Doctoral Preparation of Scientifically Based Education Researchers

by Margaret Eisenhart and Robert L. DeHaan

Finding improved ways to train education researchers has taken on new urgency as federal legislation such as the No Child Left Behind Act of 2001 and the Education Sciences Reform Act of 2002 call for "scientifically based research in education." The authors of this article suggest an approach to socializing doctoral students to a common "culture of science" (a set of norms for scientific inquiry) and preparing them for interdisciplinary studies that span the natural and social sciences. Drawing on developments in the fields of neuroscience, sociology of natural science, and the learning sciences, the authors argue for an approach to doctoral training that is consistent with a broad definition of scientifically based research.

Calls for improving the graduate training of education researchers are everywhere (e.g., Carnegie Foundation, 2003; Institute for Education Sciences [IES], 2004; National Research Council [NRC], 2002, 2004). And, although concern about graduate training in education is not new (Lagemann & Shulman, 1999; Lagemann, 2000), it has taken on new urgency as the meaning and purposes of education research have come to be codified for the first time in federal law, for example, in the Reading Education Act of 1999, the No Child Left Behind Act of 2001, and the Education Sciences Reform Act of 2002. Although these federal mandates do not use identical definitions of education research (Eisenhart & Towne, 2003), they all call for some form of "scientifically based" research in education, and they all imply the need for more education researchers who can conduct scientifically based studies. In consequence, federal funding initiatives now encourage schools of education and university departments of science and social science to train graduate students for scientifically based education research (IES, 2004; National Science Foundation, 2004).

As members of the National Research Council committee that produced the report *Scientific Research in Education* (NRC, 2002; hereinafter, *SRE*), we have been in the midst of discussions about what it means to do scientifically based research in education and to train people for it. In *SRE* and subsequent publications, we have put ourselves on record as opposing a narrow definition of scientifically based researchers as exclusively experimentalists.[1] Consistent with *SRE,* we subscribe to a broader conception of scientifically based researchers as professionals who engage in inquiry to identify or develop defensible explanations or interpretations by following six guiding principles:

1. To pose significant questions that can be investigated empirically;
2. To link research to relevant theory;
3. To use methods that permit direct investigation of the question;
4. To provide an explicit and coherent chain of reasoning;
5. To replicate and generalize across studies; and
6. To make research public to encourage professional scrutiny and critique. (*SRE,* pp. 3–5, 54–72)

In this article, we first expand upon this conception of scientifically based research by relating our work on *SRE* to new conceptions from the emerging fields of neuroscience, sociology of science, and the learning sciences. Then, we consider the implications for training the next generation of education researchers.[2]

Background

The National Research Council committee on which we served and that produced *SRE* was formed in late 2000, at a time when Congressional legislation (HR-4875) containing a restrictive definition of scientific research in education was proposed. The original bill included two sets of standards for quantitative and qualitative research that is scientifically based. Acceptable quantitative studies were required to use hypothesis testing for research and experimental designs with random assignment for evaluations. Acceptable qualitative research was defined vaguely by a list of methods and presented as a preliminary form of investigation (for a discussion, see Eisenhart & Towne, 2003). In this framing of standards, qualitative scientific research was presented, at best, as an ill-defined sometime precursor to more rigorous quantitative scientific research, especially experimental research.

From the outset, the committee agreed that the definition of "scientifically based" in HR-4875 was inadequate. We agreed that the actual practice of scientific research is more descriptively oriented, more dependent on context, less cumulative, and more intuitive—in other words, more qualitative—than is implied by the idealized model of experimentation, frequently described as the path to producing causal explanations (see also Fay, 1996; Harding, 1991; Jasanoff, Markle, Petersen, & Pinch, 1995; Kuhn, 1962/1996; Latour & Woolgar, 1979/1986). The committee acknowledged the importance of research outside "science," including philosophical, historical, and critical scholarship, and its

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contributions to education as well as to both natural[3] and social science (*SRE*, pp. 26, 74–76). We also discussed the role of practitioner-oriented research in social science, medicine, and agriculture, as well as education (*SRE*, pp. 80–91). In the course of our deliberations, we discussed social and cultural context, participant involvement, political considerations, and ethical requirements, considering all of them as inherent features of the study of social and educational phenomena—features that often preclude the use of experimental or quasi-experimental designs. We agreed that these contextual features limit reliability and generalizability in the conventional sense and that they require complex models of explanation. However, as we also agreed, they do not obviate the search for explanations or interpretations that can be falsified, that is, explanations or interpretations that can be scrutinized in light of empirical evidence and rival explanations—explanations or interpretations that were for us the sine qua non of scientific inquiry or "the culture of science" (Feuer, Towne, & Shavelson, 2002; *SRE*, pp. 28–79).

The "Culture of Science"

The committee's perspective on scientific inquiry has long historical roots.[4] Years ago, Thomas Kuhn (1962/1996) argued that natural and social science could be distinguished by their "maturity" but not by their principles of inquiry. Kuhn attributed the difference to "paradigms"—"universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners" (p. x)—that organized scientific activity in physical and natural science but, in his view, not in social science. In physical and biological science, according to Kuhn, the existence of paradigms has permitted sustained periods of "normal science"—when widely accepted tenets define the relevant questions and scientists can know "with precision" (p. 65) what to expect from a given phenomenon and can devote their time mostly to applying the tenets and refining procedures for investigating them. In comparison, Kuhn described social science as "pre-paradigmatic" (i.e., immature) because model problems and solutions were rarely accepted as such by a majority in the field. Because social science was characterized primarily by controversies over fundamentals, it did not display the more orderly progress of natural science, never achieving a period that could be defined as normal science.

