievements [12].

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Moreover, Academic research often neglects human aspects in Software Engineering (SE). For instance, Assyne *et al.*[8] and Costa Filho *et al.*[17] lacked ASD specific insights. A recent systematic literature review (SLR) by[16] covered capabilities in ASD but not in the context of team formation. The present study fills this literature gap.

We investigate the capabilities identified in the SLR conducted by [16] and those pinpointed in primary studies highlighted by Costa *et al.* [15] within the context of agile team formation, and this paper summarizes our findings. The paper also examines which capabilities are effectively utilized in team formation practices by consulting an industry practitioner responsible for team creation within an organization, alongside project managers.

This paper is organized as follows: Section 2 discusses background concepts and previous research on team formation in ASD. Section 3 describes the employed research method. Section 4 presents the results, followed by a discussion in Section 5. Section 6 covers the study's limitations and threats to validity. Lastly, Section 7 presents our final remarks, discussing potential future work.

2 BACKGROUND

2.1 Capabilities in Agile Software Development

In Agile Software Development (ASD), software engineer capabilities are discussed in various ways - competencies, skills, attributes, knowledge, and traits. Studies shed light on these terms. For example, in one study [36], capabilities impact both individual and team performance. Another study [7] categorizes capabilities as soft and hard skills, recognizing their nuances. Precision is stressed in another [46] with competence models for specific roles. Even in a study [26] not explicitly mentioning capabilities, team-level skills are defined as non-technical, arising from interactions and support.

In alignment with these varying perspectives, our study defines and investigates capabilities in the context of ASD. Capabilities in our context allude to the potential for growth and adaptability across diverse contexts [32]. We extend our exploration to encompass attributes, encompassing personal traits such as personality traits, values, and attitudes.

Vishnubhotla *et al.* [45] introduced the attributes categories: technical, social, and innovative, which hold significance at both individual and team levels. We have adopted these categories in the present study, which is structured around three perspectives:

the professional, encompassing skills, knowledge, and technical competencies; the social dimension, encompassing interpersonal interactions and teamwork; and the innovative facet, focusing on skills oriented toward innovation-based pursuits.

2.2 Team formation approaches

In Software Project Management (SPM), the goal is to deliver a software product and related artifacts (e.g., source code, models, test cases, and documentation) while meeting specific objectives and constraints [20]. To achieve this, the team needs to have the necessary skills. However, allocating individuals with the correct technical and social skills to meet multiple constraints is not an easy task, especially in large organizations. Inadequate team composition can lead to inefficiencies, increased project risks, and resource wastage [30, 1, 34, 33].

The challenge of human allocation faced by practitioners is known as the Team Formation Problem (TFP) [31]. This activity is challenging due to the diversity of attributes that results in numerous possible combinations [11, 18, 24, 2]. When faced with limited human resources and the need to form multiple teams, conflicts, and resource disputes can arise [13]. Successfully addressing the TFP involves identifying the optimal team configuration that can effectively execute development activities while adhering to project constraints [15].

The literature offers various solutions for software team formation, involving the utilization of different attributes. Some approaches focus on soft skills [24, 40] and hard skills [4, 6] attributes. Singh Jat *et al.* [30] elected team members based on performance estimates, in addition to technical and social factors, while Latorre and Suárez [34] developed a Socio-technical framework. Jana *et al.* [29] proposed a Binary mathematical model considering cost and effort targets, and Gharot *et al.* [21] implemented a scattered search algorithm. Arias *et al.* [4] allocated team members based on capabilities, function, and historical performance. Other studies consider personality [22] and social interactions [34].

Although numerous attributes have been explored in relevant works within the field of software team formation, mapping these capabilities in the context of ASD holds substantial value. Such an endeavor can provide crucial support to industry practitioners for precise human resource allocation. This is precisely the focus of our work, as detailed and explained in the following section.

