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Collaboration, interdisciplinarity, and the epistemology of contemporary science

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A R T I C L E I N F O

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A B S T R A C T

Over the last decades, science has grown increasingly collaborative and interdisciplinary and has come to depart in important ways from the classical analyses of the development of science that were developed by historically inclined philosophers of science half a century ago. In this paper, I shall provide a new account of the structure and development of contemporary science based on analyses of, first, cognitive resources and their relations to domains, and second of the distribution of cognitive resources among collaborators and the epistemic dependence that this distribution implies. On this background I shall describe different ideal types of research activities and analyze how they differ. Finally, analyzing values that drive science towards different kinds of research activities, I shall sketch the main mechanisms underlying the perceived tension between disciplines and interdisciplinarity and argue for a redefinition of accountability and quality control for interdisciplinary and collaborative science.

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Over the last century, science has grown increasingly collaborative, and most scientific knowledge today is produced by groups in which multiple scientists collaborate in order to combine their knowledge, manpower, materials and other resources (Wuchty, Jones, & Uzzi, 2007). Further, much scientific research today cut across disciplinary boundaries (Braun & Schubert, 2003; Porter & Rafols, 2009). But at the same time, there is an ever ongoing specialization in which new scientific specialties and disciplines continuously proliferate (Stichweh, 1992).

It is often argued that these developments are all tightly knit to the continued growth of the scientific enterprise, both with respect to the issues addressed and the volume of the activities addressing them. Thus, it has been a recurrent argument in reports from research policy and funding organizations at least since the 1960es that, as science move to more and more complex and demanding problems, it requires collaborations both within and across disciplines. At the same time it is also argued that as science moves towards grasping the world in ever more detail, the individual scientist needs to specialize more and more in order to master the increasingly specialized tools and to be in command of an ever growing literature. This has resulted in paradoxical situation that while interdisciplinarity is continuously proclaimed and demanded, at the same time scientists also continue to specialize (Weingart, 2000).

In this paper, I shall address these developments in contemporary science and lay the foundations for a philosophical analysis of the structure and development contemporary science. One the one hand, this analysis is a return to the structure of science and its development as a central topic for general philosophy of science; a topic that has been dormant in recent decades while interest of philosophers turned to the differences between disciplines, historical periods, and the many individual elements of the scientific enterprise. On the other hand, what I propose is an analysis of the development of science that it informed by the attention to details and differences that has been prominent since the generalized accounts of the 1960es and 1970es.

The account takes the structure of research activities as its central focus. Based on analyses of the cognitive resources employed in individual research activities it is examined how they relate to domains in a historical process, and how their distribution among the researchers involved gives rise to relations of epistemic

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dependence. For the sake of analytical clarity I shall first examine how the cognitive resources employed in a research activity relate to domains and how to understand the individual's expertise on such a picture. Next, I shall examine the epistemic dependence between scientists, and combining the analyses of cognitive resources and epistemic dependence I shall provide a renewed view of how to understand disciplines and specialties in terms of different ideal types of research activities in a two-dimensional spectrum. Finally, analyzing values that drive science in various directions I shall sketch the main mechanisms underlying the perceived tension between disciplines and interdisciplinarity and argue for a redefinition of accountability and quality control for interdisciplinary and collaborative science.

1. Philosophical accounts of disciplinary developments—and beyond

The development of disciplines or specialties, as well as their subdivision into fields or domains, was a major topic of interest within the historically inclined philosophy of science that flourished from the 1960es some decades onwards. Philosophers of science such as Kuhn, Lakatos, Laudan, Toulmin, and Shapere described the development of science by focusing on the development of individual areas of science, and the development of these areas were then described in terms of, for example, paradigm-induced normal science and paradigm changing revolutions (Kuhn, 1970), progressing and degenerating research programs (Lakatos, 1971), successive research traditions (Laudan, 1977), or domains connected through history by chains-of-reasoning (Shapere, 1977). On these traditional accounts of how individual areas within science developed over time, a scientific discipline (or specialty, field or domain) could be understood at the same time as an epistemic unit consisting of a set of closely related cognitive resources such as, for example, concepts, models and theories, and as a social unit consisting of highly similar experts who were employing and at the same time developing their shared cognitive resources.