We agree with Kuhn that, overall, research in the natural sciences appears more orderly than that in social science or education. The latter fields lack the agreed-upon theoretical models of the biological and physical sciences. From at least the time of Descartes, the physical and life sciences benefited from the simplifying methods of rational analysis, empirical specification, and reductionism that allowed early workers to tease out testable models of nature. But as the focus of the natural sciences has shifted toward new kinds of synthesis—which are required to explain properties emerging from "the exponential increase in complexity encountered during the upward progress through levels of organization" (Wilson, 1998, p. 83)—the benefits of reductionism have been questioned.

Attacks on reductionism are now heard from natural scientists who argue that it is no longer the path to progress at the frontiers of understanding in complex systems such as the structure of the universe or the human brain. "Any realistic notion of brain complexity must incorporate, first, the highly nonlinear, nonstationary, and adaptive nature of the neuronal elements themselves and, second, their non-homogeneous and massive parallel patterns of interconnections. . . . For now, perhaps the most obvious thing to say about brain function from a 'complex systems' perspective is that continued reductionism and atomization will probably not, on its own, lead to fundamental understanding" (Koch & Laurent, 1999, p. 98).

In addition, social scientists have long argued that reductionism and atomism distort or ignore the dynamic social and semiotic aspects of human experience, and, thus, of knowledge (e.g., Clancy, 1997; Fay, 1996; Geertz, 1973; Marcus & Fischer, 1986). Pushing their research into areas such as high-energy physics and endocrinology (e.g., Knorr Cetina, 1995), social scientists *of science* have convincingly shown that models of nature are influenced by social relationships and other human experiences.

Yet, despite concerns about reductionism, atomism, and the implications for experimentation, both natural and social scientists continue to search for durable and warranted claims about nature and human beings. To quote from the cultural anthropologist Clifford Geertz,

> [C]ultural theory is not its own master . . . its freedom to shape itself in terms of its internal logic is rather limited. What generality it contrives to achieve grows out of the delicacy of its distinctions, not the sweep of its abstractions. . . . Studies do build on other studies, not in the sense that they take up where the others leave off, but in the sense that, better informed and better conceptualized, they plunge more deeply into the same things. . . . Previously discovered facts are mobilized, previously developed concepts used, previously formulated hypotheses tried out; but the movement is not from already proven theorems to newly proven ones, it is from an awkward fumbling for the most elementary understanding to a supported claim that one has achieved that and surpassed it. A study is an advance if it is more incisive . . . than those that preceded it. (1973, p. 25)

Certainly, the endpoint of Geertz's interpretive science (to discover and refine systems of meaning or "webs of significance" that are incisive for understanding a particular group) differs from that of experimental science (to discover and extend general laws that are predictive). Discussing interpretive science, Geertz continues:

> The major theoretical contributions not only lie in specific studies . . . but they are difficult to abstract from such studies and integrate into anything one might call "culture theory" as such. Theoretical formulations hover so low over the interpretations they govern that they don't make much sense or hold much interest apart from them. This is so, not because they are not general (if they are not general, they are not theoretical), but because, stated independently of their applications, they seem either commonplace or vacant. One can, and this in fact is how the field progresses conceptually, take a line of theoretical attack developed in connection with one exercise in ethnographic interpretation and employ it in another, pushing it forward to greater precision and broader relevance . . . but there appears to be little profit in it, because the essential task of theory building here is not to codify abstract regularities but to make thick description possible, not to generalize across cases but to generalize within them. . . . [Nonetheless] the theoretical framework in terms of which such an interpretation is made must be capable of continuing to yield defensible interpretations as new

> phenomena swim into view. . . . If [the interpretations] cease being useful with respect to such [phenomena], they tend to stop being used and are more or less abandoned. If they continue being useful, throwing up new understanding, they are further elaborated and go on being used. (1973, pp. 25–27)

Just as certainly, these different endpoints have different implications for what researchers will focus their inquiries on. Interpretive scientists focus on meanings and diagnoses; experimental scientists focus on patterns and predictions. This difference has further implications for what research methods will be used: Interpretive scientists in search of meanings need methods such as interviews and participant/observation to illuminate those meanings; experimental scientists in search of regularities need correlations and experiments.

But *the general processes of inquiry* in interpretive and experimental sciences are virtually identical. In both cases, inquiry is a process of relying on previous work to specify new empirical investigations that lead to warranted conclusions. In both cases, warranted conclusions are arrived at by conducting empirical investigations, making links to previous research, using methods that are appropriate to the questions asked, articulating a chain of reasoning, and exposing the inquiry process and the reasoning to public scrutiny. While conventional reliability and generalizability are arguably not as important or useful in interpretive research as they are in experimental research, similar or analogous criteria for establishing the warrant of interpretive claims are commonplace (Eisenhart & Howe, 1992; Erickson, 1986; Lincoln & Guba, 1985; Sanjek, 1990). When we speak of the "culture of science" (both here and in *SRE*), we are referring to the norms of inquiry that lead to warranted claims, claims that contribute to Geertz' "delicate distinctions" as well as to Kuhn's (1962/1996) "knowing with precision," claims that come from what Redish (1999) calls a "community consensus knowledge base," defined as "the continual interaction, exchange, evaluation, and criticism [that scientists] make of each other's views" (p. 562).

