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Team Formation: A Systematic Literature Review

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Abstract
Collaborative activities require the formation of team(s), whose members may have weak or strong ties to each other, depending on the task to be completed. Team formation is a time consuming, complex, critical and essential process in the life cycle and development of the team, especially when the list of participants is disputed. To enhance learning and intellectual development in a team, it is important to select individuals based on specific prerequisites and create an environment that fosters genuine and effective interactions. However, the success of the team is not always guaranteed, and inappropriate team formation can lead to discouragement and hindered learning. As a result, researchers are exploring various clustering models and methods using best practices and other approaches to improve team formation and overcome these challenges. The process and the techniques used to form a team can vary depending on various factors, such as member characteristics, attributes, personalities, task, or context. However, despite the importance of team formation, there is no up-to-date comprehensive and systematic study to investigate and analyze its important techniques. Therefore, the main objective of this paper is to provide a comprehensive, detailed, systematic study, and to survey the most recent literature on team formation algorithms/techniques/mechanisms. This paper presents a systematic literature review (SLR) of recently published work investigating the team formation process, attributes, and techniques. Out of the 640 papers selected for review, 103 pass initial screening and accepted as papers related to team formation, and after a careful analysis, 30 papers meet the mandatory requirements/criteria defined in our protocol, using a specific selection and quality assessment method. The review reveals the current state of the art in the team formation literature and also sheds light on prospective topics for additional study. This systematic literature review can immediately assist academics and working professionals in understanding the evolving mechanisms and tactics of team formation by providing up to date information.

Keywords: team formation, team formation algorithms/methods/techniques, Systematic Literature Review (SLR)

1. INTRODUCTION

Team formation is crucial because team success depends largely on the appropriate assignment of team members to the teams. Therefore, it is important to implement and apply an effective technique to ensure (to some extent) the optimal team composition. No teams are identical nor do they operate according to the same processes with the same size, purpose, and common characteristics. Distinctions between size, types, styles of the teams, etc. are identified (Anderson et al., 2001; Borman et al., 2003; Handbook of Aviation Human Factors, 1999). In addition, attributes such as communication skills, teamwork experience, and personality traits, are criteria that affect team effectiveness and have an impact on team collaboration, efficiency and productivity (Bales & Strodtbeck, n.d.; Schermerhorn, 1948; Wieringa et al., 2006). Researchers from different disciplines, using many types of data, are trying to develop tools, techniques, and methodologies in order to facilitate the process of a successful team composition. Different goals, different teaming criteria and technologies make the task hard and complicated. Forming appropriate teams is also a challenge for most decision-makers (Mathieu & Rapp, 2009; Paris et al., 2000; Salas et al., 2008; Teamwork: Emerging Principles - Salas - 2000 - International Journal of Management Reviews - Wiley Online Library, n.d.). Traditionally formed teams tend to be a non-automated, human-dependent and error-prone process due to complexity, limited time and many other issues. Team formation strategies offer a growing range of tools and practices that increase the probability of creating an ideal team.

Studies have revealed relevant attributes in team formation. Knowledge, technical expertise, communication skills, and motivation are the main characteristics of a team and are mentioned in many studies (Blackwell, 1955; Silva et al., 2011), (Clark & Wheelwright, 1992), (Converse et al., 1991), (Haque et al., 2000), (Thamhain, 2003). Other studies combine these attributes or report the impact they have on team performance when one is missing or lacking (Lappas et al., 2009), (Campion et al., 1993b), (Allen, 1986) (Smart & Barnum, 2000), (Prasad, 1998) (Blackwell, 1955; Campion et al., 1993a; Logan, 1993; Taylor, 1975). Personality type is another attribute that many studies have emphasized and applied, (Trower & Moore, 1996), (Prince & Brannick, 1992), (Gilal et al., 2016b), (Gardner & Martinko, 1996), (Zakarian, 1999), These studies consider it as part of the solution to the problem of team formation among many other factors also identified (Sundstrom et al., 1990).

As noted, there are different characteristics of team formation. Depending on the grouping context, team members are selected in various ways and the process of team formation is computerized using various methodologies that are considered in particular teaming settings with various methodologies and techniques considered in specific grouping settings. The methodologies and techniques used to form a team may vary depending on various factors, such as member characteristics, attributes, personalities, task, or context. Search based techniques (Penta et al., 2011), genetic algorithm methods (Costa et al., 2018) [12], mathematical models (Graphs) (Lappas et al., 2009) or fuzzy genetic algorithms (Strnad & Guid, 2010) are some of them.

Despite the valuable contributions made so far, a comprehensive review of the team formation process, including all its useful elements, such as attributes and techniques, is still lacking. Furthermore, there has been no recent research on the method of team formation. The goal of this systematic review is to provide an overview and classify computational techniques, particularly algorithms/techniques/methods and attributes, that have been used to assist team formation in collaborative or cooperative environments from previous research work in the field. This paper will provide several categorized viewpoints on the methods and characteristics of team formation. This paper aims to review the latest developments in team formation and provide insights into the computational approaches that support it. We will summarize the findings and identify the knowledge gaps, challenges, and opportunities related to group formation.

This study aims to contribute to the knowledge of the field and achieve its objectives by addressing specific research questions (RQ) through the use of a systematic literature mapping method. The systematic review focuses on providing an overview and classification of computational techniques, including algorithms, methods, and attributes, used in team formation within collaborative or cooperative environments. The primary objectives are to identify the most effective attributes in the team formation process, uncover knowledge gaps, challenges, and opportunities extending our previous research (Stavrou et al., 2018).

To answer these research questions, the study conducted a systematic mapping of the literature using the method proposed by Petersen et al. (2008, 2015), as described in Section 2. The research protocol was carefully defined, and the most relevant digital libraries in the computing and educational technologies field were selected. Through a meticulous screening process, the study identified 30 research papers that align with the research objectives and meet the defined inclusion and exclusion criteria. These papers were thoroughly analyzed and categorized, as presented in Section 3, to address the following research questions: RQ-1) What are the most common research types and objectives? RQ-2) What are the most common computational techniques or methods used in team formation? RQ-3) What are the frequently measured team formation characteristics? RQ-4) Do the studies compare their results with other studies or approaches?