3 RESEARCH DESIGN

This study aims to examine and consolidate the capabilities of software engineers in ASD for team formation. We conducted an analysis of all capabilities identified in the SLR conducted by [16], which covered studies from 2017 to 2021, as well as those highlighted in primary studies outlined in the Systematic Mapping Study by Costa *et al.* [15] within the agile team formation context. Next, we cross-referenced and compared our literature analysis with the attributes employed in agile team formation within the collaborating organization, which we achieved by consulting an industry practitioner responsible for team creation. This process is detailed in Section 3.3. Finally, we arrived at a set of attributes that are indeed used in practice in team formation. Figure 1 summarizes the steps taken in this study.

3.1 Research questions

Our study used the research questions RQ.1 and RQ.2 to investigate the attributes used in measuring and predicting capabilities in ASD within team formation literature, as well as their practical application for supporting agile team formation in real-world settings.

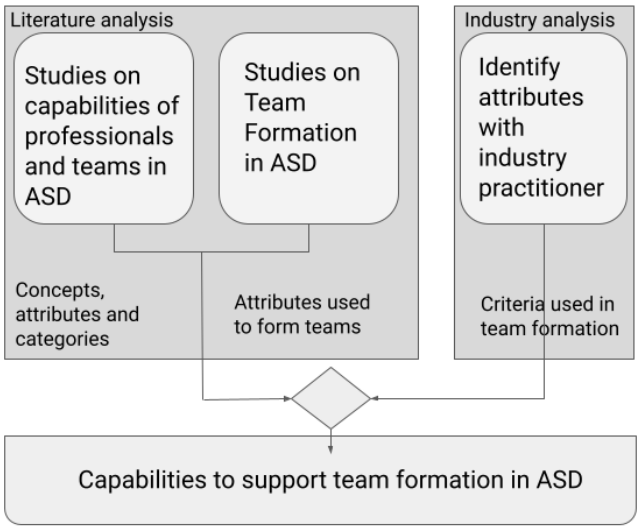

Figure 1: Research method summary.

- **RQ.1.** Which individual attributes used to measure and predict capabilities in ASD are being employed in the Team Formation literature?
- **RQ.2.** Which individual attributes are effectively applied to construct social and technical profiles to support agile team formation in the industry?

3.2 Strategy for selecting team formation studies

We employed two criteria for selecting studies from Costa *et al.*[15] for attribute analysis. The first criterion involved selecting primary studies focusing on professional team formation within the industrial context of ASD. The second criterion was that the research result of the study should be procedure or technique, as identified by Costa *et al.* [15]. This process was conducted by a researcher extractor, who selected the studies, and a researcher checker, who inspected and confirmed them in a synchronization meeting.

3.3 Data collection from the industry

We gathered data for analysis through a semi-structured interview[1] with an industry practitioner responsible for forming software teams in collaboration with project managers. The interview aimed to achieve three main objectives. Firstly, we sought to identify critical challenges faced when forming software teams. Secondly, we elicited the attributes used for selecting team members. Finally, we collected information about desired features for a supporting tool. This study focuses solely on identifying attributes used in team formation.

3.4 Data Analysis for identifying capabilities

We transcribed the interview and analyzed the resulting text, called a corpus, using the qualitative analysis tool IRaMuTeQ [10]. The corpus contained 1677 words and 47 text segments (TS). IRaMuTeQ revealed a crucial point: In 11 instances, the grouping criteria emphasized integrating social and technical characteristics for project success, aligning with findings in the literature [24, 18, 3].

[1] https://tinyurl.com/yff49dv2

3.5 Data collection from industry context

Describing context is crucial in evidence-based software engineering, especially in industrial settings [43]. In agile software team formation, understanding the context is vital for informed decision-making when selecting team attributes. We analyzed historical project data from our collaborating organization, following Petersen and Wohlin's methodology [43]. Our analysis covered People (e.g., roles, projects), Practices, and Techniques (e.g., agile methodologies and technologies). We used JavaScript scripts to examine task descriptions, tracking details through tags and associations (i.e., user ID linked to project ID).

