



## Are top-cited papers more interdisciplinary?



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### ABSTRACT

Over the last decade, the relationship between interdisciplinarity and scientific impact has been the focus of many bibliometric papers, with diverging results. This paper aims at contributing to this body of research, by analyzing the level of interdisciplinarity, compiled with the Simpson Index, of the top 1% most highly cited papers and of papers with lower citation percentile ranks. Results shows that the top 1% most cited papers exhibit higher levels of interdisciplinarity than papers in other citation rank classes and that this relationship is observed in more than 90% of NSF specialties. This suggests that interdisciplinary research plays a more important role in generating high impact knowledge.

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## 1. Introduction

It is now widely recognized that interdisciplinary research (IDR) is an effective model for stimulating innovation, sparking creativity and tackling pressing and complex societal issues (Aboelela et al., 2007, p. 330; Rafols, Leydesdorff, O'Hare, Nightingale, & Stirling, 2012, p. 1262; Rinia, 2007, pp. 5–6). Being usually problem- or mission-oriented in nature (Gibbons et al., 1994, p. 5; Hirsch Hadorn, Pohl, & Bammer, 2012; Klein, 1990, p. 58; Kueffer et al., 2012) it is claimed that IDR is especially apt to address large scientific challenges that require holistic integrative approaches from a variety of disciplines (Morillo, Bordons, & Gómez, 2003, p. 1237; NSF, 2009). IDR integrates heterogeneous knowledge to generate new one, which in turn can be diffused across several disciplines (Klein, 1990, p. 11; Liu, Rafols, & Rousseau, 2012; Meadows, 1976). Knowledge *integration* among two or more disciplines seems to be the fundamental element in the most widely accepted operational definitions of interdisciplinary research (Klein & Newell, 1998; National Academies, 2004; Porter, Roessner, Cohenm, & Perreault, 2006, p. 189; Porter & Rafols, 2009, p. 720), although slightly softer definitions of IDR (NSERC, 2012) will evoke *interaction* rather than *integration* among disciplines that *may* lead to “full integration of concepts, methodology, procedures, theory, terminology, data, organization of research and training.”

Many important scientific discoveries and breakthroughs are obtained through interdisciplinary collaboration (Cummings & Kiesler, 2014). Striking instances of large-scale fruitful IDR endeavours that are often cited as exemplary research include for instance the discovery of DNA and the identification of its double-helix structure which was made possible through collaborative research among biologists, physicists and chemists, and the Human Genome Project which

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involved scientists from many disciplines, such as biology, chemistry, genetics, physics, mathematics, and computer science (Bretscher, 2008; Institute of Medicine, 2000, p. 24; Meldrum, 1995; Olby, 1974). These large-scale undertakings are indeed spectacularly successful but nowadays IDR is more and more prevalent even in small-scale projects that address problems that are inherently interdisciplinary. Consequently IDR is gaining recognition as an efficient *modus operandi* that many claim should be globally encouraged and aptly funded.

Over the last twenty years, much has been written about the pros and cons of IDR and whether or not it should be promoted in science policy. Interest in IDR emerged in the late 1960s and gained momentum after the 1970 seminar in Nice, organized under the auspices of the Organization for Economic Co-operation and Development (OECD) (Apostel, Berger, Michaud, & CERI, 1972; Weingart, 2012, p. 12). In a simple but persuasive study, Braun and Schubert (2003) provide quantitative evidence of the exponential growth of the use of the terms ‘interdisciplinarity’ and ‘multidisciplinarity’ in the scientific literature, especially since the 1990s, a testimony to the increasing interest in that topic.

Another significant work that stirred the debate and stimulated interest in IDR is the 1994 seminal report by Gibbons et al. (1994, p. 3) in which the authors assert the existence and emergence of a new mode of knowledge production “organised around [...] particular application[s]” that is gradually replacing the established discipline-based mode. This thesis has been met with skepticism by some (Jacobs & Frickel, 2009; Rhoten, 2004; Weingart, 1997) on the basis that it “has been based on impressionistic evidence only, [which] has not been supported by theoretical considerations or by systematic empirical evidence” (Weingart, 2012, p. 12) and that “many initiatives deemed interdisciplinary are, in fact, merely reconfigurations of old studies” (Rhoten, 2004, p. 6). Nonetheless, be it a trend or a full-fledged transition, many indicators, internal and external, corroborate the idea that a shift, moving from “traditional” discipline-based research, toward an interdisciplinary mode of production, has now been initiated. These indicators include for instance,

- the changing relations between and among disciplines and the emergence of many subdisciplines (specialties), along with the increase, since the mid-1980s, in interdisciplinary citations in scientific papers (van Leeuwen & Tijssen, 2000; Larivière & Gingras, 2014);
- the emergence of numerous cross- or interdisciplinary research centers (Siedlok & Hibbert, 2014), the creation of various interdisciplinary training and academic programs (Aboelela et al., 2007; Hackett & Rhoten, 2009; Mack, 2012, p. 3; NSB, 2014, pp. 2–29–2–30; NSF, 2009), and the formation of many interdisciplinary research teams (Boni, Weingart, & Evenson, 2009; Lungeanu, Huang, & Contractor, 2014);
- the founding of numerous new scholarly associations and journals who claim or encourage interdisciplinarity as part of their mission (Jacobs & Henderson, 2012), and the emergence of object-oriented research communities through informal communication networks (Sonnenwald, 2007);
- the recognition of the importance of IDR in research governance and science policy (Cooper, 2013; Lyall & Fletcher, 2013);
- the promotion of IDR by funding agencies (Bordons, Zulueta, Romero, & Barrigón, 1999; Lyall, Bruce, Marsden, & Meagher, 2013; Lyall & Meagher, 2012, p. 610; Rhoten & Pfirman, 2007; Sá, 2008); for example, Zhang, Hao, and Yan (2001, p. 64) showed that, over the course of the 20th century, the proportion of awarded Nobel prizes that are interdisciplinary in nature has risen from 36% to nearly 50%, with a marked increase during the last quarter of the century, which can be seen as a testimony to the “interconnected nature of modern cutting-edge science [...] and] that the most interesting and ground-breaking work is done when scientists apply their talents in new fields” (Chemistry World, 2014).

Although these indicators show that there is undeniably a growing interest in IDR, not all agree that the current movement to promote and encourage IDR is worth the effort: “the case has [not] been fully made, theoretically or empirically, for the general superiority of interdisciplinarity over disciplinary knowledge” (Jacobs & Frickel, 2009, p. 60). Furthermore, many active researchers in the bibliometric community assert that “the literature [...] has not reached a point that permits meaningful assessment of IDR” (National Science Board, 2010, p. 5–35) and that “developing a generally agreed-on concept of interdisciplinary research and measuring how it has grown have proven to be challenging” (NSB, 2014, p. 5–18). Jacobs and Frickel (2009, p. 52) remain critical and assert that: “systematic efforts to develop evaluative criteria for judging interdisciplinary knowledge have been slow to develop, and direct empirical evidence on how the quality of interdisciplinary research is assessed remains thin.” Despite these critics, there is much agreement that there is a need for more empirical data on the worth and validity of IDR. In order to contribute to this ongoing debate, this paper assesses the interdisciplinarity level of papers, and its relationship with the scientific impact of scientific papers, as measured by percentile rank in the citation distribution.

## 2. Literature review

Empirical research on the measurement and evaluation of IDR is indeed slow to materialize, but throughout the past decade or so the bibliometric community has been increasingly focusing on that problem and IDR has emerged as an important topic in the scientific literature.

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