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NEH Panel: A Model for Philosophers

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Abstract

Cross-disciplinary research (CDR) is an increasingly important part of the contemporary research 'landscape'. Despite its growing importance there remain a large number of barriers to successful CDR and many of these barriers are poorly understood. In particular there are challenges at the conceptual and communicative levels that have received relatively little attention. In this paper it is argued that these challenges are appropriate topics of analysis for philosophers. Appropriate methodologies for such an inquiry are considered and the case is made that agent based models (ABM's) are an appropriate and under utilized resource. Current research using an ABM approach to philosophical issues in CDR is then described.

Introduction

Cross-disciplinary research (CDR) is often required to address urgent, persistent, and complex problems confronting contemporary societies. Examples of such problems include climate change (Eaglesham and Hardy 2009), sustainable agriculture (Robertson et al. 2008), the human and ecological costs of war (Machlis et al. 2011), and the AIDS pandemic (Stillwaggon 2005). Because of their complex, contextual, and dynamic nature, these problems require *research* responses that are sensitive to the specific character of each problem and generate knowledge that can inform both local action and global strategy. These responses are inherently *cross-disciplinary*, integrating knowledge from the different intellectual disciplines that are relevantly related to the problems at hand. For example, work on climate change requires input from geographers, meteorologists, hydrologists, sociologists, ecologists, ethicists, among others (Hanson et al. 2006).

As a result of the increasing attention to, and concern about, these issues there is a rapidly growing community of scientists deeply committed to doing CDR and doing it well (NAS 2005). Yet CDR is challenging and difficult, and the growth in interest has outpaced attention to the *process* of work across disciplines.

The challenges that confront attempts to *do* CDR are manifold, including the academic reward system (NAS 2005), lack of conducive institutional cultures (Klein 2010), lack of training opportunities (Rosa and Machlis 2002), turfism (Campbell 2005), the disparate spatial and temporal scales of collaborating disciplines (Benda et al. 2002), disciplinary chauvinism (Schoenberger 2001, Stokols et al. 2003), the complexity of group processes conducive to effective research (Jakobsen et al. 2004, Shrum et al. 2007), and the appropriate roles for stakeholders (Anonymous 2004, Kahan 2010). Focusing more squarely on the practice of cross-disciplinary *scientific* research, challenges include developing a truly integrative research question (Baron 2010), finding common ground between CDR team members, problems with scale and scope working across disciplines, developing a mixed methods approach, creating an analytical framework for combining and analyzing data sets, and developing a meaningful final product (Marzluff et al. 2003, Lélé and Norgaard 2005, Graybill et al. 2006, Miller et al. 2008).

It is our view that each of these more specific, research-focused challenges is fundamentally related to the need for teams to achieve some form of conceptual integration and to be able to share relevant information efficiently. That is, efficient *team communication* is essential. Progress on these complex research challenges requires collective, coordinated effort. In a scientific context, effort of this type increases the demand on groups to communicate in ways that lie outside the bounds of conventional, disciplinary scientific inquiry. Thus, we agree with the observation made in NAS (2005) that communication is the "heart" of cross-disciplinary activity, understood as comprising "the conversations, connections, and combinations that bring new insights to virtually every kind of scientist and engineer" (NAS 2005 p. 19). This centrality is reflected in the persistent, decades-long call for improving communication among collaborators within many crossdisciplinary contexts, such as human organizations

(Likert 1932), transprofessional health sciences (Frank 1961), universities (Jantsch 1972), the sciences and engineering (Klein 1996, Chan et al. 2002, NAS 2005), and natural resources (Heemskerk et al. 2003).

More specifically, 'communication' in the context of CDR concerns the transfer of information and insight across disciplinary boundaries that make possible the epistemic combination and integration constitutive of CDR. Among the communication challenges that threaten successful CDR are the existence of different disciplinary languages and the false appearance of agreement that can arise when the same word is unknowingly used with different meanings (Schoenberger 2001), managing disagreement and conflict (Moritz and Watson 1998, Bennett et al. 2010), and building and maintaining a productive mutual identity (Littlejohn and Foss 2008). As Frank (1961) noted 50 years ago, unspoken disciplinary assumptions are "rarely formulated" and "are taken for granted by the members of each group who imply but do not explicitly disclose them in their attempts at communication" (Frank 1961 p. 1801).

Philosophy and CDR

Philosophical interest in CDR has, to this point, focused on the twin challenges of developing shared conceptual frameworks from the disparate disciplinary perspectives that researchers bring to the table and identifying forms of language that facilitate information sharing across disciplinary perspectives.