The most detailed attempt at describing the relation between the cognitive and social aspects of a given area of science could be found in Kuhn's account of normal science. On Kuhn's account, scientists within a given specialty have been through substantially the same kind of training, and through this training they have required very similar and strong mental sets; what Kuhn referred to first as a paradigm and later as a disciplinary matrix. On this analysis, the mastery of the disciplinary matrix in the form of concepts, generalization, values and exemplars, as well as the ability to apply it to recognize, define and creatively solve new research puzzles were seen as the core elements of the expertise that enabled the individual practitioners of a given specialty to contribute to its development. Further, by drawing on this disciplinary matrix that they all shared, each of the practitioners in the specialty could be seen as epistemically autonomous agents who were each able in similar ways to recognize the same, potential new research puzzles that could be solved in ways similar to previously recognized puzzles.

Such an account implied that as a social unit, a specialty or discipline was a community of scientists with highly similar expertise based on their possessing more or less the same set of cognitive resources that enabled them to identify more or less the same problems and methods for their solution. Conversely, as an epistemic unit, a specialty or discipline was a set of cognitive resources that were transferred historically from one generation to the next through a particular form of rigorous training. A specialty or discipline was therefore characterized by a close, bipartite relation between the scientific community and the cognitive resources that members of this community employed, while the individual scientists and the activities that they engaged in could be seen as tokens of the types of similar community members working on similar problems. On this model, to the extent that there were differences in the cognitive resources between different scientists, these were primarily seen as a latent reservoir that only in a phase of crisis would become manifest as different responses to anomalies and thereby serve as a mechanism for risk spreading during the development of alternative paradigms and an eventual paradigm shift.

It also follows from such an account that, due to their highly similar contributory expertise,[1] members of the community would be epistemically autonomous agents largely agreeing on what to perceive as research questions and what to accept as solutions. Hence, although individual scientists as epistemically autonomous agents could compete on priority in solving some given research problem, they would all have the same ability to recognize the problems and appreciate their solution. By the same token, they would also each have the same ability to detect shortcomings of proposed solutions and provide improvements. Although this was rarely addressed explicitly in the accounts advanced by Kuhn and others, quality control based on the critical scrutiny of new results by epistemic autonomous peers could therefore be seen as firmly embedded in the disciplinary community. Hence, the beauty of this close, bipartite relation between epistemic resources and the community of scientists employing these resources was how it tied together expertise, education, and quality control.

At the same time, the fundamental challenge for this account based on a bipartite relation between a community and its cognitive resources is how to avoid the circularity that "[a] paradigm is what the members of a scientific community share, and conversely a scientific community consists of men who share a paradigm" (Kuhn, 1970, p. 1976). Kuhn argued in the 1970 Postscript that for the analyst, this circularity could be broken by isolating the scientific community first and then the corresponding paradigms could be discovered by scrutinizing the behavior of the communities' members. For the "empirical techniques" required for the exploration of community structures, Kuhn referred to the then emerging sociological literature on communication patterns and invisible colleges as advanced by, among others, Hagstrom (1965), Price (Price & Beaver, 1966) and Crane (1969). However, as this research developed over the following decades it became clear that it did *not* offer the clear and unequivocal identification of specialties or disciplines that Kuhn had anticipated. Instead, it revealed a multitude of criss-crossing relations established by the multitude of individual scientists whom Kuhn had reduced to more or less identical tokens of the type of community members in his focus on the close, bipartite relation between a community and its shared cognitive resources.

There are several reasons why we cannot identify a unique structural level at which the relation between scientific community and cognitive resources can be unequivocally defined. First, whereas scientists within a given scientific field may share a core set of well-established cognitive resources, at the same time it is the aim of science to continuously develop these cognitive resources, and during this process of science-in-the-making only a few scientists within a given field may be sharing the new cognitive resources being developed to supplement the resources already

[1] The notion of contributory expertise has originally been advanced by Collins and collaborators (Collins & Evans, 2002) as the ability to contribute to the domain's development, but without specifying the various components of this ability. See Goddiksen (2014) for a more detailed specification based on a criticism of Collin's work, as well as Collins & Evans (2015a, 2015b) for replies to this criticism.