Section 4 further analyzes the results of our literature review, providing additional insights into the features and techniques found in the literature. Section 5 discusses the opportunities and challenges in group formation research, while Section 6 presents the conclusions and limitations regarding our research.

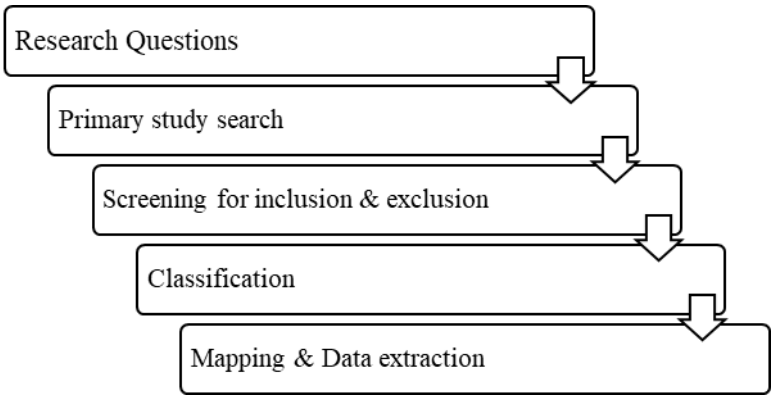
By conducting this comprehensive review, the study aims to contribute to the existing body of knowledge in the field, define clear research objectives, and identify primary studies on algorithms for team formation.

2. RESEARCH METHODOLOGY

Systematic mapping is a research assessment method that guides literature reviews to address a specific issue (Petersen et al., 2015). It involves methodical steps to search, analyze and evaluate literature using specific criteria. This review method aims to provide an overview of the field of interest, reduce systematic errors, and enhance the legitimacy of analyzed data for more reliable results (Buller & McEvoy, 2012; Charband & Jafari Navimipour, 2016; Petersen et al., 2008, 2015).

In this paper we followed the five-step process (Fig 1) proposed by Petersen (Petersen et al., 2008, 2015) with, additionally, snowball, back-tracing approaches, and additional searches that included "team OR group", "project OR task", "multifunctional OR role OR allocation", "knowledge OR expertise", which were used to supplement our searches.

Figure 1. Sequential steps of Petersen



2.1 Search Strategy

To define the search terms, we first defined the search string considering the most relevant terms related to previously known papers related to our research topic. To conduct our research, we selected relevant online databases. To create the search string, we used frequent keywords contained in the research questions extracted from highly cited papers (Table 1). Three main keywords have been defined: "team formation", "team collaboration" and "algorithms". Other very common terms were often used in the related literature, such as 'team allocation', 'team selection', 'team composition' etc. Each keyword forms a category that contains their respective synonyms. Paper searches based on category keywords C1, C2, and C3 are merged based on the Boolean operator "AND", and for each keyword synonym and category using the "OR" Boolean operator.

Table 1. Category, Synonyms and Search String

Ref.	Category	Synonyms	Search String
C1	Team formation	team creation, group creation, team formation, group formation, team design, group design, team forming, group forming, team, group	(group OR team OR team creation OR group creation OR team formation OR group formation OR team design OR group design OR team forming OR group forming) AND (Methods OR approach OR technique OR model OR framework OR tool) AND (Knowledge OR collaboration OR coordination OR cooperation OR team learning OR team coordination)
C2	Algorithms	methods, approach, technique, model, framework, tool	

C3	Team collaboration	knowledge, collaboration, coordination, cooperation, team learning, team coordination	

Since each online database uses different mechanisms and standards, the developed search string was adapted to each database to work properly and conduct our search. Our literature search using the keywords identified relevant papers from various databases, including ACM Digital Library (8), IEEE Xplore Digital Library (23), Elsevier - Science Direct (23), SpringerLink (15), Google Scholar (26), Microsoft Academic (2), and Scopus (6), resulting in a total of 103 papers.

2.2 Screening of Papers for Inclusion & Exclusion

The final analysis included only 30 papers in the systematic literature review, after examining more than 103 publications using a scientific approach known as systematic literature review. Many steps were taken to gradually filter the papers and determine which were more relevant to the research objectives. Returned papers were screened using multi-level criteria, which were either for inclusion or exclusion (Table 2). The process is described below:

Practical Screening: This is the screening in which we narrow down the range of published papers, by reading each paper's title and abstract (and sometimes the introduction) to verify close relevance to the review's goals and questions. The relevant keywords of each paper were also examined.

Table 2. Inclusion & Exclusion Criteria

Inclusion	**Exclusion**
If several papers are related to the same paper, only the most recent paper is selected.	Papers that present studies relating to education environments only (meaning classrooms)
If the paper describes more than one study, each study is assessed individually.	Papers that do not present studies relating to team formation algorithms or techniques
If there are versions of the same study, a short and a full one, the full version must be included.	Papers in languages other than English
Include Papers from 2010.	Not relevant to the research questions
Include only published papers.	Papers that lack original contribution or novelty in research. Similar research has already been published.
Include Papers related to Team/Group formation	

Quality Appraisal: To ensure the quality of strongly related papers, the remaining papers were assessed after full reading. This task applies the exclusion filter to selected papers, answering the question using a Boolean scale (0 or 1) (Table 3).

Table 3. Quality Appraisal Criteria

No.	Question
1	Does this study follow a scientific methodology in order to prove its contributions?
2	Are the research objectives clear?
3	Was the research design appropriate to address the aims of the research?
4	Does this study identify a task or a project?
5	Does the study clearly explain or present the methods with equations or techniques?
6	Does the study identify specific member attributes or criteria?
7	Is the technique used clear and supported through experiments?
8	Does the study have clear tests, experiments, or case studies that support their research?
9	Does the study have comparison results with other studies or techniques?