The first challenge, that of developing shared conceptual frameworks, has been the focus of work by William Newell (Newell 2001). According to Newell genuinely interdisciplinary work requires the synthesis or integration of the differing conceptual frameworks represented. Roughly, the requirement is the construction of a single new conceptual framework or 'worldview'. In my view the kind of commonality of perspective required for successful CDR is one of the major open questions in this area and a major reason for research project to be discussed shortly. With that said, Newell's research still sets the standard for work in this area so I will continue to use his terms (synthesis/integration) to describe the CDR challenge of creating a workable conceptual framework for the members of an interdisciplinary inquiry.

The second challenge, that of indentifying forms of language that facilitate communication within CDR teams, has been the focus of Sanford Eigenbrode, Michael O'Rourke, and their colleagues (Eigenbrode et al 2007). The key insight of Eigenbrode and O'Rourke is that what CDR teams need to talk about are their various approaches to doing science. Most scientists however do not have a discipline neutral language (or set of terms) in which to hold such a discussion. The value of conducting discussions in a language that all parties feel equally at home in, is discussed in Crowley et al 2010. Eigenbrode and O'Rourke argue that explicitly philosophical terminology, drawn from work on the nature of science, can provide such a discipline neutral language. If these discussions are further structured by an initial set of prompts, the resulting conversation should focus on issues that the scientists in question need to address and do so in a genuinely constructive fashion. Eingenbrode and O'Rourke have developed a workshop to test these ideas (Eigenbrode et al 2007) and results so far suggest that the their ideas about the value of philosophical language are being born out (personal communication).

To sum up, philosophical investigation of CDR has given us some sense of where we are trying to get to (i.e. synthesis/integration – (Newell 2001)) and how to get there (dialog about styles of inquiry framed in the language of philosophy both to make the critical issues clear and to provide a shared, neutral form for that discussion - (Eigenbrode et al 2007)). This leaves open a philosophical question that is both intellectually challenging and of genuine practical value. That is, what are the underlying mechanisms (cognitive and social) that account for the ability of structured philosophical dialog to facilitate such 'syntheses? An analogy may help to make the issue clearer. As early as the 1600's people had identified the disease rickets (a softening of the bones sometimes leading to twisted or bowed long bones e.g. legs) and by the 1800's were aware of treatments (exposure to sunlight, access to dairy products) but it was not clear until the 20th century (and the discovery of vitamin D) that the reason why the treatments for rickets were successful was understoodl. I think we are in a parallel situation with regard to the facilitation of CDR. We have a desired end state and some ways to get there but strictly limited understanding of why the techniques that work do so.

Working toward an understanding of the mechanisms that facilitate CDR requires rethinking the methodology appropriate for pursuing philosophical questions. A standard approach is conceptual analysis, in which a critical notion is broken down into its component notions. For example 'knowledge' is analyzed as, 'justified, true, belief (e.g. Gettier 1963). But this approach won't help us make sense of the variety of mechanisms that generate successful CDR because conceptual analysis works with what is common to a range of cases rather than focusing on their variety. But it is just the variety of mechanisms that is at issue here. So while conceptual analysis may contribute to the development of the kind of general and hence neutral language that is so critical to the work of Eigenbrode and O'Rourke, it is not an appropriate tool for this investigation.

A second philosophical method, of more recent vintage but gaining acceptance, is experimentation (see Knobe and Nichols 2008 for a survey of this approach). Such an approach would involve the empirical study of a variety of CDR teams along with the attempt to influence their success or failure in various ways. Such an approach has some initial appeal. Indeed it might be argued that the work of Eigenbrode and O'Rourke just is such an approach. The problem here is that such experimental work is extremely resource intensive (e.g. time and money) and as a consequence it is unlikely that enough experimental work can be done any time soon to fully determine the mechanisms of successful CDR.

This leaves a final methodological approach open to philosophers interested in the mechanisms of CDR – modeling. Traditionally philosophical modeling has been analytic in nature. That is, it has attempted to capture the phenomena to be modeled in terms of a set of equations. Such an approach is clearly inappropriate for the study of the mechanisms of CDR, if only because we do not yet know enough about the phenomena to discriminate between good and bad models! Fortunately philosophy has begun to recognize that much of what it studies can usefully be thought of as emergent phenomena, generated as a byproduct of the interaction of independent agents pursuing their own personal level goals. That is, many interesting philosophical issues may be seen as the products of complex adaptive systems and as such may be usefully modeled using the techniques of agent based modeling (ABM). What follows is a preliminary report on an attempt to make sense of the conceptual and communicative mechanisms of successful CDR teams using the techniques of ABM.

An Agent Based Model of CDR

Ultimately a full model of CDR mechanisms should address both the internal conceptual architecture of individual researchers and the nature of communication networks by which such researchers share their findings and theories. However, being new to modeling it seemed advisable to build up to a 'dream' model in stages. My initial step was a 'proof of concept'. Was it possible to build an agent based model which was plausibly interpreted as containing agents attempting to learn about their environment and communicating with one another about what they had learned; but conducting their learning using different methods?

