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Interdisciplinary Collaboration: Cognitive Conditions and Tools

White Paper for SBE 2020: Future Research in the Social, Behavioral & Economic Sciences

Abstract

Interdisciplinary collaboration figures centrally in frontier research in many fields. Participants in interdisciplinary projects face problems they would not encounter within their own disciplines. Among those are problems of mutual understanding, of finding a language to communicate both within projects and with the scientific community and society at large, and of needing to master concepts and methods of different disciplines. We think that a concentrated research and development effort is necessary to analyze, on the one hand, cognitive conditions of successful understanding, communication, and interaction and, on the other, to develop specific tools and methods that support and facilitate interdisciplinarity both in practice and in educational projects that prepare future generations of professionals within and outside of academia. Those tools need to be developed and their cognitive efficiency measured.

Text

Research on interdisciplinarity has focused so far primarily on measuring and mapping interdisciplinary research (http://www.idr.gatech.edu/), and on documenting a fundamental shift to collaborative knowledge production. Closer to what we think is necessary for the future of interdisciplinarity is the emerging "science of team science" (SciTS). SciTS focuses on "processes by which scientific teams organize, communicate, and conduct research. The field is concerned with understanding and managing circumstances that facilitate or hinder a range of collaborative research efforts—from determining the effectiveness of large-scale collaborative research, training, and translational initiatives to understanding how teams connect and collaborate to achieve scientific breakthroughs that would not be attainable by either individual or simply additive efforts" (Börner, et al., 2010).

Adding to the "mixed-methods" approach of SciTS research, we would argue for the necessity of research that utilizes in particular methods and results developed in cognitive science, broadly defined, over the last decades (Derry, Gernsbacher, & Schunn, 2005; Nersessian, 2006).

Challenging research questions that address cognitive conditions of interdisciplinary collaboration include:

- *How can communication strategies be developed that help disciplinary experts move outside of their comfort zones and appreciate and learn from the ways in which others' view problems and simplify complexities?*
- *How to deal with framing conflicts?* Any disciplinary approach to a certain problem space conceptualizes the problems within this space differently. Disciplines often use different strategies to identify problems, and they develop specific terminologies and schemes to structure problems. Moreover, they apply different normative standards to determine what counts as an acceptable method and what counts as a "solution" of a problem. And: any set of problems and concepts that is involved when we approach a problem space can be organized in conflicting hierarchies. -- All this can be conceptualized as "framing." The concept of framing has been elaborated in conflict research to describe how parties to conflicts and in inter-cultural settings make sense of what is going on and interpret and construct reality according to priorly acquired habits of thinking, conceptual tools, theories, and system of beliefs. In this context, it has been assumed that the resolution of conflicts and communication problems might be possible by "reframing," that is when people change their original frames. The concept of *framing* can be used to describe inevitable limitations of mutual understanding in interdisciplinary collaboration, and *reframing* to conceptualize the learning processes that are necessary to overcome these limitations. How could reframing be stimulated, structured, and guided?
- *How to promote and improve meta-cognition?* Research on failing interdisciplinary collaboration has shown that meta-cognitive awareness of cognitive misalignments and methods to overcome them are crucial for successful collaboration. What are the general conditions those methods need to fulfill to be cognitively effective?