2.3 Classification Scheme

For each paper, we used the categories proposed by Wieringa (Wieringa et al., 2006) to analyze, classify and categorize the types of studies described in them. The categories of study types are:

Validation Research: novel, unimplemented techniques commonly used in experimental settings.

Evaluation Research: techniques that include implementation, advantages and disadvantages and have been applied in practice.

Solution Proposal: Proposed solutions, which may be new or an extension of others, with potential benefits of using case studies or comparative results to improve their arguments.

Philosophical Papers: papers that often use conceptual frameworks or taxonomies that present a new direction or point of view to the field.

Opinion Papers: papers expressing personal opinions about whether an approach is good or bad with their implementation.

Experience Papers: personal experience of the author explaining how and what has been applied in practice.

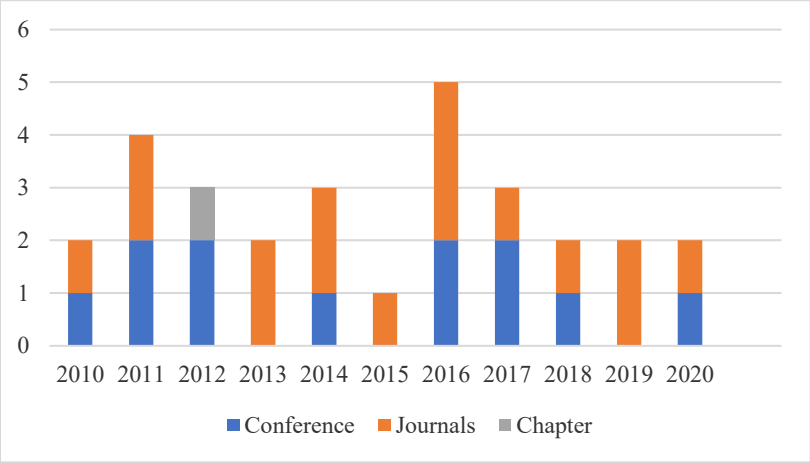
2.4 Data Extraction & Mapping

We followed the steps and categories outlined in the previous sections to identify the necessary data to extract elements from the included papers for our team formation review. We extracted the following information from each paper: Author, Year, Title, Keywords, Findings of the proposed solution, Computational techniques, Publication type (Journal, Conference, etc.), Team formation characteristics, Study parameters (communication cost, skill grading, etc.), Digital library, and Comparison results with other studies. We stored and analyzed these data qualitatively and/or quantitatively to answer the research questions presented in previous sections, and also performed statistical analysis, such as the number of publications per year, their type, venue and so on.

3. ANALYSIS & RESULTS

During the systematic literature review, 103 papers were reviewed, and only 30 relevant papers, published in the period 2010-2020, were included for final evaluation. The selected papers were published in various outlets, from conferences and workshops to journals (Fig 2).

Figure 2. Distribution of papers according to their type over the years



The necessary data required in order to create the review of team formation include publication type, research type, research objective (the classification of the research objectives is discussed in section 3.1), the technique or method used, and whether each paper compares its results with other studies or other techniques/methods. This information was collected from 30 papers in a tabular form to help us explore the team formation process (Tables 4). The findings of the team formation studies are organized in a structural manner by presenting appropriate answers to the study's research questions (VS = has comparison).