There is a small but significant philosophical literature using agent based models to address issues in social epistemology. The work of Kevin Zollman (Zollman 2007) and Patrick Grim (Grim 2004) focuses on the impact of network structure on the development of consensus within communities. The work of Michael Weisberg (Weisberg forthcoming) looks at methods for communities to learn. He models such learning as the investigation of a space, where that space is to be thought of as a space of hypotheses rather than a physical space.

Developing my own model then could be done by combining Weisberg's 'learning' models with Grim and Zollman's network models. Using Netlogo I developed a 'landscape' for my agents to explore. Following Weisberg this landscape is to be thought of as a 'space' of hypotheses or theories about the nature of the world. Each hypothesis was associated with a 'correctness' score, intuitively, a measure of how accurate that hypothesis is. Two types of agents were then added, differing only in how they 'explored' the landscape. Since hypotheses are locations we can describe an agent as holding the hypothesis on which it is located. One class of agents (stickers) used a hill climbing algorithm to investigate their immediate locality for increasingly correct hypotheses. The other class of agent (switchers) took advantage of the simple ring network that was established among the agents. Switchers looked at the correctness score of their immediate neighbors in the network and 'jumped' to the vicinity of the neighbor with the highest correctness score if that score exceeded that of the hypothesis the switcher was currently entertaining. Finally stickers who had reached a local maximum would adopt the switcher strategy and 'jump' nearby their most correct immediate network neighbor (if that neighbor was more correct than the sticker in question).

An initial experiment was run to determine if the variety of agents in a population had any impact on that populations ability to learn (i.e. successfully explore the hypothesis space). Using small populations (10 agents) and the average 'correctness' score of the population (when all agents had ceased moving) as an outcome measure, 3 population types (all stickers, all switchers, half and half) and two network states (no network, simple ring network) were evaluated. On a single 'landscape' each of the 6 conditions was 10 times. Results are shown in the following table.

Population and Network Type	Mean Correctness	Mean + 1 std. dev.	Mean – 1 std. dev.
Landscape	501.0691	566.8759	435.2623
All switchers - no network	501.0691	566.8759	435.2623
All stickers - no network	598.1869	654.5303	541.8435
Half and half - no network	548.5504	629.8601	467.2407
All switchers - ring network	681.4579	690.7926	672.1233
All stickers - ring network	693.2691	693.2691	693.2691
Half and half - ring network	692.9557	694.6302	691.2812

Table 1: Results of Agent Type on Population Learning

What these results make clear is that population make up does make a difference. The differences are more significant in the absence of communication but even when communication occurs populations do better the more stickers they contain. By itself this result is of limited interest but what it does establish is that the impact of different styles of learning (i.e. ways of doing science) can be successfully modeled in an ABM context. Given that result it makes sense to move onto more sophisticated models of CDR.

Further development of the ABM's of CDR should occur in at least two directions. First, within the simple model describe here a wider variety of outcome measures need to be assessed. For example, time to stasis (no moving agents) seems relevant to the evaluation of a populations learning ability. Path tracking may also be worth considering, that is, do agents typically increase their 'correctness' or do they cycle through both better and worse hypotheses? The second direction in which to push this work is towards greater sophistication in the modeling of communication. Key features of CDR involve both the difficulty and the value of such communication. To add such features to an ABM may well require a two level model. That is, one in which the agents' conceptual architecture is modeled as well as their behavior (movement and communication). Such a two level approach would allow for types of information which in turn could be used to explain the value of CDR (agent 1 has a kind of information that agent 2 lacks) and its difficulty (agent 2 may struggle to process the information it is being given because it is of a new type and so foreign to agent 2's information processing techniques). The move to types of information also raises the question of what sorts of information need to be shared in order for a problem to be successfully solved. It also raises the question of how similar two conceptual architectures need to be before they can successfully make use of one another's information. In short, a model having types of information would be in the position to begin to evaluate just what is involved in answering Newell's synthesis/integration question.

Conclusion

Cross-disciplinary research is an increasingly important part of our attempts to solve some of the most pressing problems our species confronts. As a consequence understanding the conceptual and communicative mechanisms that facilitate CDR is both intellectually exciting and of genuine practical value. Philosophy has a key role to play in the study of CDR both in providing a linguistic frame for CDR teams to negotiate their shared form of inquiry and in attempting to identify how features of disciplinary styles of thought and communication interact to support or frustrate efforts at CDR. This later project, whose early stages I described above, is best carried out using an ABM approach. This is turn strongly suggests that there is a critical role for the study of complex adaptive systems within the humanities. Such a study will in turn require humanists to become far more familiar with ABM techniques than they have to this point. In short, there is a real place for computer simulation in the humanities. So … its time we stopped worrying and learnt to love simulation!

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