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Perspective

How a systems perspective can help us with the interdisciplinarity puzzle

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1 Introduction

The future of scientific knowledge production is by many envisioned as an interdisciplinary one. To an increasing extent knowledge generated within separate disciplines will be integrated to develop effective (technological) solutions or innovative theoretical answers for the complex problems of today and tomorrow. We will arrive in a mode-2 (or are) and later a mode-3 of knowledge production, depicting the increasing reach of applied science by multi-disciplinary teams focusing on concrete societal problems (Carayannis & Campbell, 2012). Some authors have coined this a post-disciplinary era, in which the traditional disciplinary structures are non-existent or gradually become irrelevant (see eg., Weingart, 1997). Quantitative studies of science indeed point toward these trends of increasing disciplinary interconnectedness or interdisciplinarity, but the ways in which other forms of production (or organizing science) are replacing the academic system of disciplines is a question largely left unanswered. How is the scientific system reshaping itself, and how can we take stock of these patterns of change?

To what extent, for example, are interdisciplinary fields or topic-oriented specialties replacing the traditional disciplinary system? Which other organizations or institutions than the university are entering the system of knowledge production, and in which fields or sectors is this happening? How do these organizations challenge the disciplinary boundaries? In this short 'perspectives note' I would first like to reflect on the concept of disciplines and the different ways in which the disciplinary structure is changing. Against this background, I will propose a tentative agenda for future quantitative science of science research in particular[①].

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[①]This is an extended and more elaborate version of an answer I provided to one of the questions posed by prof. dr. Ismael Rafols during the in-person defense of my Ph.D. dissertation (June 27th, '22), titled Disciplines, specialization and interdisciplinarity in the social sciences and humanities' (Eykens, 2022). In this context, I was asked to provide my thoughts on more appropriate science mapping endeavors. My thesis is freely available online: https://repository.uantwerpen.be/docstore/d:irua:12471

2 What are disciplines?

Concluding that disciplines are disappearing and that a new mode of knowledge production is emerging is done more often in the science of science literature than tracing the origin and functions of these concepts. Today there still exist many discipline-based organizations, journals, departments and professions, so to simply claim that disciplines have lost their relevance does not do justice to reality. Let us therefore briefly take a step back and first come to terms with what a discipline-based knowledge system is and further on where we might be going.

When disciplines first emerged at the beginning of the 19th century, their most prominent function was integrating both knowledge production and communication under a common problem framework. They could be regarded as coherent systems for organizing, producing and disseminating scientific knowledge through communicating the research produced amongst its members and the students enrolled in disciplinary programs. The curricula used within disciplinary communities were also strongly organized around a canon or central paradigm, which brought continuity (Stichweh, 1992). The communities surrounding a disciplinary body of knowledge were relatively small. Up until the end of the 19th century, many university departments still counted less than 10 members and one chair. This created the possibility for disciplines to be rather stable communities. In the case of the social sciences and humanities disciplines, the research carried out by its members was largely nationally oriented and often published in national languages.

Although the interaction between these disciplinary communities was less frequent than what we witness today, it was not entirely absent. Disciplines which are considered traditional today are very often the result of interdisciplinary innovations. The sociological discipline originated, amongst others, from the interdisciplinary thinking by August Comte. Comte combined insights from physics, biology and medicine to come up with a theory of society. Communication science is a more recent example of a nowadays established discipline which emerged from interdisciplinary interaction between political sciences, sociology and psychology. Interdisciplinary specialisms and eventually new disciplines might thus emerge from disciplinary interaction. And while this gradual disciplinary evolution justifies a perspective in which we only make use of, for example, discipline categories to capture change of the system, other dynamics are at play as well.