Table 4. Information about relevant studies

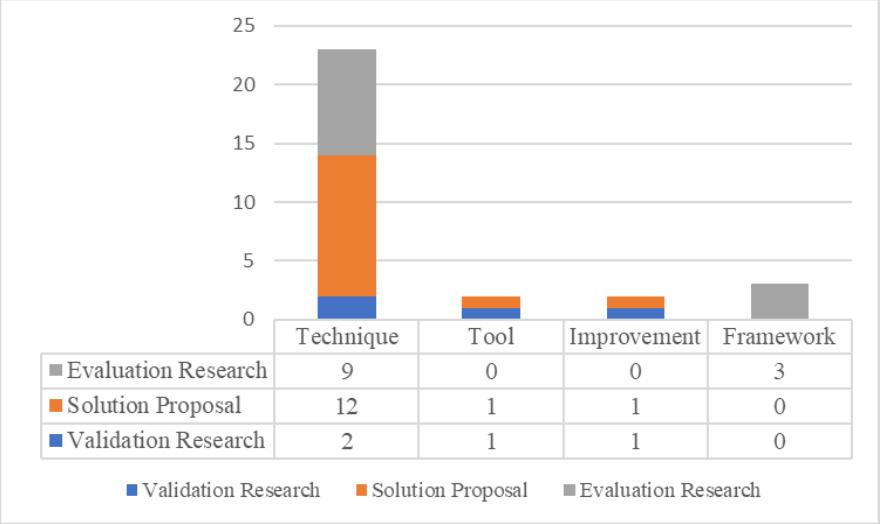
Ref	Publication Type	VS*	Research type	Research objectives	Title	Techniques or Methods
(Feng et al., 2010)	Journal	YES	Technique	Evaluation Research	A method for member selection of cross-functional teams using the individual and collaborative performances	Multi-objective genetic algorithm
(André et al., 2011b)	Conference	NO	Tool	Evaluation Research	Formal model for assigning human resources to teams in software projects	Delphi algorithm & Personality
(Farhadi et al., 2011)	Conference	YES	Technique	Evaluation Research	An effective expert team formation in social networks, based on skill grading	Approximation algorithms
(Mazur & Chen, 2011)	Journal	NO	Technique	Evaluation Research	A task-member assignment model for complex engineering projects	Genetic algorithm
(Agustín-Blas et al., 2011)	Journal	NO	Technique	Evaluation Research	Team formation based on group technology: A hybrid grouping genetic algorithm approach	Genetic algorithm
(Ren et al., 2011a)	Conference	YES	Tool	Evaluation Research	Cooperative Co-evolutionary Optimization of Software Project Staff Assignments and Job Scheduling	Genetic algorithm
(Gajewar & Sarma, 2011)	Chapter	YES	Improvement	Solution Proposal	Multi-skill Collaborative Teams based on Densest Subgraphs	Approximation algorithms
(Farhadi et al., 2012)	Conference	YES	Framework	Solution Proposal	Teamfinder: A co-clustering-based framework for finding an effective team of experts in social networks	Data mining (Clustering technique)
(Britto et al., 2012a)	Conference	NO	Technique	Evaluation Research	A hybrid approach to solving the agile team allocation problem	Multi-objective & Fuzzy systems
(Zhang & Zhang, 2013)	Journal	NO	Technique	Solution Proposal	Multi-objective team formation optimization for new product development	Multi-objective Particle Swarm Optimization
(Tavana et al., 2013)	Journal	NO	Technique	Solution Proposal	A fuzzy inference system with application to player selection and team formation in multi-player sports	Fuzzy systems
(Neshati et al., 2014)	Journal	YES	Technique	Evaluation Research	Expert group formation using facility location analysis	Greedy algorithm
(Kamel et al., 2014)	Conference	YES	Technique	Solution Proposal	Realistic team formation using navigation and homophily	Approximation algorithm
(Jiménez-Domingo et al., 2014a)	Journal	NO	Tool	Evaluation Research	A multi-objective genetic algorithm for software personnel staffing for HCIM solutions	Multi-objective genetic algorithm
(Wang & Zhang, 2015)	Journal	NO	Technique	Solution Proposal	A win win team formation problem based on negotiation	Agent-based negotiation algorithm for team formation
(Huang, Lv, et al., 2017)	Journal	YES	Technique	Evaluation Research	Forming Grouped Teams with efficient collaboration in social networks	Heuristic algorithm
(J. Yang et al., 2016)	Conference	YES	Technique	Solution Proposal	Forming a research team of experts in expert-skill co-occurrence network of research news	Approximation algorithms
(Akhavan et al., 2016)	Journal	NO	Technique	Solution Proposal	Selecting new product development team members with knowledge sharing approach	Fuzzy multi-objective integer nonlinear programming
(Stylianou & Andreou, 2012a)	Conference	NO	Technique	Evaluation Research	A Multi-objective Genetic Algorithm for Software Development Team Staffing Based on Personality Types	Multi -objective genetic algorithm
(Arunachalam et al., 2016b)	Journal	NO	Technique	Validation Research	Resolving team selection in agile development using NSGA-II algorithm	Multi -objective genetic algorithm
(Huang, Sun, et al.,	Journal	NO	Technique	Solution Proposal	A team formation model with personnel work hours and project	2 Approximation algorithms

2017)					workload quantified	
(Ding et al., 2017)	Conference	NO	Technique	Solution Proposal	Online formation of large tree-structured team	Competitive algorithm
(Arias et al., 2017a)	Conference	NO	Framework	Validation Research	A Multi-criteria Approach for Team Recommendation	Multi-criteria
(X. Yang et al., 2018)	Conference	YES	Improvement	Evaluation Research	Team Formation with Relationship Strength Based on Meta Path in Heterogeneous Network	Approximation Algorithms Graph
(Paredes-Valverde et al., 2018b)	Journal	NO	Technique	Evaluation Research	An ontology-based approach with which to assign human resources to software projects	Semantic
(Garshasbi et al., 2019)	Journal	NO	Technique	Validation Research	Optimal Learning Group Formation: A Multi-objective Heuristic Search Strategy for Enhancing Inter-group Homogeneity and Intra-group Heterogeneity	Multi -objective genetic algorithm
(Rahmanniyay et al., 2019)	Journal	NO	Technique	Solution Proposal	A multi-objective multi-stage stochastic model for project team formation under uncertainty in time requirements	Heuristic algorithm
(Miranda et al., 2020b)	Journal	NO	Technique	Solution Proposal	A multi-objective optimization approach for the group formation problem	Multi objective genetic algorithm
(Putro et al., 2020)	Conference	NO	Technique	Solution Proposal	Intelligent Agent to Form Heterogeneous Group Based On Personality Traits with Genetic Algorithm	Genetic Algorithm
(Krouska & Virvou, 2020)	Journal	NO	Technique	Solution Proposal	An Enhanced Genetic Algorithm for Heterogeneous Group Formation based on Multi-Characteristics in Social Networking-based Learning	Genetic Algorithm

3.1 Most common research types and objectives (RQ-1)

To address RQ1 (Table 1), we conducted a classification of the selected papers based on their research objectives. Upon thorough reading, we propose four major categories for classifying the papers. **Technique/ Procedure:** Papers that focus on implementing specific techniques or procedures for team formation. **Tool/Notation:** Papers that provide mechanisms or procedures to support team formation. **Improvement/ Extension:** Papers that present extensions or improvements to existing algorithms or procedures for team formation. **Framework:** Papers that propose technical solutions in the form of team formation algorithms. In addition, as discussed in Section 2.3, we adopted the classification categories proposed by Wieringa (Wieringa et al., 2006), which group studies based on their study type. Table 4 provides the classification and study types of the included papers, offering insights into the research data.