For us, then, a fundamental component of training programs that prepare scientifically based education researchers is socialization into these norms of scientific inquiry. This is not to say that epistemological differences between postpositivist research (as in *SRE*), interpretivist research, critical research, and postmodernism should be ignored. Indeed, such differences have been widely explored in a number of recent publications (e.g. Eisenhart, 2005; Erickson, 2005; Moss, 2005; Siddle Walker, 2005), as have their implications for preparing students to understand diverse epistemological perspectives and methodologies (Metz, 2001; Pallas, 2001; Young, 2001). Furthermore, training programs in education research cannot ignore the complex contexts of educational practice (Anderson, 2002; Labaree, 2003). Our point is that, in addition to these considerations, training programs that aim to prepare scientifically based education researchers should make the norms of scientific inquiry a central component.

Distinctions Between the Natural and Social Sciences Are Crumbling

Another development with implications for training scientifically based education researchers is the crumbling of the distinctions between the social and natural sciences. These fields are blending increasingly into each other as cutting-edge research questions focus on topics that span traditional boundaries between the "hard" and "soft" sciences (see also Heath, 1999; NRC, 2000; Simon, 2001). For example, research concerning the role of intentionality in natural science, of neural chemistry in cognition, and of complex nonlinearity in the learning sciences—all attractive topics for education researchers—call for attention to the insights of both natural and social science. In consequence, it seems that the training of students in scientifically based education research should be attuned to these new developments.

Intentionality in Natural Science

An issue that has long been the province of social science (but not natural science) is that of human intentionality. Traditionally, studying people was different from studying atoms or molecules. Unlike the actions of molecules, those of human beings—human behaviors, intentions, and beliefs—are in large part volitional. Human actions depend on what humans think they are doing. A parent who sends her child to private school does so for reasons, not because the molecules in her body move her in that direction. In addition, this parent is in a special position to know what she is doing and why she is doing it; she does not have to observe these actions to know what they mean. Moreover, a social researcher might observe the same action (sending a child to private school) by another parent, yet not be able to conclude reliably that the second parent took the action for the same reason. Furthermore, the way that the action of sending a child to private school is identified (e.g., as a "move away from a failing public school" or as a "decision to support faith-based schools") and how it is explained (e.g., "because my child was not learning to read" or "because I want my child to grow up Catholic") become constitutive of the action itself (Searle, 1984, pp. 57–59). A parent's concern about failure to read (or growing up Catholic) can impel the action intended to correct the problem. These intentional features of human action have long been of interest in social and education research, whereas they usually play no role in the observations that an investigator makes in fields such as astrophysics or molecular chemistry.

However, intentionality is no longer the exclusive province of social science. With the advent of modern neurobiology, many aspects of human behavior that were previously considered exclusively topics of the social and behavioral sciences have been opened to study with biochemical and biophysical methods. Multichannel, single-cell electrophysiological recording and neuroimaging techniques such as functional magnetic resonance imaging (fMRI) and positive emission tomography (PET) brain scanning, as well as the ability to identify specific neural pathways and measure their moment-by-moment activities, are all strategies that can now be applied to studies of such issues as intentions, goal setting, learning, and emotional states (Damasio, 1999; Kolb, 1998; OECD, 2002). Analysis of brain function has even aided investigations of social interactions in progress, through the new methodology of hyper-scanning (Montague et al., 2002). This technique allows human behavioral experiments to be performed with interacting participants while brain images are collected from both through linked MRI scanners.

Research on the neural basis of motivation and reward in human beings and animals is now an active area of study by neurobiologists using combinations of psychophysical, electrophysiological, neuroanatomical, and molecular methods to identify neurons or neural pathways active in specific behaviors. There are roughly 100 billion neurons in the human brain, and each one may be connected to thousands of others. At any moment, many neurons are active simultaneously, enabling information signals to flow in many directions at once, establishing patterns of connectivity (Damasio, 1999; Koch & Laurent, 1999). Changes in motivation, attention, learning, and emotion have been shown to depend on neurons with different patterns of connectivity, whose activities are mediated by diverse neurotransmitters. For example, the elements of goal setting can be studied in active, alert experimental animals by decoding "cognitive signals" arising from individual neurons. The intention to reach for an object, the intended direction of a hand-reach, even the decision to reach for one object over another as determined by a prior preference, can be analyzed with such techniques (Musallam et al., 2004). A different approach, using imaging techniques, is described by Shizgal and Arvanitogiannis (2003). In this work, a specific group of dopamine neurons that connect the midbrain to diverse areas in the forebrain were shown to play defined roles in motivation, learning, and attention functions.

Investigations of social interactions and the intentions of researchers also blur the traditional boundaries between social and natural science. Sociologists Bruno Latour and Steve Woolgar's study (1979/1986) of a neuroendrocrinology laboratory at the Salk Institute for Biological Studies makes the point that intentions and social interactions among the scientists participating in an investigation do matter in the natural sciences. In the lab, researchers studied chemical substances released by the brain. Their work focused on the nature and order of "releasing factors." Taking the example of one factor, Thyrotropin Releasing Factor, or TRF(H), the sociologists showed how the agreed-upon interpretations of its structure were mediated by literary inscription devices (concepts, theories, formulas, and equipment read-outs), social interactions, and power relationships in the lab. In particular, they showed how influential members of the lab team were able "to convince others that what they [the lab leaders] do is important, what they say [about scientific phenomena] is true, and that their proposals are worth funding. They are so skillful, indeed, that they manage to convince others not that they are being convinced but that they are simply following a consistent line of interpretation of available evidence" (Latour & Woolgar, 1979/1986, pp. 69–70).[5]

Building on this early work of Latour and Woolgar, researchers in the sociology, anthropology, and history of science have identified sociological and cultural aspects of several domains in the natural sciences: high energy physics (Traweek, 1988), mollusk reproduction (Callon, 1986), and reproductive technologies (Rapp, 2000), to name only a few (see Knorr Cetina, 1995, for a thoughtful review). These studies further illustrate how social and cultural dimensions affect the construction of (hard) scientific claims.