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- *Given what we might call the "universal partiality" of any single perspective on a sufficiently complex problem, how can the insights and cognitive processes of multiple perspectives be brought together and shared in ways that don't paper over important gaps and incommensurabilities highlighted by different ways of knowing?* To the extent that a single and final understanding of a sufficiently complex issue—one that is not only technically complicated but also is understood differently from different perspectives—is inherently over-simplistic, the question is: How can we conceive of interdisciplinary "outputs" that do not yield paralysis but instead contribute to social learning and problem-solving?
- *Collaboration without communication?* It has been argued that interdisciplinary *communication* is most successful when people simply steal each others' ideas without really understanding what they mean in their original disciplinary context, whereas interdisciplinary *collaboration* works best when people from different disciplines set each other boundaries within which they then develop their discipline-specific contributions, again without really understanding what others are doing. This leads to the question: What is the minimum of mutual understanding that is really necessary to make collaboration work? To what extent do collaborators need a shared language and mutual cognitive alignment? To what degree is the integration of knowledge domains really necessary?
- *How to train and prepare the leadership of interdisciplinary projects?* What are the skills and cognitive capacities necessary for leading interdisciplinary teams? What kind of resources and training/institutional infrastructure needs to be developed to educate future professionals in interdisciplinary team leadership and to support leaders right now?
- *How to structure interdisciplinary work processes and teams from a cognitive point of view?*
- *How can we better understand the interplay between the cognitive aspects of interdisciplinarity and the larger socio-political realities that cognition and the knowledge it generates are embedded in?* As interdisciplinary researchers grapple with the cognitive aspects of complex societal problems, it is important to consider—and develop tools and strategies that account for—the ways in which the tensions that arise in interdisciplinary activity reflect and interact with larger societal tensions. While it is appropriate that the spaces carved out by the various disciplines should be respected and protected, perhaps even buffered against some of the distractions and complexities that come from the acknowledgement of socio-political embeddedness, interdisciplinary teams are inherently more vulnerable to the social aspects of their collaboration. This poses some challenges not present in disciplinary activity, but also new possibilities in terms of the alignment of multiple ways of knowing towards the generation of socially beneficial research outcomes.
- *How can dialog be facilitated among interdisciplinary researchers regarding the societal affordances of the knowledge they participate in developing?*

Besides promoting reflection on cognitive challenges of interdisciplinary collaboration, we consider it of paramount importance to develop *tools* that are specifically designed to cope with those challenges. Exemplary types of new tools include:

- *Argument visualization tools*. Arguing for theses, positions, and decisions is a central component of science. Tools that allow visualizing the structure of argumentations graphically can help to represent discipline-specific ways to frame a problem; can promote meta-cognitive awareness of cognitive misalignments; and can structure meta-cognitive communication. Argument visualization tools allow the reflection on framing processes and facilitate interdisciplinary understanding and learning.
- *Knowledge representation tools*. Realizing the Peircean provocative insight that knowledge is not located in individual "minds," but in the signs used in communities of sign users, it should be a challenge to revolutionize the process of knowledge production by exploring the possibility to switch from the publication of individual "contributions" to the collective social development of knowledge that is represented in one unified and globally accessible "knowledge world" on the internet. The challenge is how to structure and design such a knowledge world including appropriate evaluation mechanisms so that it can be used and developed by everyone, independently from educational level and disciplinary and cultural background.
- *Automated problem-representation tools, tailored to user interests.* Based on discipline-specific framing processes, interdisciplinary collaborators face a plethora of terminologies and conceptual

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hierarchies that, although developed independently in different disciplines, often express overlapping semantics. Thus, there is a need for search engines and knowledge management tools that allow an automated representation of problem domains that is tailored to specific user perspectives; that allow to link discipline-specific terminologies and concept hierarchies to related terminologies and hierarchies in other disciplines; and that allow to switch between alternative representation systems.

- *Knowledge integration tools.* Since the late 1950s, *systems dynamics* has been developed to integrate various types of disciplinary or partial knowledge in a common causal model. In many cases, those causal models have been further developed to obtain mathematical models that can be implemented in computer simulations. This kind of integration is used today in fields such as sustainability research, resource management, global change studies, technology assessment, urban planning, and human-machine-interaction. However, there is a need to develop both a better understanding of how to integrate knowledge from a cognitive point of view, and better methodologies for creating those models and systems.
- *Curricula and teaching materials.* To prepare future generations of interdisciplinary collaborators and team-skilled professionals tools such as those listed above needs to be trained in educational settings.

This response to NSF/SBE's "grand challenges" request has been prepared by the following persons and initiatives:

- Michael Hoffmann, "AGORA: Participate – Deliberate" argument visualization project (http://agora.gatech.edu/)
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- Jan C. Schmidt, Social, Culture and Technology Studies at the Darmstadt University of Applied Sciences, Germany (http://www.h-da.de/)
- Michael Decker, Institute for Technology Assessment and Systems Analysis (ITAS) at the Karlsruher Institut für Technologie (KIT), Germany (http://www.itas.fzk.de/home_e.htm).
- Paul Hirsch, Environmental Conflicts and Collaboration at Maxwell School of Syracuse University
- and the Philosophy of/as Interdisciplinarity Network (PIN-net; http://www.pin-net.gatech.edu)

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