Figure 3. Distribution of papers in each category

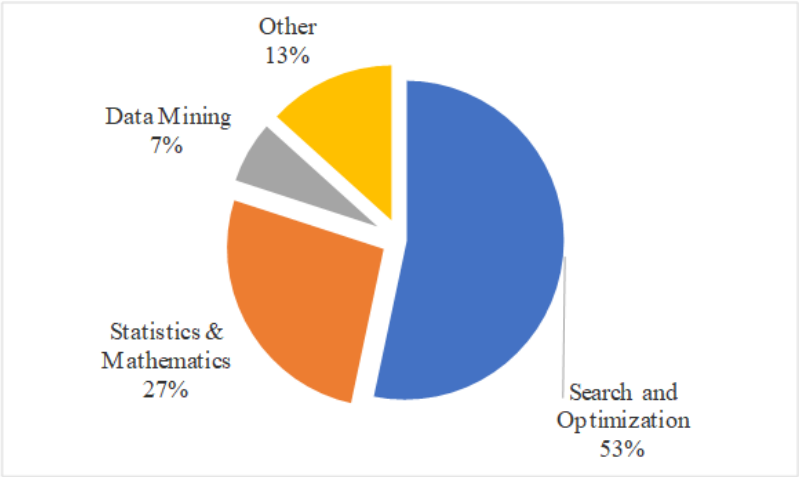


As shown in Fig 3, the most explored category in the literature is the "Techniques" category with 19 papers. In this category, according to their research objective, nine of these studies propose a solution to a problem ('Solution Proposals'). The proposed solution is either new or an extension of an existing technique, providing potential benefits over the existing solution, using examples or other arguments. The potential benefit of the solution is presented using case studies (small examples) or other arguments. The remaining nine techniques ("Evaluation Research") are implemented in practice and evaluated. This includes analysis of their implementation, benefits and drawbacks. Next is the 'Framework' category, with 3 studies, which proposes a model (technical foundations) that supports the creation or facilitates the use of team formation algorithms, and finally the 'Tools & Improvements', category with 2 papers, in which the main objective was to develop or extend a tool that implements a specific algorithm for team formation.

3.2 Most common computational techniques or methods (RQ-2)

To address research question 2, we thoroughly analyze each of the selected articles, focusing on the computational techniques proposed as solutions to the team building problem. We identified more than 18 different techniques, which we divide into four main categories (Fig. 4).

Figure 4. Categories of the techniques



The most prevalent category, comprising 53% of the contributions, is "Search and Optimization". This category includes a number of algorithms, including genetic algorithms (GAs), heuristic and greedy algorithms, dynamic programming, and backtracking. GA is the most commonly used technique, accounting for nearly 20% of the papers studied. GAs are guided by natural selection and use mechanisms such as crossover and mutation to effectively explore the solution space.

The second largest category, accounting for 27% of the papers, is "Statistics and Mathematics". In this category, researchers use regression models, approximation algorithms, distance measures, and statistical methods to accurately quantify and evaluate team formation criteria. These techniques use statistical analysis and mathematical models to provide a solid foundation for decision making.

The "data mining" category, which represents 7% of the contributions, includes techniques such as clustering, association, and classification. These data mining techniques aim to extract meaningful patterns and relationships from large data sets to provide insights for the team building process.

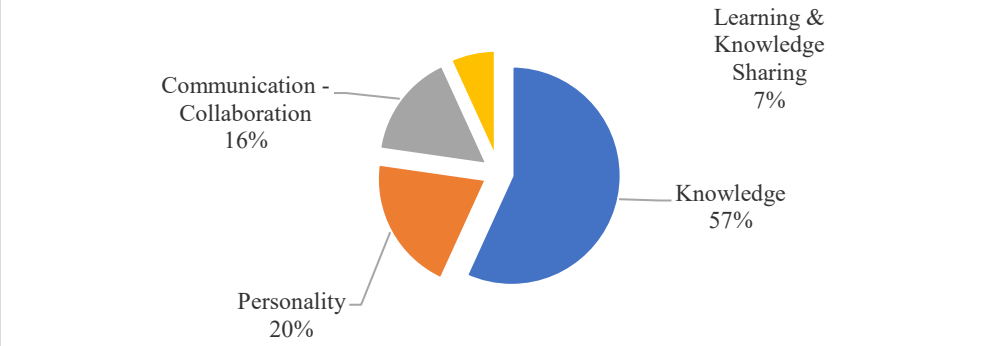
The remaining 13% of studies fall under the "other" category, which includes various computing techniques. In particular, fuzzy logic and Bayesian networks are commonly used to deal with the uncertainties associated with individual profiles and to allow decision makers to take subjective factors into account. In addition, Gray decision theory, the Analytic Hierarchy Process, and ontology techniques play a supporting role by helping decision makers make informed judgments rather than automating the team-building process.

By explaining each of the computational techniques, we aim to provide a comprehensive understanding of the specific approaches used in the work discussed and their relevance to the team building problem. This expanded explanation will enhance the reader's understanding of the various computational tools used in the field and facilitate further exploration and analysis.

3.3 Most commonly measured team formation characteristics (RQ-3)

The reviewed papers report that certain characteristics are critical for effectively assigning team members to tasks during team formation. Knowledge expertise was found to be the most widely used characteristic in the majority of primary papers reviewed, accounting for 57% of the analyzed papers. Technical knowledge, which refers to specific skills and expertise in a particular field or industry, such as programming, finance, or mechanics, was the most common type of knowledge expertise used in these studies. The level of technical knowledge was often described as a percentage or with predefined values such as "bad," "average," "good," or "very good," depending on the criteria being assessed (Akhavan et al., 2016; Bellhäuser et al., 2018; Farhadi et al., 2011; Feng et al., 2010; Ren et al., 2011b; Zhang & Zhang, 2013).

Figure 5. Team Formation Characteristics



Usually, more than one type of characteristic is used in the team formation process. Figure 5 shows the main category types considered in the selected papers. After the knowledge characteristic, the second most frequent type of characteristic was personality traits (20% of the papers). This characteristic was reported in many studies in our review process and is derived from psychometric instruments such as Belbin's Team Roles and the Myers-Briggs Type Indicator (Aritzeta et al., 2007; *Myers-Briggs Type Indicator (MBTI) | SpringerLink*, n.d.). Communication and Collaboration characteristics such as communication, motivation, leadership, preference and other metrics that can establish connections between members are used in 16% of the papers. 'Learning & Knowledge Sharing", which reflects individuals' skills in acquiring useful information from others, and the ability to share knowledge among team members, is used in 7% of the papers.