However, as Latour (2004) has recently written, the fact that enduring scientific claims are socially constructed does not *explain* them. Social construction does not explain, for example, why hard-won evidence about hormones works to save lives or produce babies. Thus researchers in these fields have made clear that understanding science facts, experiments, processes, and theories requires analyses of intentions, social interactions, *and* nature (see also Jasanoff, Markle, Petersen, & Pinch, 1995).

In summary, as intentions and social aspects of natural scientists' claims have become legitimate subjects of study by social scientists, cognitive neuroscience has extended the study of human intentions into physiology and neurochemistry. Modern education research, which until recently aimed to further the understanding of matters such as intentionality in learning or the construction of meaning from observation, now must take a cross-disciplinary viewpoint, informed by findings and methodologies from both the social and the natural sciences. Attempts to reduce learning to one dimension or another have routinely failed to produce warranted explanations of the process.

Studies of Learning Span the Social and Natural Sciences

Much of the evidence about optimal conditions for learning is summarized in the recent NRC report *How People Learn: Brain, Mind, Experience and School* (NRC, 2000), written under the supervision of a committee that included education researchers, psychologists, and cognitive scientists. This report stresses that traditional work in the "learning sciences," building on and extending work in neuroscience, is now able to search for explanations that rely on knowledge of the brain, cognition, development, social interaction, and culture to account for the interactivity of students' biological capacities for learning, their personal and interpersonal resources and supports, and the socially and culturally organized information and environments to which they are exposed (NRC, 2000).

An example of this broadening of learning research is described by Donald (2002) in a chapter in which she reviews research on student "orientation" toward learning. A large body of convincing data indicates that students can take either a deep orientation, in which they are highly motivated to learn and seek to relate to and maximize understanding of new knowledge, or a superficial orientation, which involves little motivation and results mainly in rote memorization. Donald (2002, p. 5) argues that students may adopt either a deep or a superficial orientation, depending on socially constructed cues given by the instructor. At the same time, evidence is emerging from the cognitive neurosciences that learning can be enhanced pharmacologically. Recent studies analyzing the mechanisms of drugs known as memory enhancers indicate that those drugs produce their results (thus far only in laboratory animals) through activation of a nuclear protein known as CREB (Tully, Bourtchouladze, Scott, & Tallman, 2003). Activated CREB is known to switch on genes in neural cells whose protein products strengthen synapses involved in long-term memory (Hall, 2003), an essential component of learning. It is at least worth speculating that the mechanism for switching a student from a superficial to a deep orientation may also have something to do with activation of CREB.

In sum, the field of education research has dramatically broadened its reach in recent decades. Cutting-edge research in learning and education now ranges across the disciplinary boundaries that have heretofore separated the social and natural sciences. Thus it seems that an important aspect of preparing scientifically based education researchers is to train students who are familiar with, and are expected to contribute to, such interdisciplinary work.

Preparing New Researchers

Currently, education professionals do not agree on the breadth or depth of training that graduate students need to become competent education researchers (Viadero, 2004). Two recent national reports (Levine, Abler, & Rosich, 2004; NRC, 2004) have taken up this issue, but many questions remain. Our involvement in *SRE* and our reading of the literature lead us to propose that education researchers (as a group) need training in five broad areas: (a) diverse epistemological perspectives; (b) diverse methodological strategies; (c) the varied contexts of educational practice; (d) the principles of scientific inquiry; and (e) an interdisciplinary research orientation. As indicated above, the first three areas have recently been addressed by others. Here we aim to develop the last two.

Socialization to the Principles of Scientific Inquiry

In the natural sciences, it is generally agreed that socialization to the principles of scientific inquiry requires research experience or apprenticeships and that these should begin early in the training sequence (DebBurman, 2002; Narum & Conover, 2002; NRC, 2003a, 2003b, 2004). The preparation of new researchers in the "hard" sciences is commonly praised for its effectiveness in providing these opportunities. In physics for example, novice researchers traditionally begin with 4 years of a highly focused undergraduate major. According to a survey by Hilborn, Howes, and Krane (2003), most undergraduate physics curriculums cover a common set of standard topics that place physics majors in a tightly organized, agreed-upon set of required courses and course sequences. Greater latitude is permitted only gradually, as the students' knowledge, research interests, and abilities increase. Course sequences for chemistry and biology majors may include a wider diversity of subjects but nonetheless are well focused within the discipline. Together with instrumentation labs, experiments, and problem-solving assignments, the requirements for science majors generally control and monopolize students' time, thus socializing them in the practice and norms of their discipline in ways that other degree programs (outside the hard sciences) do not (Eisenhart, 2001; Nespor, 1994; Traweek, 1988). An important part of this socialization is the research experience that is offered to promising undergraduates in "directed studies" projects or in the form of extra credit activities associated with upper-division courses that bring the undergraduates into faculty research facilities.

