Philosophy of Science Series: Harnessing the Multidisciplinary Edge Effect by Exploring Paradigms, Ontologies, Epistemologies, Axiologies, and Methodologies

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Abstract

Health professions education (HPE) researchers come from many different academic traditions, from psychology to engineering to rhetoric. Trained in these traditions, HPE researchers engage in science and the building of new knowledge from different paradigmatic orientations. Collaborating across these traditions is particularly generative, a phenomenon the authors call *the multidisciplinary edge effect*.

However, to harness this productivity, scholars need to understand their own paradigms and those of others so that collaboration can flourish. This Invited Commentary introduces the Philosophy of Science series—a collection of articles that introduce readers to 7 different paradigms that are frequently used in HPE research or that the authors suggest will be increasingly common in future studies. Each article in the collection

presents a concise and accessible description of the main principles of a paradigm so that researchers can quickly grasp how these traditions differ from each other. In this introductory article, the authors define and illustrate key terms that are essential to understanding these traditions (i.e., paradigm, ontology, epistemology, methodology, and axiology) and explain the structure that each article in this series follows.

Editor's Note: This article is part of a collection of Invited Commentaries exploring the Philosophy of Science.

In ecology, *the edge effect* refers to characteristics observed when the boundaries of 2 different habitats meet (e.g., when forests meet rocky outcrops).[1] When the edges of ecosystems intersect, a greater biodiversity exists.[2] In other words, there is more life in the spaces where different habitats meet. Similar generative properties manifest in

scientific research when scholars from diverse academic domains (i.e., different research habitats) engage in multidisciplinary collaboration.[3–5] We label this productivity and effectiveness the *multidisciplinary edge effect.*

To harness the multidisciplinary edge effect, we must first understand how each researcher builds knowledge from within a particular tradition. This tradition, typically adopted from the scholar's home discipline,[2] embraces assumptions that shape the way researchers engage in science.

For instance, a neurologist will likely engage in science from a biomedical perspective. From within this tradition, the neurologist learned that the human nervous system is a tangible structure that can be objectively observed and measured. There is an understanding of the nervous system that neurologists and other scientists (e.g., anatomists) developed, tested, and adopted (including, for example, the idea that there is a central nervous system and a peripheral nervous system). To collect data about how an individual patient's nervous system aligns with or deviates from the norm, a neurologist will use a variety of tested and validated tools and techniques including, for example, conducting a physical exam (e.g., observing the patient's coordination and reflexes) and running diagnostic tests (e.g., magnetic resonance imaging and electromyography). With these data, the neurologist can diagnose a patient and

recommend a course of treatment derived from evidence-based guidelines and best practices.

In contrast, a sociologist will embrace a different conceptualization of science, and so will engage in research using an approach that is different from the neurologist's. Instead of the biomedical tradition, the sociologist likely trained to engage in scientific research from a sociological perspective. Within this tradition, the sociologist learned to examine the interactions between individuals and the social structures that surround them. There is no objectively correct or true conceptualization of these interactions; instead, there are multiple competing conceptualizations. Some emphasize individuals' subjective experiences and so conceive of social structures as the products of the interactions of individuals (i.e., symbolic interactionism[6]). Others emphasize mutual influence, arguing that individuals are shaped by, but also simultaneously shape, social structures (i.e., Giddens's theory of structuration[7]). To understand human behavior, sociologists might collect some objective data (e.g., nonparticipant observations of an individual's actions) but will also rely heavily on subjective data (e.g., interviews with individuals to understand their lived experiences). With these data, the sociologist can offer one interpretation or explanation of why individuals and/or social structures exist and act as they do.

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Clearly, the neurologist's and the sociologist's ideas about and approaches to research are based in different traditions. They each work from a different *philosophy of science*—that is, they each hold dissimilar foundational conceptions, values, and practices for engaging in research. *One tradition is not necessarily better than another; they are simply different.* Each tradition offers a specific way of looking at the world, at the work of building knowledge, and at the appropriate methodologies to use to engage in research.

Health professions education (HPE) research is a domain where scholars working from different research traditions, like the neurologist and the sociologist, regularly collaborate.[8–10] HPE scholars come from a wide range of academic disciplines—from medicine to anthropology, from nursing to engineering, from occupational therapy to rhetoric. When researchers from these different domains engage in HPE's collaborative research, they bring together disparate philosophies of science to wrestle with the complex phenomena that are the foundation of education for the health professions. These collaborating researchers bring together ways of thinking about and of engaging in research that reflect dissimilar, sometimes even conflicting, understandings of what legitimate knowledge looks like, what we can know about a phenomenon, and the best ways of developing new knowledge. In HPE, working across these divides has consistently been regarded as productive and generative.[8,10,11] The work of understanding another researcher's tradition and of explaining one's own enables a deep and robust study of a particular HPE-related phenomenon, enabling the multidisciplinary edge effect to be realized. But nobody has suggested that such work is easily accomplished.