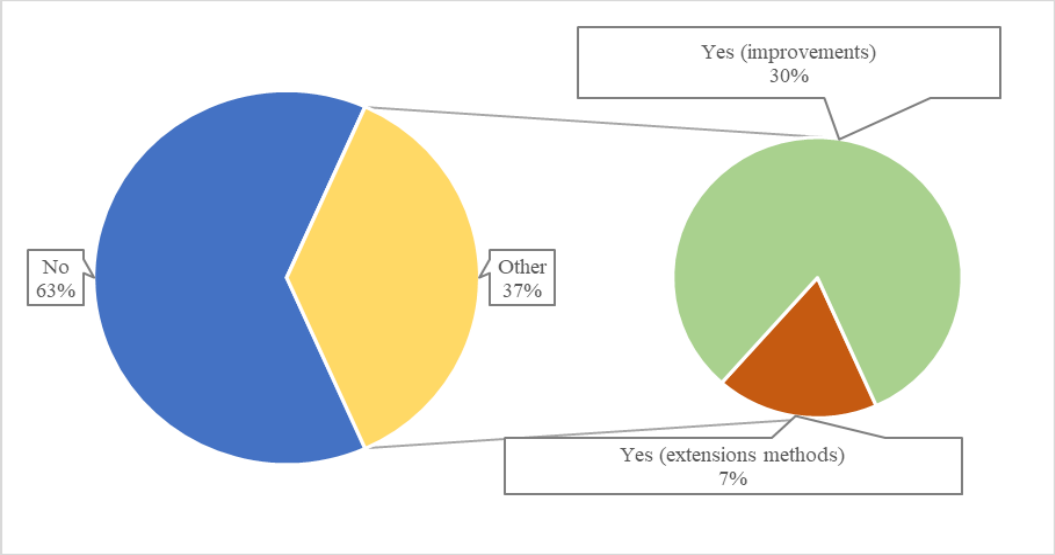
3.4 Comparative Analysis: Papers Assessing Results in Comparison to Other Approaches (RQ-4)

Although many studies implement team formation algorithms, the lack of source code or pseudocode to reproduce and reuse the team formation algorithm and the different approaches in each study make it difficult to find or categorize studies with comparison results. When a study or research has comparative results with other studies or research, it means that the findings of the current study or research have been compared and contrasted with the findings of previous studies or research on the same or similar topic. This type of comparison can provide valuable context and perspective for the current study or research, and can help validate or invalidate the findings. It can also help identify gaps in previous research and suggest areas for further study.

By comparing and contrasting the results of different studies or research, scientists and researchers can gain a deeper understanding of the subject and ultimately make more informed decisions and recommendations based on the available evidence. Additionally, comparative research helps identify similarities and differences between studies and can help understand the bigger picture of the subject or problem. It also helps identify strengths and weaknesses of past and current research.

In our review we categorized studies which show or present benefits, drawbacks and comparison results with other studies. Unfortunately, most studies (63%) do not compare their results with others (Fig 6). On the other hand, 37% of the studies which have comparative results are mostly extensions of previous studies, such as (Farhadi et al., 2011, 2012; Feng et al., 2010; Gajewar & Sarma, 2011; Huang et al., 2016; Kamel et al., 2014; Neshati et al., 2014; Ren et al., 2011b; J. Yang et al., 2016; X. Yang et al., 2018). This means that the present study builds on the findings of earlier research and aims to further explore or expand the topic. In these cases, the present study is often designed to address limitations or gaps identified in previous research. By comparing and contrasting the results of the current study with those of previous studies, researchers are able to gain a more complete understanding of the topic and make more informed conclusions and recommendations. Additionally, this type of research often helps to confirm or disprove previous findings and identify new areas for future study. In many cases, researchers will use results from previous studies as a starting point for their own research and build on it by adding new data, new methods, new perspectives or new hypotheses. This type of research is called "extension research" and it is valuable because it helps to strengthen the evidence base and to provide more robust and reliable conclusions.

Figure 6. Papers with comparison examples



4. DISCUSSION AND FUTURE TRENDS

To accomplish the research goals of this SLR, 30 studies in the field of team formation have been reviewed and evaluated. The objectives were to identify recent advances in team formation across contexts, investigate useful characteristics and grouping process methodologies/techniques, summarize and depict findings in a structural way to highlight knowledge gaps, challenges, and opportunities.

It is clear that the team formation process has been examined from two critical angles. The first concerns the characteristics that influence team formation, and the second concerns the methods applied to certain situations. Sections 4.1 and 4.2 provide additional information on these viewpoints. The results of the analysis of the study allowed the classification of the contributions into different categories. Finally, based on the knowledge gaps identified in the relevant literature, constraints, limitations and possibilities are described.

4.1 Characteristics of Team Formation

There is a substantial body of research on how teams are formed. The papers cover a wide range of topics, such as compiling information about team members while using various models of the team formation process in different circumstances. The team formation process depends on the parameters selected for each study, as shown in Figure 5. It is evident that the research varied in terms of the selected attributes and their number.

In this context, some research studies (10 papers) focused on the use of a particular attribute to form productive teams (Agustín-Blas et al., 2011; Ding et al., 2017; Farhadi et al., 2011; Gajewar & Sarma, 2011;

Huang et al., 2016; Neshati et al., 2014; Paredes-Valverde et al., 2018a; Ren et al., 2011b; Wang & Zhang, 2015; J. Yang et al., 2016). That is, these studies emphasized a particular attribute, such as technical expertise/knowledge in a particular domain, as the primary criterion for team building. On the other hand, another group of studies (6 papers) considered two attributes simultaneously (André et al., 2011a; Arunachalam et al., 2016a; Farhadi et al., 2012; Feng et al., 2010; Jiménez-Domingo et al., 2014b; Paredes-Valverde et al., 2018a). These studies aimed to examine the effects of combining two specific attributes, such as technical expertise and cooperation/collaboration, on team building outcomes.

In addition, a smaller group of studies (4 out of 30 papers) examined the process of team formation with three specific attributes (Arias et al., 2017b; Feng et al., 2010; Huang, Sun, et al., 2017; Mazur & Chen, 2011). These studies aimed to explore the possibilities of multicriteria team formation under increasingly complex conditions and recognized that the inclusion of more team member attributes would lead to a more complicated team formation process.