Further specialization within disciplinary lines, is another relevant dynamic which increases interdisciplinary interaction. The mere growth of a discipline for example, psychology leads to the emergence of many sub-fields and specializations within the discipline. The American Psychological Association (APA) for instance was established in 1892, and had two organizational units. These counted 31 members in

total. Today the association counts more than 120,000 members and consists of 54 divisions or interest groups, representing sub-disciplines or topics of interest (see https://www.apa.org/about/apa/archives/apahistory). Psychology is of course not the only example. Many other, rather traditional disciplines have undergone similar trajectories. Starting as a coherent and relatively small structure with a focused set of research problems and an educational program, they change into an archipelago of sub-disciplines with the parent discipline functioning as an overarching governing structure.

Next to specialty formation within a pre-existing disciplinary context, differentiation external to the academic system can also lead to the emergence of entirely new fields and specialties which are mostly discipline independent from the onset. An example of a specialty without a linear disciplinary predecessor is scientometrics. This specialty established itself in response to societal and political needs (e.g., monitoring of the outputs produced by the academic community) and behaves much like a discipline. It has a well-developed cognitive identity with a structured research program, devoted journals and conferences, but no equally strong socio-institutional frame of reference (e.g., no devoted departments in a large share of universities, no clear educational curriculum with introductory handbooks and master's education programs).

Many other aspects or systems of social life are also taken into the scientific laboratory without having a pre-established disciplinary community. We can think of the many, now established 'studies' fields, like media, gender and disability studies, but also financial mathematics, research on sexually transmittable diseases and more recent research on SarsCoV2 as other examples. It should have become clear that new specialties or sub-disciplines are not solely a consequence of growth of the scientific system. A broader academic or societal interest is also needed for a new field to be able to establish and further develop itself. For the development and emancipation of the criminological discipline in Belgium, the initiation of a crime prevention policy in the 1980s has been an important catalyst (see Pauwels and Verhage, 2019). For criminology (and other disciplines and specialties as well) other types of organizations also play an important role in terms of knowledge production; the NICC (the National Institute for Criminological Research), to name one, is a relevant and large research performing organization in Belgium. To turn back to psychology, in Belgium the sub-discipline of clinical psychology got introduced as a graduate program in 1965 as a response to real societal needs (Richelle et al., 1992). Differentiation of the welfare and health system in this case propelled sub-discipline formation. Clinical psychology now is one of the main branches of the discipline in Belgium and beyond.

From being coherent and relatively small structures, discipline categories today serve a broader function. They integrate different specialized bodies of education and research and serve as a reference point for the academic and non-academic communities. Disciplinary journals and associations for example, still have an important role to play in establishing research programs, ethics guidelines, methodological manifests, diagnostic manuals, awarding grants and prizes, communicating with political and societal stakeholders, etc. Next to disciplines, different types of research specialties fulfil a similar function as the traditional discipline. Like universities, other research performing organizations have entered the knowledge production system. In a sense, we are moving away from what was once a purely scientific system, that is solely based on universities and disciplinary communities, to a complex knowledge system. A system in which different types of entities, including disciplines, play an equally important role, and in which interdisciplinary is only one of the potential forms of interaction.

3 From single to multiplex networks

The knowledge system as it is often perceived in bibliometric research resembles a hierarchical tree. Broad fields of science encapsulate the disciplines, and sub-disciplines or specialties all reside under the disciplines. In the classification systems which resemble this tree, clear boundaries exist between the different levels and the entities residing within them. This view indeed facilitates our understanding of the scientific system and has enabled a lot of research, for example, quantitative comparisons between fields or mapping interactions between them. From the above, however, it should've also become clear that this hierarchical view does not entirely align with the complexity of the actual knowledge system. As specialties are not always clearly tied to discipline, and some topics are more disciplined than others. Organizations other than the university today often fulfil an important role in knowledge production. I would therefore like to advocate for a perspective which takes into account this complexity of interaction on the level of specialties, disciplines and organizations. An approach in which the traditional hierarchical ontology based on fields, disciplines and specialisms is reconsidered by using a flat ontology: disciplines, fields, specialisms and different types of research performing organizations exist in the same knowledge space. We can thus view science as being part of a broader knowledge system in this way (see also Weingart, 2003).

