What's in a team? Variability and discrepancies in the conceptualization and operationalization of scientific teams

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This study explores the conceptualization of 'team science' within the field of scientometrics, identifying key attributes that define scientific teams through a systematic literature review and AI-assisted analysis. We examine definitions and operationalizations from 26 pivotal studies, synthesizing a unified definition centred on three main attributes: interdisciplinary composition, shared goals, and collaborative effort. Our findings highlight the diversity and inconsistency in current descriptions, suggesting a need for a more standardized framework. This paper contributes to the discourse on team science by proposing a refined, empirically testable definition aimed at enhancing comparative studies and improving team dynamics in scientific research.

1. Introduction

Team-based research has now become the norm in many fields (Guimerà et al., 2005; Wuchty et al., 2007) with researchers distributing tasks and establishing more or less formal forms of division of labour (Larivière et al., 2016; Latour & Woolgar, 1979). Different streams of literature have addressed the phenomenon of science teams from different perspectives for quite some time (Börner et al., 2010; Falk-Krzesinski et al., 2010; Hall et al., 2008). Some of the disciplines interested on team science are research evaluation, scientometrics, science of science, sociology of science or psychology among others. But these studies tend to conceptualize teams differently, which can potentially limit their findings and/or restrict the comparability of their research on science teams with other research that may share common interests.

Science teams challenge current notions of credit and reward in the scientific ecosystem (Walsh & Lee, 2015), as it becomes increasingly difficult to attribute and distribute it based solely on authorship (Biagioli (ed.) & Galison (ed.), 2013). The scientometric community has come up with various ways in which this can be done based on different combinations of number of authors and author order (Gauffriau, 2021; Sivertsen et al., 2019). Still, they offer technical solutions which partly ignore a bigger issue. Our lack of understanding on how science teams operate, especially worrisome, our lack of consensus on what do we mean when referring to teams. (Falk-Krzesinski et al., 2011, p. 146) summarizes it nicely:

> *[D]efinitions of core terminology and typologies of practice and theory related to SciTS too often remain impressionistic or parochial; areas of inquiry remain somewhat disconnected; and methodological approaches have been limited. So*

that the scientific community can more strategically understand and improve collaborative science, more research is needed to validate claims for team science

One of the most common operationalization of team science is co-authorship (Calero et al., 2006; Ma et al., 2023; Wuchty et al., 2007). In other cases, co-authorship is not strictly necessary and teams will be defined from an organizational perspective (Ensley & Hmieleski, 2005; Hoegl & Proserpio, 2004; Read et al., 2016). This can even lead to studies on collaboration and co-authorship within teams (Bone et al., 2020). This diversity in the forms in which teams and conceptualized and operationalized leads us to a foundational question: What does in fact constitute a team in the context of scientific research?

As with most social constructs, a neat, one-sentence definition of team science is likely to be elusive. Not have there been many attempts to arrive at a definition of team science; an all-encompassing definition that captures what it means to describe a collection of scientists as a team. In this paper we aim at problematizing discrepancies in the current definition of teams found in the literature.

This study is part of a project in which we will combine conceptual and empirical work to better understand the main attributes needed to define a scientific team. Here we present our findings of the first part of this study, in which we review current literature on science teams within the lenses of research evaluation. From our review of the literature and our conceptual analysis on scientific teams we will identify the core attributes common to the different interpretations of teams in order to present and describe the unique and necessary conditions and characteristics of science teams, as opposed to other types of teams.

2. Data and methods

2.1 Search query and document selection

Our aim is to understand how scientific teams are defined and operationalised. To this end, we conducted a review. We limited our search to the fields of scientometrics and research evaluation in order to prioritise precision over recall in our search strategy. Then we conducted two search queries: 1) one to identify reviews within the topic of scientific teams, and 2) the other to identify research articles studying teams published in the journal Research Evaluation. From these searches we identified frequently co-cited studies to add to our corpus of papers. Following we detail the whole process.

Searches were conducted in December 2023 using the Web of Science Core Collection. The first query used was:

Search: (TI=("team science" OR "research teams" OR "science teams" OR "research team" OR "science team" OR "research group" OR "research groups") AND DT="review")
OR (TI=("team science" OR "research teams" OR "science teams" OR "research team" OR "science team" OR "research group" OR "research groups") AND TI=("review" OR "meta-analysis")) and 6.238 Bibliometrics, Scientometrics & Research Integrity (Citation Topics Meso)

It yielded 15 records which cited 922 references overall. Of these, 14 were co-referenced by at least 3 reviews. For the second search a more general search query was designed given the scope of the journal Research Evaluation. In this case we used the following query:

Search: TI=(team or group*) AND SO="research evaluation"*

It yielded 12 records which cited 679 references out of which 6 were co-cited by at least 3 articles. After removing duplicates, we ended up with a list of 46 publications. These 46 publications were downloaded and reviewed by 3 researchers who searched for explicit definitions of a scientific team. After several rounds, they narrowed the total number of publications to 26.

2.2 AI-assisted publication analysis

We conducted our publication analysis assisted by ChatGPT, specifically using the GPT-4 model. The conversation has been made fully available (OpenAI, 2024). Next we briefly define its contents. We first conducted an analysis of the content of each of the 26 records. We uploaded each record one by one and ask three questions with regard to each of them: 1) level of agreement with coders, 2) to extract the quoted definition of teams indicating page and paraphrase such definition, and 3) infer attributes which could be considered essential to define a team given such definition. As observed in the conversation referenced, this process was supervised and in one occasion (Moed, 2018), its responses had to be corrected and refined.

