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COMMENT

Levels of Expertise and Trading Zones:
A Framework for Multidisciplinary Collaboration

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In their provocative article [Collins & Evans (2002)], Harry Collins and Rob Evans point science and technology studies towards investigation of experience and expertise (SEE), an area that has long been of concern for cognitive scientists.[1] Cognitive scientists, however, have avoided studying what happens when experts interact in ways that pull them out of their core expertise.

SEE, therefore, has great potential for shedding light on the kinds of multi-disciplinary interactions that are becoming prevalent on the cutting edge of technology. In this brief Comment, I will focus on two examples: a converging-technologies initiative sponsored by the NSF, and an attempt to create a new kind of expert on human-environmental systems. Collins and Evans are right that, in cases like these, we cannot afford to wait for the 'expert's regress' to tell us, in hindsight, who the experts really were, because by then technological systems will be in place.

Collins and Evans distinguish between three levels of expertise:

1. None
2. Interactive
3. Contributory

These three kinds of expertise can be linked to three kinds of trading zones.[2] The first is a network controlled by an élite in which there really is no trade: those not in the élite either obey, or they are ignored. The élite can be a group of experts who use their specialized knowledge to dictate how a socio-technical system will function.[3] The expertise of such an élite is black-boxed for other participants in the network; access to the knowledge is tightly controlled.

The second is a boundary-object trading zone,[4] where experts from different fields interact around the development of a technology or system

Social Studies of Science **32/5–6(October–December 2002) 933–938**

[0306-3127(200210/12)32:5–6;933–938;031465]

– like radar or MRI.[5] Here the system of concern serves as an object that links the participants in the network, but experts from different fields see the boundary object in ways dictated by their expertise. This kind of a trading zone includes a continuum, from limited, adversarial interactions where different groups of experts try to 'throw their parts of a technology over the wall' to each other, to a more constructive engagement among interacting experts who agree on common goals. AIDS research protocols served as a boundary object for activists, medical researchers and statisticians, each of whom saw them in a different way.[6] Initially, groups of activists demanded changes in the protocols and researchers made some concessions – a primitive trading zone, more adversarial than cooperative. But as activists grew in sophistication and attracted allies among statisticians, the trading zone became more collaborative and the activists moved from reacting to interacting to, in some cases, contributing.

Contributory expertise brings us to the third kind of trading zone, in which the participants share a common understanding of a goal and collaborate closely. In the parlance of cognitive science, they must share a continually evolving representation of a techno-social system that would normally serve as a boundary object.[7]

I would like to suggest a relationship between the three levels of expertise outlined by Collins and Evans and the three types of trading zone outlined above:

Trading zone	Élite	Boundary object	Shared representation
Expertise	None	Interactive	Contributory

Now let us apply this framework to two emerging areas of multidisciplinary collaboration. The National Science Foundation recently held a conference on Converging Technologies (NBIC) for Human Performance, linking biotechnology, nanotechnology, information technology and cognitive science.[8] The model for collaboration that emerged was disciplinary depth combined with the ability to share expertise. The framework outlined above allows us to discuss possible levels of sharing, on a continuum:

1. None, in which each discipline tries to dominate the trading zone or threatens to exit;
2. Interactive, in which disciplinary experts create creoles around boundary objects representing technological possibilities;
3. Contributory, in which experts from these four areas engage each other deeply, learning enough to contribute jointly to development of a new technological system.

Consider, for example, how converging technologies could be used to create a 'super soldier',[9] featuring:

- IT to link the soldier into a command network that included information on threats and support;

- Nanosensors to provide information about the immediate environment, including biological and chemical threats;
- Genetic modifications that include improvements to the soldier's physique and nervous system.

Each of these capabilities is coupled with the other ones, so at least a close interaction among expertises is required – and just as Brian Wynne's sheep farmers should have been contributing experts in post-Chernobyl remediation, so soldiers should be intimately involved in these new technologies from the earliest design phases. Because this is potentially an area of Golem technology (to adapt a distinction from Collins and Evans), another kind of expertise obviously needs to be added: ethics.

The question is whether this ethics expertise should belong to the political sphere that Collins and Evans set up as a separate trading zone. The risk is the same as that with the expert's regress: ethicists, politicians and other stakeholders will be reacting to a technology that exists, rather than playing a rôle when the technology is more open-ended.

A better approach would be to have practical ethicists join this super-soldier project as interacting experts, working closely with the researchers to explore societal implications as the technology produces new breakthroughs. These interacting experts would not replace the need for a close examination by others who were outside of the project and therefore could not have 'gone native'; indeed, the interacting ethicists could serve as capable translators for ethicists and social scientists who should be involved in decisions about the future of the technology, but lacked the specialized knowledge necessary to open all of its black boxes.