In education, undergraduate training in the field is quite dissimilar from that described above (Donald, 2002). Students entering graduate education programs rarely have prior undergraduate experience conducting research. At the master's level, most education programs focus on preparing teachers. Many entering doctoral students have previously been classroom teachers; thus few come from undergraduate or master's degree programs that include opportunities for supervised research in any field. For these reasons, students entering doctoral programs in education may find it particularly hard to appreciate research, at least at first (Labaree, 2003).[6]

According to Labaree, research demands analytic, intellectual skills that focus on ideas and not on social relationships. In contrast, classroom teachers (and undergraduates from many other majors) bring a perspective on education that is strongly normative, that focuses on producing valued outcomes rather than on answering questions about the world. Moreover, teaching is, at its core, highly interpersonal, dependent on the social relationships between teacher and student. Finally, a major characteristic of the teacher's worldview is its dependence on professional experience, or "craft" knowledge (Hiebert et al., 2002). This highly contextualized, experiential emphasis can make it difficult for teachers to appreciate arguments from the theoretical or research literature or to see how their work might contribute to that literature. Thus graduate students in education may begin their doctoral work without even seeing the need for education research.

Another important difference between graduate programs in education and those in the sciences has to do with levels of support, especially for research apprenticeships. Student fellowships and stipends, assistantships, travel monies, and opportunities for enrichment are less generous and more restricted in education than in the social or physical sciences (Levine et al., 2004). Overall, 79% of doctoral students in fields other than education receive financial assistance for graduate work; but among education doctoral students, only 50% receive assistance (National Center for Education Statistics [NCES], 2002, p. 13). A recent comparison of assistantship amounts by discipline shows a striking pattern of differential privilege (based on NCES, 2002, pp. 15, 21, Tables 4 and 5): Annual stipends for doctoral assistantships in education averaged about $6,800, half the amount paid for similar positions in the life and physical sciences. For Fiscal Year 2005, annual stipends for National Science Foundation graduate fellowships, which set the standard in the sciences, are $30,000, with an additional $10,500 cost-of-education allowance per award (http://www.nsf.gov/pubs/2004/nsf04615/nsf04615.htm).

Limited financial support for graduate students in education research also decreases the chances that students will be enrolled full time. According to NCES figures, 63% of Ph.D. students in fields other than education were enrolled full time and all year, as compared with only 24.8% of education Ph.D. students. Seventy-one percent of education Ph.D. students saw themselves as primarily "employees enrolled in school" (rather than as primarily "students"), in contrast with only 18% of other Ph.D. students (NCES, 2002, pp. 6–7). Given the figures for financial support, it is not surprising that many graduate students in education work at outside jobs and identify with nonstudent roles while attending school.

In short, graduate training programs in education research face a more diverse and challenging set of obstacles to socializing students to the norms of scientific inquiry than are faced by traditional programs in natural science or even other social sciences (Berliner, 2002). First, there is more for students to learn in education programs. The students must experience firsthand the culture of research (Berliner, 2003; Labaree, 2003; Richardson, 2003). They must learn how to pose researchable questions, whether requiring quantitative or qualitative methods and data; they must develop strategies for sampling, data collection, and analysis. They must learn ways of reasoning and arguing from evidence, means of assessing quality, styles of writing for technical reports and publishable articles, and ways of scrutinizing and constructively critiquing other's work.

In addition, graduate programs in education research must find ways to socialize students into the culture of science without the advantages of full-time focus or commitment. They must instill the culture of science without benefit of the resources for research apprenticeships that characterize training in the physical and biological sciences. They must do so with fewer overall resources and with a more diverse student population. And they must accomplish all of this in ways that enable graduating education researchers to participate in investigations that cut across the broad range of fields and methods that bear on education-related questions. Succeeding at all of this is no small task.

Developing an Interdisciplinary Research Orientation

The dramatic progress in science and technology in recent decades has led to the emergence of whole new fields, such as bioinformatics, neuroscience, proteomics, and nanotechnology. These developments have forced a recognition that many of the most productive research questions lie at the interfaces between traditional disciplines. Similar changes will, predictably, characterize future education research. Training programs for researchers in the sciences are already adjusting to the new interdisciplinarity (e.g. NRC, 2003b; Sung et al., 2003). Programs in education have been slower to take advantage of these developments—what Shulman refers to as "distributed expertise" (1999, p. 164)—regarding educational phenomena (see also Berliner, 2003).

On most campuses, the current field-limited preparation of education researchers (i.e., preparation in the field of education only) promotes an atmosphere in which graduate students can become intimidated by, or dismissive of, investigative areas outside their own specific domains of interest. We would like to see graduate training programs in which students learn to appreciate the relevance of interdisciplinary approaches to problems of learning and education, become familiar with research methods in several domains, and come to recognize the specific goals and limitations of investigations in each.