4 RESULTS

4.1 Describing industry context

We have unveiled crucial contextual facets for framing the scope of our study. Our interviewee, with over ten years of experience as a manager, is the primary person accountable for forming all the software teams in collaboration with the project managers in the organization under study. It executes approximately fifty projects per year in several technological domains (e.g., Web systems, mobile systems, AI, augmented reality, embedded systems, and hardware), focusing on diverse market segments (e.g., security, biometry, and business intelligence).

Examining the organizational landscape further, we discerned intricate team dynamics, as depicted in Figure 2. Team sizes exhibit notable diversity, with the most common configuration comprising four members, observed across more than 30 projects. This is followed by teams of three, six, seven, five, and nine members. It's worth noting that projects occasionally involve teams exceeding ten members, although the frequency of such instances decreases significantly beyond the ten-project mark.

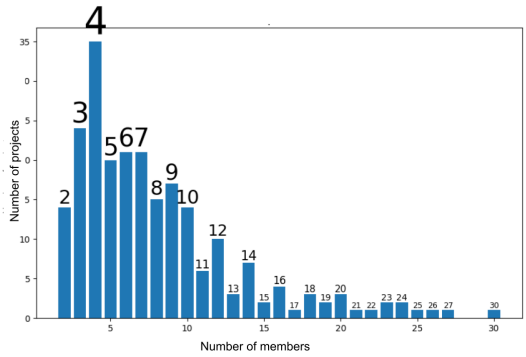

Figure 2: Team size.

Another noteworthy insight derived from the practitioner interview pertains to the ideal team size. This insight was further validated through the examination of project data. It was confirmed that team size is a variable that dynamically adjusts in accordance with project complexity. In essence, projects entailing a higher degree of technological intricacy and a wider array of required technologies inherently demand a larger number of team members. This correlation between project complexity and team size highlights the pragmatic approach of adapting team composition to the unique demands of each project, ensuring the allocation of sufficient human resources to effectively address the project's multifaceted challenges.

Within the scope of 279 projects analyzed, the distribution of methodologies becomes more apparent. Notably, out of these projects, a substantial count of 268 projects, corresponding to approximately 96.1%, employed the Scrum methodology. In contrast, a notably smaller subset of 10 projects, constituting around 3.9%, utilized the Kanban methodology. This data underscores the prevalent dominance of Scrum.

4.2 Responses to research questions

RQ.1. Which individual attributes used to measure and predict capabilities in ASD are being employed in the Team Formation literature?

In response to RQ.1, the investigation revealed that out of a total of 69 individual social attributes cataloged by [16], we identified 35 that were addressed in the team formation studies. Additionally, from a total of 73 individual technical attributes cataloged by (omitted for review), we identified 11. Lastly, out of 22 innovative attributes, we found 5 that were discussed in the context of team formation.

Table 1 provides a comprehensive overview of attributes that have been discussed in the literature focused on team formation. These attributes are categorized into social, innovative, and technical dimensions. Notably, certain attributes stand out in terms of usage frequency, reinforcing their significance. Among the social attributes most frequently mentioned in the literature were Communication, Collaboration, and personality traits such as Introverts & Extroverts, Intuition & Sensing, Thinking & Feeling, Judging & perceiving. Moving to the Technical category, the attributes of Programming language and Programming experience emerged as significant.

RQ.2. Which individual attributes are effectively applied to construct social and technical profiles to support agile team formation in the industry

In addressing RQ.2, the study delves into the effective application of individual attributes in constructing social and technical profiles to facilitate agile team formation within the industry context.

The analysis of attributes, as outlined in Table 1, underscores the significance of various attributes in both the social and technical dimensions. Notably, attributes such as Teamwork, Communication, Collaboration, Introverts and Extroverts, and Thinking and Feeling garnered attention in both the literature and industry practices. These attributes highlight the importance of interpersonal skills, effective communication, and diverse personalities in shaping successful agile teams.