Next, we conducted a global analysis of the 26 publications in which we aimed to formulate a unified definition of scientific team and identify the main attributes which were common to all the studies analysed. We looked into main attributes, secondary attributes and main points of discrepancy among studies. During the process we would conduct some checks to ensure that the analysis was being done correctly (e.g., by asking to enumerate the list of publications analysed).

3. Results

According to our findings, a scientific team could be defined as follows:

A science team is a collaborative group composed of individuals from diverse disciplinary backgrounds, unified by a shared goal to address complex scientific questions or societal issues. These teams integrate a range of expertise, resources, and methodologies through structured collaboration and inclusive processes, aiming to produce innovative, interdisciplinary, and actionable outcomes. Effective science teams operate within a framework of shared responsibility, where members engage in open communication, mutual learning, and adaptability to change, fostering an environment that values each member's contribution towards achieving collective objectives.

Based on this definition, we find three attributes which could be considered as essential to identifying a collaborative research effort as a team. These are the following:

Interdisciplinary composition. The involvement of team members from various disciplinary backgrounds was mentioned by 24 of the studies. They indicated that teams would be composed by members from different disciplines. But they express different levels of disciplinary integration. For instance, Fiore (2008) emphasizes the interdisciplinary nature of such collaboration, with different fields interacting with each other. However, in Stokols and colleagues indicate that such integration will vary depending on how boundaries between fields are established. This will define a team as inter-, cross-, multi- or trans- disciplinary (Stokols, Hall, et al., 2008; Stokols, Misra, et al., 2008).

Shared goals. This was mentioned in 22 studies. The underlying idea that all team members should have a common goal, although how broad or specific this should be is not necessarily clear. For instance, Bennett & Gadlin (2012) discuss the importance of articulating a "shared vision and setting goals shaped by a central scientific idea" (p. 768). Something that the team leader will have to design and recruit team members and build its strategic research plan with it in mind. Andrade et al. (2009) also mention having "shared goals and common interests" (p. 303) but in this case as common feature rather than a requirement.

Collaborative effort. Mentioned in 20 papers, it refers to the distribution of labour and structured process in which tasks are assigned and communication channelled within team members. Here differences arise in the efficiency of teams with regard to their distribution of tasks. Lee et al. (2015) indicate that this will depend on the team size and variety of tasks distributed, underlying the fluidity and versatility of researchers on assuming different roles depending on needs. Dodson et al. (2010) focus their study in the health sector, highlighting the need for a more rigid structure with specialized roles which combine clinical and research expertise, engaging also with non-scientific stakeholders such as patients and practitioners.

Along with these attributes, there are other attributes which are pointed but some of the studies, but which do not achieve such levels of agreement. Among these we highlight the need for teams to be flexible and adaptable, integration of resources (i.e., funds, staff, material resources), stakeholder engagement, and outcome oriented.

Differences on their conceptualization of teams will have a direct impact on how they are operationalised, observing important differences on how they identify teams and define them as units of analysis. Here we observe four different operational definitions of teams. These are:

1. **Intra-organizational units.** Here teams are defined as institutionalised organizations belonging to a given institution, such as departments, laboratories or research centres. An example of such approach is observed in the study conducted by Engels et al. (2013).

2. **Output oriented teams.** Operationalised through co-authorship, teams are defined with goals centred around joint publications. This approach is followed by Bennett & Gadlin (2012).

3. **Project-based teams.** In this case funding is the unifying theme in this operationalisation. Teams are formed around research projects, enforcing role delineation and task distribution. Here an example can be found in the work by Lee et al. (2015).

4. **Cross-organizational units.** As in the first case, teams are also institutionalised, however they are not constrained to single institutions but built through institutional partnerships to fulfil a common goal. An example here is found on alliances in the health sector to tackle public health challenges (Stokols, Misra, et al., 2008).

4. Discussion and next steps

Our analysis shows several critical dimensions that underlie the concept of team science, revealing the nuanced and multifaceted nature of scientific teams. The identified attributes—interdisciplinary composition, shared goals, and collaborative effort—serve as foundational pillars that distinctly characterize effective science teams. However, the variability in how

these attributes are emphasized and operationalized across different studies points to the need for a more harmonized definition that can accommodate the diverse practices and theoretical underpinnings prevalent in team science research. Such discrepancies not only complicate the task of developing a universal framework but also challenge the implementation of policies and practices that accurately reflect the dynamics of scientific teamwork.

Moving forward, we expect to complete this review further and complement it with empirical analyses which can further illustrate differences between science team dynamics vs. collaborative efforts. Integrating these insights into a broader scientometric and policy framework will be crucial for developing robust indicators of team science efficacy and for fostering environments that enhance the productivity and creativity of research teams. Such efforts will not only help in standardizing team science metrics but also in crafting policies that promote effective collaborations, thereby advancing the frontiers of knowledge and innovation.

Open science practices

Data and methods have been developed to make the study fully replicable, including search query strategies and retrieval dates. Furthermore, the complete prompt and outputs received from ChatGPT have been reported and are publicly available (OpenAI, 2024).

Author contributions

NRG: Conceptualization, Formal Analysis, Funding Acquisition, Methodology, Writing-original draft
FvS: Formal Analysis, Data Curation , Methodology, Writing-review & editing
MMT: Formal Analysis, Data Curation, Writing-review & editing
VP: Formal Analysis, Data Curation, Writing-review & editing
JM: Conceptualization, Formal Analysis, Supervision, Writing-review & editing

Competing interests

Authors declare no competing interests.

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