The importance of such an interdisciplinary approach has been affirmed by funding agencies interested in supporting scientifically based research in education. The director of the U.S. Department of Education's Institute of Education Sciences is quoted as saying, "I believe that new researchers are not getting exposed to all the skills they need at the graduate level to do the kind of work we're interested in funding." (Viadero, 2004, p. 30). Moreover, the Department of Education's Request for Applications for the new Predoctoral Interdisciplinary Research Training Program in the Education Sciences states:

> The design, testing, and implementation of new teaching methods will require scientists who are well trained in cognition, learning, and motivation, and who also are prepared to grapple with the challenges of extending laboratory-derived knowledge of these topics to teaching and learning in complex, real-world environments. Researchers who can straddle the worlds of cognitive science and education practice are very badly needed. (http://www.ed.gov/programs/edresearch/applicant.html, p. 3)

To nurture an orientation to interdisciplinary research, students must become familiar with a broad span of disciplinary and methodological approaches and become comfortable working in collaboration with experts in other disciplines. To encourage interdisciplinary training of graduate researchers, national and private funding agencies are developing special programs that emphasize collaborations and studies that span traditional disciplinary limits. For example, the National Science Foundation supports an Integrative Graduate Education and Research Traineeship (IGERT). The IGERT program is designed to "catalyze a cultural change in graduate education, for students, faculty, and institutions, by establishing innovative new models for graduate education and training in a fertile environment for collaborative research that transcends traditional disciplinary boundaries" (www.nsf.gov/pubsys/ods/getpub.cfm?nsf04550). Programs of this nature generally offer integrated, research-based graduate education and training activities in emerging areas of science and engineering. Projects usually are organized around an interdisciplinary theme involving a diverse group of faculty members, graduate students, and postdoctoral fellows with appropriate expertise in research and teaching. The interdisciplinary theme provides a framework for integrating research and education and for promoting collaborative efforts within and across departments and institutions. Students in such programs gain the breadth of skills, strengths, and understanding to work in an interdisciplinary environment while being well grounded with depth of knowledge in at least one major field or discipline.

Calls for education research training programs that embody such interdisciplinary approaches have been heard for some years (e.g. Schoenfeld, 1999), and successful examples of such programs already exist. A pioneering effort at interdisciplinary graduate training in education began at the School of Education of the University of California, Berkeley, with the development, under Alan Schoenfeld's leadership, of the Education in Mathematics, Science and Technology (EMST) program. A number of guiding "assertions" defined the development of student researchers in this program (Schoenfeld, 1999). First, Schoenfeld argued, researchers need to guard against the dangers of narrow compartmentalization, but they must also avoid superficiality. Second, researchers must gain a deep understanding of the nature of evidence and truth-claims, and learn how to identify and frame meaningful problems. Third, core courses should engage beginning researchers with major education issues and provide opportunities for students to gain differing perspectives on these issues and become proficient in a wide range of methods for addressing them. And fourth, students should have opportunities to engage in research and become steeped in research culture as early as possible in their careers.

Through its early success in these efforts, EMST served as a model for other programs, such as those at Northwestern University and the University of Colorado, Boulder. Some two-thirds of the faculty members in Northwestern University's School of Education and Social Policy have backgrounds in disciplines other than education, and the school prides itself on a doctoral program that is highly interdisciplinary (Viadero, 2004). In the Institute of Cognitive Science (ICS) at the University of Colorado, Boulder, doctoral students specialize in a "home department," such as Education, Computer Science, or Linguistics, and conduct interdisciplinary work in other research areas. The program consists of course requirements, a practicum, and selection of a dissertation topic that represent the interdisciplinary nature of cognitive science. A doctoral student in a joint ICS/education program, for example, might take ICS courses such as Issues and Methods in Cognitive Science; Readings and Research in Cognitive Science; Psychology (or Educational Psychology) courses such as Human Learning and Advanced Growth and Development; and education courses such as Research on Teaching. Other courses, such as in linguistics or neuroscience, can be added depending on a student's interests and needs. Research experience begins in the student's first year with a research practicum, followed by dissertation research with a faculty member in an interdisciplinary research area or through one of several related research centers, e.g., the Center for Lifelong Learning and Design or the Center for Spoken Language Research. (For further details, see www.colorado.edu/prospective/graduate/academics/artsscience/cog-science.html.) Programs such as these illustrate that interdisciplinary training is possible and already well developed in some cases. But they only hint at the many disciplines that could collaborate in the study of topics of current interest in education.

Designing Doctoral Training Programs in Education Research

In our view, it is unlikely that a single graduate program could cover well all five of the broad areas that we listed at the beginning of this section. Given the characteristics of the field, the students, and the resources in education, as well as the need for more and stronger education researchers, it is likely that schools and colleges of education will choose one or two emphases from among the five areas. In the next section we will propose a four-part program for improving the training of education researchers in the norms of interdisciplinary scientific inquiry.

Because we place great emphasis on early research experience and an interdisciplinary orientation, we suggest first that the Ph.D. program in education research be separated from (but include parts of) the doctoral training for practice-oriented educational leadership. In theory, separate degree programs already exist on some campuses in the distinction between the Education Ph.D. (research oriented) and the Ed.D. (practice oriented), the latter emphasizing "craft" knowledge (Hiebert et al., 2002). But recent reviews of these programs suggest that there is often little difference between the two (Carnegie Foundation, 2003). Though no panacea, a separate research-intensive Ph.D. program such as that described below opens possibilities for improving the preparation of education researchers.

Before proceeding, we must note that there are pertinent arguments *against* separate doctoral training programs in education. One is that true expertise in education requires substantial familiarity with both research and practice: Education experts need to understand the constraints of research and the complexities of practice (Labaree, 2003; Richardson, 2003). Labaree, for example, argues that doctoral preparation of education researchers should be designed to narrow the cultural divide between teachers and researchers. He calls for the construction of a "hybrid program that marries theory and practice, as is only appropriate for research preparation in a professional school; instead of pushing teachers to drop practice for a new career in theory, it would seek to induct them into a practice of research that draws heavily upon knowledge from the practice of teaching while simultaneously informing that practice" (p. 21).