Moreover, the insights from the industry practitioner shed light on additional social attributes that are pivotal for team formation but may not have received extensive attention in the literature. These attributes encompass Aptitude, Person's attitudes, Person's initiative, Leadership, Generating ideas, and Creative problem-solving. This emphasizes the industry's recognition of qualities like individual initiative, leadership potential, and innovative thinking in the formation of agile teams.

It is noteworthy that certain attributes, while extensively discussed in the literature, did not resonate strongly with the industry practitioner's insights. This includes attributes like Intuition and Sensing, Judging and perceiving, Teamwork oriented, Willingness to confront, Tenacity, and Perseverance. This discrepancy highlights potential disparities between academic discourse and practical industry experiences regarding the significance of these specific attributes.

In the Technical category, the attribute Programming language emerges as a key consideration for both scholarly discussions and industry practices. This underscores the pivotal role of technical proficiency, particularly a shared programming language, in fostering effective collaboration among team members.

Ultimately, this study offers a comprehensive understanding of individual attributes and their effective application in constructing

social and technical profiles to support agile team formation in the industry. The findings contribute valuable insights for practitioners seeking to enhance their team composition strategies and underscore the importance of aligning attributes with the unique demands of agile software development projects.

5 DISCUSSION

In this study, we aimed to investigate and identify the essential capabilities for forming successful agile teams in the context of ASD. The analysis revealed a comprehensive set of attributes, categorized into social, technical, and innovative aspects, that play a crucial role in team composition. By categorizing capabilities, we highlighted the importance of considering essential competencies required by the industry [12].

Our findings align with and expand upon existing literature and can provide support for team formation particularly when not all available human resources possess highly specialized skills [37]. We observed parallels between scholarly discourse and industry practices regarding the attributes deemed essential for agile team formation. Notably, certain social measures [19], such as teamwork, communication, and collaboration were consistently emphasized across both academic research and industry perspectives. However, we also identified distinctions, with the industry placing value on attributes like individual initiative, leadership qualities, and creative problem-solving, which were not extensively discussed in the literature.

In analyzing the subcategories, it's evident that some have received more attention than others. The Interpersonal and Personal subcategories seem to have garnered greater focus, with attributes such as collaboration, teamwork orientation, and traits of introversion/extroversion being frequently discussed, they may be associated with the increased adoption of agile methods [19]. In contrast, the Communication subcategory and the Enterprising subcategory in the Innovative category have received comparatively less focus, suggesting the need for further exploration and investigation. Understanding these trends can help practitioners better prioritize and emphasize certain attributes when forming agile teams.

The insights derived from this study have several implications for practitioners involved in agile team formation. The comprehensive list of attributes provides a valuable reference for project managers, HR professionals, and team leads to assess and select team members based on a holistic understanding of their capabilities. Collaboration, for example, has been shown to enhance decision-making [28] and has provided insights to improve developers' professional status by acquiring new skills [38]. Therefore, combining social and technical aspects is crucial for achieving success in ASD

Our findings shed light on attributes that might have been overlooked in previous team formation strategies. The identification of attributes like "Person's attitudes," "Person's initiative," "Leadership," and "Creative problem-solving" emphasizes the need to consider individual characteristics that extend beyond technical skills. Incorporating these attributes into team composition strategies can lead to more diverse and dynamic teams capable of addressing complex challenges in ASD.

The insights gained from this study can be directly applied in industry settings to improve team composition practices. Organizations can use the identified attributes as a basis for designing assessment tools, interview protocols, and performance evaluation criteria. By aligning team composition with the identified capabilities, organizations can enhance the likelihood of forming cohesive and high-performing agile teams.