Other studies in our review used different attributes based on the available datasets and their specific research objectives (Arias et al., 2017b; Arunachalam et al., 2016a; Britto et al., 2012b; Farhadi et al., 2012; Garshasbi et al., 2019; Kamel et al., 2014; Miranda et al., 2020a; Putro et al., 2020; Tavana et al., 2013; Zhang & Zhang, 2013). These attributes included factors such as cooperation/collaboration, personality traits, roles within teams, and connections among members.

Technical expertise/knowledge in a particular field emerged as the most commonly used attribute in the work reviewed. This attribute was consistently used in most studies due to its significant influence on team outcomes (Agustín-Blas et al., 2011; André et al., 2011c; Arias et al., 2017b; Britto et al., 2012b, 2012b; Ding et al., 2017; Farhadi et al., 2011; Feng et al., 2010; Gajewar & Sarma, 2011; Huang, Sun, et al., 2017; Huang, Lv, et al., 2017; Jiménez-Domingo et al., 2014b; Mazur & Chen, 2011; Neshati et al., 2014; Paredes-Valverde et al., 2018a; Ren et al., 2011a; Stylianou & Andreou, 2013; X. Yang et al., 2018).

Cooperation/collaboration characteristics have also been discussed extensively in the literature (Anagnostopoulos et al., 2010; Feng et al., 2010; Gajewar & Sarma, 2011; Huang et al., 2016; Largillier & Vassileva, 2012; Magnisalis et al., 2011; Mazur & Chen, 2011; Wi et al., 2009; Zhang & Zhang, 2013). These traits capture team members' willingness and ability to work together effectively. Similarly, personality traits have been considered in team formation (André et al., 2011a; Bellhäuser et al., 2018; Gilal et al., 2015, 2016a; Licorish et al., 2009; Putro et al., 2020; Stylianou et al., 2012; Stylianou & Andreou, 2012b; Zhang & Zhang, 2013) because they contribute to team cohesion and are easy to identify for research and experimental purposes.

More recent studies have introduced additional attributes that focus on team members' roles and connections within the team. Three studies explicitly included these attributes in the team-building process (André et al., 2011a; Farhadi et al., 2012; Huang et al., 2016). By considering these attributes, researchers sought to examine how the roles and relationships among team members influence overall team dynamics and performance.

It is important to note that the selection of team formation criteria, although seemingly simple, requires significant effort on the part of researchers to collect and record data as objectively as possible. Attribute selection plays a critical role in determining the effectiveness of team-building strategies and must be carefully considered in the research process.

4.2 Techniques Used in Team Formation

It is evident that the use of evolutionary algorithms is one of the main methods in the team formation process (Fig 4). Approximately 50% of the reviewed papers used these evolutionary methods (Agustín-Blas et al., 2011; Akhavan et al., 2016; Arias et al., 2017b; Arunachalam et al., 2016a; Huang et al., 2016; Jiménez-Domingo et al., 2014b; Mazur & Chen, 2011; Neshati et al., 2014; Putro et al., 2020; Rahmanniyay et al., 2019; Ren et al., 2011b; Stylianou & Andreou, 2012b, 2013; Zhang & Zhang, 2013) or a combination of an evolutionary method with another technique, for example fuzzy with genetic algorithms (Britto et al., 2012b; Tavana et al., 2013). The most widely used method was the genetic algorithm. This was applied in more than 10 studies (Agustín-Blas et al., 2011; Mazur & Chen, 2011; Ren et al., 2011b). Data mining, which consists of techniques based on clustering and association rules, were also used, particularly for homogeneous grouping (Farhadi et al., 2012; X. Yang et al., 2018). Other studies used a variety of methods to achieve their goals, such as Approximation algorithms (Farhadi et al., 2011; Ren et al., 2011b), mathematics and statistics, which is composed of regression models, distance measures, statistical methods, and others (Farhadi et al., 2011; Gajewar & Sarma, 2011; Kamel et al., 2014)). Other papers employed multi-agent systems (Soh, 2004; Wang & Zhang, 2015), or decision making approaches using the Analytic Hierarchy Process, and semantic ontologies (Paredes-Valverde et al., 2018a). In general, studies using these techniques do not try to automate tasks associated with forming teams but rather suggest the team.

It was interesting to discover that the majority of solutions try to maximize the project requirements. Finding a team whose members' talents align with the needs of the intended project is the goal here (Akhavan et al., 2016; Arias et al., 2017b; Feng et al., 2010; Huang, Sun, et al., 2017; Jiménez-Domingo et al., 2014b; Kamel

et al., 2014; Wang & Zhang, 2015). Typically, dozens or even hundreds of potential team members with a variety of abilities are considered for the position. Therefore, it is difficult to assemble the best team without computer support. Other solutions try to improve working relationships, which entails creating a cohesive team where members may easily commit to each other (Acuña & Juristo, 2004; André et al., 2011a; Chiang & Lin, 2020; Colomo-Palacios et al., 2012; Gilal et al., 2016a; Martínez et al., 2010). This goal often appears in solutions based on psychometric instruments. The major objective of some of the studies is to identify a team that can reduce project or communication costs by selecting team members based on their individual costs (Farhadi et al., 2012; Gajewar & Sarma, 2011; Neshati et al., 2014; X. Yang et al., 2018). Other options, which focus on delivering the final product as quickly as possible so that team members can move on to other projects, aim to assemble a team that can minimize project delivery time (Arunachalam et al., 2016a; Rahmanniyay et al., 2019).