Another argument against separate Ph.D. and Ed.D. programs is the historically low status of the Ed.D. degree. As a result, some believe that all education doctoral candidates should get a Ph.D.[7] to mark the rigor of the program. Whatever the reason, recent reviews of doctoral training in education (Carnegie Foundation, 2003; Labaree, 2003; Richardson, 2003; Viadero, 2004) suggest that most of the field has implicitly accepted the value of a unified doctoral degree that offers the same (or very similar) training for both rising researchers and administrators/practitioners.

Although we appreciate these arguments, we think that the model of separate doctoral programs for researchers and practitioners, as practiced, for example in the health sciences, is worth re-considering in education. As many readers will know, poorly trained doctors with low reputations were a serious social problem at the beginning of the 20th century. The Carnegie-commissioned Flexner Report (1910) is generally credited with substantially improving the quality and reputation of medicine by insisting that training programs meet higher standards.[8] Abraham Flexner had been a high school teacher, educated at Johns Hopkins University, master of his own private school; later in his career, he became the first director of the Institute for Advanced Studies at Princeton University. Recognized for a 1908 critique of higher education in the United States (*The American College*), he was commissioned by Henry Pritchett of the Carnegie Foundation for the Advancement of Teaching to survey 155 medical schools in North America. The most important contribution of the Flexner Report (1910) was to define standards for a university-connected, scientifically based medical school program; one that sought to integrate hands-on laboratory and clinical experiences based on a rigorous knowledge of the basic sciences with closely supervised work with patients. Science, Flexner said, provided a continuous source of new knowledge and skills that could and should inform medical education. Although there were substantial commonalities between what medical practitioners and medical research scientists needed to know, Flexner saw that there were also differences. Clinicians needed a general investigative disposition or "habit of mind" that promoted a problem-solving attitude toward disease states, whereas researchers needed deeper theoretical and methodological expertise. Clinicians needed case experience; researchers needed laboratory experience. Thus Flexner advocated clinical training in medical school culminating in the M.D. and research training in the university leading to the Ph.D.

Other health educators have voiced similar concerns about the relations between research and clinical practice. Spurred by the need to fill large numbers of new faculty positions in the nation's nursing schools, the American Association of Colleges of Nursing (AACN) has begun discussions of the desired qualities of special research-focused doctoral programs in nursing. Although research-oriented Ph.D. programs in nursing have existed since the 1970s (Stevenson & Woods, 1986), in response to an impending shortage of faculty with doctoral degrees, the AACN appointed a task force in 1999 to revise the quality indicators for doctoral programs and to address differences among the Ph.D., D.N.S. (Doctor of Nursing Sciences) and N.D. (Nursing Doctorate) degrees. According to a recent white paper (AACN, 2001), a research-focused doctoral program in nursing must, among other requirements, train graduates who are able to "conceptualize and implement productive programs of research and scholarship that . . . are at the cutting edge of the field of inquiry . . . and can attract and engage students." Courses for students of such programs should include "(a) historical and philosophical foundations to the development of nursing knowledge; (b) existing and evolving substantive [clinical] nursing knowledge; (c) methods and process of theory/knowledge development; (d) research methods and scholarship appropriate to inquiry; and (e) development related to roles in academic, research, practice, or policy environments" (http://www.aacn.nche.edu/publications/positions/qualityindicators.htm).

The merits of separate research and professional degrees have also been a subject of continuing debate in many fields of higher education outside the health sciences (e.g. Sarason, 1993). In an early statement, the Council of Graduate Schools (CGS) took the position that "the professional doctor's degree (M.D., J.D., etc.) should be the highest university award given in a particular field in recognition of completion of academic preparation for professional practice, whereas the Ph.D. should be given in recognition of preparation for research, whether the particular field of learning is pure or applied" (CGS, 1966, p. 3). In the late 1980s, the National Board for Professional Teaching Standards was established "to improve teaching by establishing uniform teaching criteria and assessment methods for gauging how well standards are met" in order "to do for teaching what the Carnegie Corporation did for medical standards and prestige through the Flexner Report" (Baratz-Snowden, 1992). With similar intent, Lagemann calls for a transformation of schools of education into "the educational equivalent of teaching hospitals" (2003, p. 12) designed to combine professional education, research, and educational services. With Lagemann, we would stress the importance of the interaction between aspiring education researchers and practitioners. Certainly, researchers must be attuned to the conditions and issues of practice (Labaree, 2003; *SRE*), a position also taken by Flexner (p. 59). And just as certainly, practitioners need to be familiar with the strengths and limitations of research. But we would like to reemphasize a conclusion that was reached by the *SRE* committee about the difficulties of attempting to offer graduate training for scholars in education: "The breadth and depth of topical areas as well as multiple epistemological and methodological frameworks are nearly impossible to cover adequately in a single degree program" (*SRE*, p. 93). Although we are conscious of the tension generated by the need to provide education students with both breadth and depth of knowledge—a problem shared with other research fields (Breslow, 2003; Hyman, 2003; Stacy, 2003)—we have tried to strike a balance in what follows.

We briefly outline below a proposal for strengthening the doctoral training leading to the Ph.D., with an emphasis on scientific norms of inquiry and interdisciplinarity—an emphasis that we believe is consistent with calls for more scientifically based research in education. We do not feel qualified to develop a similar outline for an advanced practitioner/administrator professional program or for other types of education research that do not aim to be "scientific" in the way that we define it here. We hope that others will take up these challenges.