The analysis of team size dynamics, responsive to project complexity, closely connects with identifying technical, social, and innovative capabilities. This adaptive process reflects a practical allocation of resources to address multifaceted challenges in ASD. Flexible team sizing ensures coverage of crucial technical skills, enabling members to address project complexity. Additionally, the prevalent Scrum usage versus limited Kanban adoption signifies a preference for iterative methods and underlines Scrum's social skill emphasis. Conversely, Kanban's limited adoption may stress innovative agility, aligned with its workflow optimization focus.

6 THREATS TO VALIDITY

The findings of this study may have been influenced by potential biases in both the study selection process and the data-collecting phase.

Bias in the study selection process. To address potential bias in study selection, we implemented clear criteria to identify the relevant studies, and the selection process underwent verification by another researcher.

Bias in the interview with a single practitioner. While the chosen solution was assessed using real-world insights and expert guidance, it is plausible that it might not encompass the full spectrum of industry characteristics. To mitigate this concern, the selected practitioner held a pivotal role as the decision-maker in team composition, lending significant weight to the insights gathered.

7 CONCLUSIONS

This paper presents a comprehensive view of the essential attributes and capabilities shaping successful agile teams in the context of Agile Software Development by conducting a comparative analysis. It contrasts the software engineers' capabilities identified in a prior review with those used in agile team formation based on recent studies. To gain insights into real-world practices, we conducted a semi-structured interview with a key practitioner from a software organization. The study identified 35 social attributes that were addressed in the team formation studies, along with 11 technical attributes and 5 innovative attributes that were discussed in the context of team formation. These findings offer valuable insights for both industry and academic research. The study also pinpointed new trends for further research in the field, including the need for more investigation into attributes related to communication, creativity, and enterprising. Future research could involve larger samples, longitudinal studies, and cross-industry comparisons to validate and extend the current findings. Further, we intend to incorporate certain findings from our analysis into a decision support system for team formation and validate its effectiveness with practitioners experienced in agile methods.

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Table 1: Comparative study: Individual attributes

Category	Sub category	Attribute	[30]	[25]	[23]	[41]	[34]	[39]	[42]	[27]	[35]	[14]	[5]	[6]	Ind.
Social	Affective	Aptitude													✓
		Person's attitudes													✓
		Person's initiative													✓
		Teamwork									✓				✓
		Leadership													✓
	Comm.	Communication	✓												✓
		Oral communication	✓												✓
	Interpersonal	Customer orientation					✓								
		Collaboration					✓	✓		✓					✓
		Seeks help					✓								
		Helps others					✓								
		Teamwork oriented					✓				✓				
		Willingness to Confrnt					✓		✓						
	Personal	Introverts & Extroverts		✓	✓		✓								✓
		Intuition & Sensing		✓	✓		✓								
		Thinking & Feeling		✓	✓		✓								✓
		Judging & perceiving		✓	✓		✓								
		Formal Education				✓									
		Decision making							✓						
		Negotiation skills							✓						
		Openness					✓								
		Conscientiousness					✓								
		Agreeableness					✓								
		Neuroticism					✓								
		Tenacity					✓		✓						
		Education				✓									
		Perseverance					✓	✓							
		Pro-active/initiator/driver					✓								
		Thoroughness					✓								
		Sense of mission					✓								
		Strength of conv.					✓								
	Work ethics	Flexibility							✓						
		Responsibility								✓					
		Honesty/ ethics								✓					
		Task prioritization									✓				
Innovative	Creativity	Generating ideas													✓
		Creative problem solving													✓
	enter-prising	Gathering/evaluating information							✓						
	Integ. persp.	Openness to ideas	✓												
	Mng. chng	Intelligent risk-taking							✓						
Technical	SW constr.	Programming Language				✓						✓			✓
		Manage Software Construction							✓						
	SW config.	Manage SW releases							✓						
		Plan SW configuration management							✓						
		Conduct SW configuration management							✓						
	SW security &safety	Quality											✓		
	SW proc.& LC model	Process implementation & management							✓						
	Diverse	Accurate effort estimate												✓	
		Domain knowledge				✓									
		Prior work experience					✓								
		Programming experience					✓					✓			

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