How can we describe this knowledge systems perspective and what does it offer us? As we have already noted, a map of a knowledge system as opposed to a more traditional science system would be flat instead of hierarchical. Different disciplines,

types of specialisms and organizations can all be part of the same mapping. Second, as opposed to a science system, in which universities are the main knowledge producers, in the broader knowledge system more openness to include other types of organizations is possible. Other institutions and organizations than the research university can be identified as relevant research performing organizations as well. Third, the knowledge systems perspective allows for dynamicity. As opposed to using a fixed classification scheme, from a knowledge systems perspective new specialisms can emerge over time, while others can disappear. It is recognized that different entities find themselves at different stages of development.

4 Conclusion

I would like to conclude with some questions and ideas on how we could increase our understanding of the (future) knowledge system. Can we develop a better quantitative understanding of the complex relationships between specialized bodies of knowledge, (inter-)disciplines, and organizations? For example, by making use of 'traditional' scientometric methods like multi-mode networks? Scientometric studies have been conducted in which networks of two different types of entities are constructed (see Hellsten et al., 2020 for a recent example), but not with the explicit intention of increasing our understanding of changes in the entire knowledge producing system. If we combine such methods with more qualitative, in-depth explorations we could also provide insights into competition and cooperation mechanisms between fields.

Such a methodology could however give us insight into how different discipline categories or journals are related to topics and organizations. Which topics are related to many different traditionally disciplined categories? And by including different types of organizations other than the university, can we see that different topics and specialties are being studied by them? Do we find that some topics are moving outside of the university? Is specialization of particular universities or organizations into specific subjects noticeable (Weingart, 2003)?

The study of citation relations between these different types of entities will not always yield insightful results. Therefore, another interesting avenue is to model researcher behavior. In an ideal world, where we have granular and unambiguous data about the career trajectories of researchers, we would be able to study how researchers navigate this knowledge system. The migration of researchers from particular subsystems to another could inform us about information passing along. Questions we could ask in this light are: How do researchers move from one discipline and/or topic to another throughout their careers? And how do specialties and disciplines borrow knowledge from each other? And in the context of which

topics does this happen? What role do different types of organizations play in this system? While I do recognize that bibliographic data about scientific research offers huge potential in studies of science, other opportunities still lie ahead.

If we look across disciplinary boundaries, we find historians, sociologists and philosophers of science who make use of a vastly more diverse range of data sources and methods (notes and other archival material, letters exchanged by scientists, curricula, images and diagrams, meeting minutes, policy documents, etc.). Possibilities are already emerging for the quantitative analysis of these sources as well. Fields like computational history and philosophy of science make use of machine learning methods in order to get a more comprehensive understanding of what these sources might tell us about the evolution and dynamics of science. Looking ahead or studying the present, scientometricians might be of help in developing methodological frameworks to trace the usage of scientific research outside of academia, or trace how policy influences drive the development of new research frontiers.

The key idea is to create more comprehensive mappings of science and where scientific knowledge is going/being used or applied in order to get a more accurate understanding of how the knowledge system is changing and which interactions play a role. Is interdisciplinarity indeed one of the main driving forces? Or do we observe specialization of different organizations and can we distinguish new divisions of labour within the knowledge system? The issue of data quality and availability is of course very relevant when trying to take stock of such a complex system. The problem of ambiguity of researcher identities and their affiliations, for instance, is not all that new for scientometrics.

Efforts are being made to develop more comprehensive and qualitative data. In the meantime, it might be useful to first focus on smaller case-studies and make use of a participatory research design. By zooming in on one specific subject of interest and, together with the researchers and stakeholders involved, creating meaningful maps of the knowledge system surrounding these subjects I believe we will be able to come up with better answers to questions about for example, interdisciplinarity, which in essence come down to the changing nature of the knowledge system as such.

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