A second, very different example of an emerging multi-disciplinary trading zone involves a new approach to human-environmental systems. Brad Allenby, a prominent industrial ecologist, has called for the development of Earth Systems Engineering Management (ESEM), which would involve creating a new kind of expert.[10] ESEM begins with the premise that no corner of the globe is unaffected by human beings, given our technological 'advances', and therefore we have a responsibility to manage our planet intelligently. Human beings, nature and technology are all closely coupled in a dynamic system whose interactions are hard to predict. Therefore, ESEM is what Collins and Evans refer to as a 'reflexive historical science'.

This kind of system cannot and should not be managed via an élite trading zone, in which resources are ruthlessly exploited or a particular environmental ideology is imposed on all participants. Instead, most environmental regulation involves a trading zone among multiple agencies with interacting expertise.[11] But ESEM implies moving beyond this kind of careful, often-adversarial trading zone to a continuous dialogue with the complex system that will produce shared representations – a dialogue that will include knowledge scientists and ethicists as contributing experts.

Consider a complex system like the Florida Everglades, home to 68 endangered species, multiple eco-systems and a surge in human development. Managing such a system will require experts who are skilled at multiple disciplinary languages and recognize the political agendas of competing agencies and stakeholders. These ESEM experts will not have a privileged view of the 'true' system; instead, they will have to facilitate contributions from multiple experts and stakeholders, serving at least as the kind of 'translator' mentioned in Collins and Evans' Thesis 4 (258).

Is this kind of ESEM expertise actually possible? The only way to find out is to try to create it.[12] SEE should include the study of new kinds of expertise that emerge in trading zones exemplified by ESEM and by the NBIC converging technologies. Indeed, some SEE practitioners will become contributors to multidisciplinary trading zones forming around new technologies, combining scholarship, expertise and activism.[13]

Notes

1. Much of the literature in cognitive science is concerned with differences between experts and novices on the sorts of normal science problems encountered in textbooks; see, for example, the classic papers by Larkin et al. (1980), and Chi et al. (1981). For more recent research on how people become experts, see Ericsson (1996).
2. Peter Galison (1997) used the metaphor of 'trading zones' to describe how physicists and engineers worked together to build complex particle detectors. They had to develop a 'creole', or reduced common language, that allowed them to reach consensus on design changes. Gorman & Mehalik (2003) describe three stages in the evolution of actor-networks and apply them to a series of examples that combined ethical motives with novel designs.
3. Scott (1998) is full of examples.
4. Boundary objects are 'most useful in analyzing cooperative and relatively equal situations; issues of imperialist imposition of standards, force, and deception have a somewhat different structure' (Bowker & Star 1999: 297). In other words, élite control networks do not have boundary objects.
5. Galison (1997) describes the trading zone around radar, and Baird & Cohen (1999) describe the zone around MRI. None of these authors use the concept of a boundary object in connection with trading zones – that connection is original to this Comment.
6. The AIDS example is based on Epstein (1996).
7. In these shared representation networks, participants in the trading zone have to have the same perspective on key aspects of the technological system at the boundaries of their different expertises. According to Bowker & Star (1999: 298) boundary objects are 'plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use and become strongly structured in individual site use'. A shared representation has to structure individual site use, but not in a top-down fashion – such a representation has to evolve constantly from shared practices in service of a common goal. See Gorman & Mehalik (2003) for examples.
8. The report from this December 2001 symposium is not yet out. For a press release, see *http://www.wtec.org/ConvergingTechnologies/*.
9. See *http://www.technologyreview.com/articles/talbot1002.asp* for MIT's ideas on how to use nanotechnology to create a super soldier.
10. The best concise account of ESEM is Allenby (2001).
11. Sheila Jasanoff's work is full of examples of regulatory trading zones where expertise is negotiated, though she does not use the term 'trading zone'. Her work blurs the separation between the political and technical phases: 'It is a final irony of

environmental decision making that, in the effort to keep politics distinct from science, the processes of scientific fact making so freely accommodated themselves to the demands of politics' (Jasanoff 1992: 217).

12. A group of us are engaged in developing ESEM courses and degrees at the University of Virginia; for more information, please contact the author of this Comment.
13. Woodhouse et al. (2002) discuss the possibility of combining scholarship and activism in the article following the one by Collins & Evans (2002) in the same issue of *Social Studies of Science*. Woodhouse et al. are concerned with 'the problem of how to *re*construct technoscience to promote a more democratic, environmentally sustainable, socially just or otherwise preferable civilization' (Woodhouse et al. 2002: 297–98). One way is to view SEE as an area of interactive and potentially contributory expertise regarding the social benefits and drawbacks of new technologies as they emerge. The National Nanotechnology Initiative includes major funding for societal implications of nanotechnology, but it remains to be seen whether any of this funding will be directed toward SEE efforts, or whether it will instead be directed towards what Collins and Evans refer to as the 'political dimension' (Roco & Bainbridge 2001).

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