Outline for a Doctoral Program in Scientifically Based Education Research

Doctoral training for education research expertise (i.e., Ph.D. programs) must be both broad and deep. To that end, we propose the following general outline:

1. *Core courses.* Courses in subjects traditional for education programs, as well as in relevant interdisciplinary areas such as neuroscience, sociology of science, and linguistics, should be required for all entering doctoral students; these courses must be scholarly, rigorous, and intense enough to bear the burden of familiarizing students with the orienting concepts in each field, the culture of scientific inquiry, and the special demands of research in education.
2. *Research experience.* Doctoral students should have at least two kinds of training experience with a research project under the guidance of a faculty member. First, with close monitoring and support, students should be given the opportunity to engage in all phases of an investigation, from identifying a research problem to research design, to data collection and analysis, to communication of the results. Second, students should have the experience of pursuing a significant line of research on their own (under the supervision of one or more faculty members), and completing a report about it in the form of a technical report, a dissertation, a reviewed grant application, or a series of articles. This research experience should be of sufficient depth and duration to bring the student to a reasonable level of expertise in at least one disciplinary domain and should require exposure to related research perspectives and methodologies in at least one other discipline.
3. *Teaching experience.* Doctoral students should gain a solid grounding in education practice or policy through required experiences such as teaching in a K–12 classroom, interning for a state education agency, or taking courses with teacher-practitioners, possibly through a series of practice-oriented rotations.
4. *Interdisciplinary collaborations.* In addition to interdisciplinary courses and seminars, opportunities should be provided for doctoral students to build networks with students and researchers in other departments where studies relevant to education are being conducted.

To initiate the changes necessary for the development of a strong cadre of scientifically based education researchers, schools and colleges of education will need to receive additional institutional support. We challenge federal, state, and private funding agencies to provide greater funding for intensive and sustained graduate training programs in scientifically based education research. Given the important role that research on education should play in informing educational policymaking and practice, and given the challenges faced by the field, graduate training programs in scientifically based education research should be supported at a level comparable to that in other sciences.

Conclusion

Extending the discussions that produced *Scientific Research in Education*, we have argued that support for "scientifically based research" in education—broadly construed—is important and justified. But we have also noted that training programs for doctoral students in scientifically based education research must take advantage of the opportunities and challenges presented by emerging scientific research across disciplines—exciting research that bears directly on educational phenomena. We have suggested that current models of graduate research training that are restricted in focus to a single discipline are not adequate for the kind of preparation that scientifically based education researchers need. We have made a number of recommendations for strengthening graduate programs accordingly, with the aim of producing graduates who have a high degree of expertise and research skill in at least one area of educational investigation and a broad background of familiarity with the greater expanse of education-related research. We hope that this article and others like it will spur conversations, debates, and actions that lead to a reinvigoration and broadening of doctoral programs in education research.

NOTES

[1] All of the views expressed in this article are ours alone. They are not authorized by the NRC or by other members of the NRC committees on which we have served.

[2] We are well aware (e.g. Eisenhart, 2005) that our conception of scientifically based research is considered incomplete or is opposed, in part or in whole, by many who study education from interpretivist, critical, postmodern, or other perspectives (e.g., Erickson, 2005; Erickson & Gutierrez, 2002; Howe, 2004; Kezar & Talburt, 2004; Lather, 2003; Moss, 2005; St. Pierre, 2002; Willinsky, 2001, 2005). This article is not the place to engage their arguments in detail, but it is our hope that our ideas will stimulate such writers to propose their own justifications and alternatives for doctoral training in education.

[3] Throughout this article we use the term "natural science" (meaning "the science of nature") to refer to physics, chemistry, biology, and geoscience. This suggests the unfortunate implication (which we certainly do not accept) that the social sciences are somehow unnatural. To avoid this dilemma, we occasionally use "physical and biological sciences." In this case, "physical" refers to physics, chemistry, and geoscience.

[4] Opposition to this view of scientific inquiry also has deep roots (see references in note 2).

[5] In addition to noting the distinction between the intentionality of objects of study (e.g., of the people who participate in a study) and the intentionality of the researchers who study them, our point here (with Latour and Woolgar) is that natural scientists—although they may study atoms rather than people and need not concern themselves with intentionality of atoms—can no longer ignore the role of intentionality in their own research.

[6] We recognize that not all graduate programs in education research attract large numbers of former classroom teachers. However, our experiences at Virginia Tech, the University of Colorado, and Emory University and our knowledge of the education programs participating in the Carnegie Initiative on the Doctorate suggest that very often they do.

[7] Some research universities, such as Harvard, do not offer a Ph.D. in education, for historical and economic reasons; yet the requirements for their Ed.D. degree are virtually the same as those for the Ph.D. at the institutions offering them.

[8] But see Lagemann (2003), who argues that efforts to reform medical training were under way before Flexner's study and report.

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AUTHORS

MARGARET EISENHART is University Distinguished Professor and Bob and Judy Charles Professor of Education in the School of Education, University of Colorado, Boulder, 249 UCB, Boulder, CO 80309-0249; margaret.eisenhart@colorado.edu. Her research interests include educational anthropology, ethnographic research methods, women's studies, and women in science.

ROBERT L. DEHAAN is Senior Science Advisor, Division of Educational Studies, and Candler Professor of Cell Biology, Emeritus, at Emory University, North Decatur Building, Room 254, 1784 N. Decatur Road, Atlanta, GA 30322; rdehaan@emory.edu. During some of the writing of this paper, DeHaan was Director of the Committee on Undergraduate Science Education at the National Research Council, Center for Education. His current research interests include K–12 and undergraduate science education, educational research, analytical reasoning, and education to promote innovation.

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