5. OPPORTUNITIES & CHALLENGES OF TEAM FORMATION

The present literature review makes it clear that there are current trends in the field of team formation. It is also evident that the existing literature mainly focuses on the automated team formation process from a broader perspective, possibly overlooking the specificities of particular environments such as education, sports, business, etc. It would be valuable to consider re-evaluating the process incorporating these perspectives as well. However, there are still many weaknesses and gaps in the current research. They serve as a basis for defining the following directions for future research:

To effectively form teams in various contexts with diverse criteria, a well-defined model that includes all aspects of the team formation process should be created in collaboration with other fields such as education, training, and psychology. This model can then be used as a standard in all team formation initiatives.

There is a lack of sufficient solutions to address team formation in different contexts. What is needed is the creation of a computational system that will provide assistance in the main grouping functions and learning preferences.

The majority of solutions are tested using hypothetical or simple cases. These techniques may not be equally effective or scalable in real-world settings, that is, they may not adequately address complex situations.

In order to create teams that meet the needs of projects, the majority of papers define a set of attributes that represent the knowledge and skills of prospective team members. However, the way that these attributes are specified is often rather vague. For instance, when quantifying programming language experience, the considered attribute simply contains a score indicating the degree of the attribute and does not identify the languages. As a result, it is impossible to determine the exact extent of the person's experience.

The specific context of the team formation problem determines the selection of the appropriate technique to be used. However, there are many suitable methods that can be applied in the team building process depending on the situation, which prompts researchers to question the reasoning behind the chosen technique.

Project managers and potential team members often raise concerns about the assessment of attributes. This approach can lead to subjective and unreliable results, as the data generated may not accurately reflect the actual situation. The literature review indicates that this gap exists due to the fact that most solutions focus on the allocation phase without providing a systematic way to monitor the knowledge and skills of the staff.

Lack of community access to information and solutions. The reviewed papers cannot be evaluated in other contexts because they lack the tools required for other researchers to reproduce and use their findings. As a result, there are not many studies that compare their findings with similar ones in the literature.

Poor contributions are readily apparent in the realm of quality measures that assess the effectiveness of team formation from multiple perspectives. Because of this, using quality of service (QoS) as an evaluation framework for team formation is a fruitful way to determine whether the process of forming the teams has been successful. Furthermore, regarding the methodology of the studies, it is evident that there are no ready-made solutions available for use, nor the data collected during their studies. Consequently, replication of the studies becomes unfeasible, and the cost of (i) conducting comparative studies with the available tools and (ii) transferring the technology to industry is high.

5.1 Implications

Several trends in the field of team formation are observed based on the literature reviewed. The present literature review places a central emphasis on the automated process of team formation from a general perspective, potentially overlooking the view of educational contexts and cooperative learning often applied in educational institutions. It would be beneficial to enrich it by incorporating these topics as well, where collaboration with others is important. However, there are still many issues that are not properly handled during team formation. These problems include weaknesses and gaps in the reviewed literature. They are used to emphasize the conclusions drawn from the examination of team formation in many studies. These implications relate to research perspectives: implications for current research as well as practical applications.

5.1.1 Relevance to Future Research

The implications of our review for the field of team formation are significant, as it highlights the need for a comprehensive approach that considers both technical and non-technical characteristics. Traditionally, team formation has focused primarily on technical skills, but our review challenges this perspective. By comparing computer-based and pedagogical outcomes, we identified strengths, weaknesses, and gaps in current research that suggest team-building strategies may not be generalizable when based only on local data sets. To address these limitations, we propose the development of a comprehensive paradigm that captures the specifics of team formation in different settings. This paradigm should be developed in collaboration with fields such as education, training, and psychology to ensure a holistic approach.

Our review not only evaluates team building effectiveness from multiple perspectives, including qualitative measures that reveal inadequate contributions, but it also highlights the increasing importance of non-technical characteristics or soft skills, such as personality traits and social attributes, in effective team building. However, there is a significant lack of research regarding the costs and benefits associated with the use of soft skills in team building, which presents a valuable direction for future research.

By challenging the prevailing notion that team building focuses on technical characteristics, we call for a more comprehensive approach that considers both technical and non-technical aspects. We urge researchers to consider contextual factors that influence the selection of team-building techniques, aiming to better understand the circumstances in which certain approaches are more effective than others.

Overall, our review provides a roadmap for future research in team building that identifies areas for further investigation and argues for a shift in the prevailing perspective.

6. CONCLUSION & LIMITATIONS

Team formation has emerged as a prominent area of research in recent decades, and our systematic review provides a comprehensive overview of the current state of team formation from various perspectives. This review is beneficial for researchers seeking to understand team formation or learn about existing solutions, methods, or techniques. Most of the reviewed papers effectively achieve their objectives by optimizing project requirements, selecting team members based on their individual attributes, or improving working relationships through team composition that aligns with project requirements. The presented techniques and methods aim to facilitate successful team formation based on each study's objective or to achieve superior performance compared to other or previous studies. Additionally, we found that more than six different types of characteristics were measured, each having a different effect on team formation.

Despite the growing number of publications and the variety of computational approaches supporting team formation, we identified a lack of comparability among the results across studies, as discussed in Section 3.4. Most studies only incorporate a limited number of fixed sets of characteristics, typically focusing on just two: technical expertise and personality traits. This limitation restricts the diversity of team compositions, probably due to the complexities that arise when increasing the set of parameters for selecting suitable team members.

Moreover, many proposed approaches primarily focus on validating algorithm efficiency rather than evaluating the impact on team performance after formation. This highlights the need for further improvements in team formation to optimize its functionality. An important aspect to consider is the development of integrated solutions that offer superior performance. In future research, we plan to explore some of the directions presented in this review. This includes investigating the most relevant technical and non-technical attributes for team formation, providing a concrete attribute list, and conducting tests to implement and benchmark existing algorithms for performance and efficiency.

It is essential to acknowledge the limitations of this study. Firstly, despite conducting searches across major online databases, there is a possibility of additional scientific publications that could contribute to a more comprehensive understanding of the field and available solutions. Lastly, this literature review did not include non-English publications, thus excluding team formation approaches explored in other languages.

In summary, this comprehensive review highlights the importance of improving team formation processes and sets the stage for future research endeavours.

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