For HPE's multidisciplinary collaborations to happen, researchers need to articulate their reasoning, theories, and values so that their scientific *paradigms* can interface. A scientific paradigm was defined by Kuhn as "the set of common beliefs and agreements shared between scientists about how problems should be understood and addressed."[12] A paradigm consists of the concepts, practices, and language that define a particular approach to science.

The neurologist and the sociologist might decide to collaborate to better understand competency-based learning. To engage in a productive collaboration, these HPE researchers need to develop an appreciation for and comprehension of their different paradigms. In other words, the neurologist and the sociologist must understand that they each hold different perceptions of the nature of reality, of the nature of knowledge, the ways in which individuals can engage in research, and the values underpinning all of these.

Understanding the various paradigms represented in HPE's multidisciplinary research is a daunting task. As researchers, we do not often reflect on the strengths and weaknesses of our paradigms, and rarely are we explicitly taught the value of alternate research paradigms. Multidisciplinary collaboration requires clinician–educators and HPE research scientists to "jettison the security of familiar tools, ideas and specialties"[13] and to wrestle intellectually with the basic belief systems of other domains.

It is precisely this grappling work that this series of Invited Commentaries on the Philosophy of Science is designed to support. There are few resources available that accurately but accessibly explain the paradigmatic differences behind various disciplinary practices. Therefore, we developed this series of articles as a collection of primers, each offering an introduction to the research paradigms reflected in HPE's multidisciplinary collaborations. Each manuscript presents a concise and accessible description of the main principles of a paradigm so that researchers can quickly grasp how these traditions differ from each other. The paradigms addressed in this series are: *positivism,*[14] *postpositivism,*[15] *critical theory,*[16] *constructionism,*[17] *sociomaterialism,*[18] *postmodernism,*[19] and

Table 1

Illustration of How Different Research Paradigms Shape Examinations of Competency-Based Medical Education (CBME) Through the Elements of Ontology, Epistemology, Methodology, and Axiology

Element of a paradigm	Questions this element asks	Illustration of how each element can be applied to CBME
Ontology	What is real? What is the nature of reality?	What is competence? • Is competence a single state of being or does it comprise multiple competencies? • Is competence a fixed, nonchanging concept? Or, are we constantly renegotiating and interpreting the meaning and status of competence? • Is an individual's competence fixed, in flux, or context dependent?
Epistemology	How do we know what is real? What is the nature of knowledge?	How can we know if someone is competent? • What is the underlying meaning of competence? • Are there multiple ways of determining competence? • Is competence a social construct? • Is competence objectively observable? Measureable?
Methodology	How do we come to know what is real? How do we build knowledge?	What procedures can we use to determine competence? • Is competence best explored through experimental design, standardized testing, or surveys? • Is competence best explored through in-depth exploratory methodologies like ethnography, phenomenology, or discourse analysis? • Perhaps we require a mixed-method approach to fully understand competence.
Axiology	What are the values underpinning all of the above?	Which value system are we supporting in espousing a particular definition of "competence"? • Are we centering a clinician's perspective of competence at the expense of patient perspectives? • What values does this inquiry advance, and what values does it diminish? • What value does the inquiry have to different stakeholders and consumers?

realism.[20] This is not an exhaustive list of all the paradigms of science; instead, it includes the paradigms that are often used in HPE research and those that we believe will increasingly be part of our community's interdisciplinary collaborations. We also include an article[21] that explains how the terms *theory, theoretical framework*, and *conceptual framework* can be defined and applied in different ways across different approaches to science.

These articles should not be interpreted as full, definitive, comprehensive descriptions of each paradigm; instead, each offers a starting point for considering what it means to engage in research within a particular paradigm.

Each article provides an overview of the main concepts and research traditions associated with an individual paradigm. Following the approach set out by Guba,[22] each article in this series addresses 3 questions that are central to understanding a paradigm:

1. **What is the nature of *reality?* What is the nature of *being?*[22]** The answers to these questions articulate the *ontology* of the paradigm. While it may seem much too abstract to be of use in HPE, ontology is the foundational building block of science. These questions require us to reflect on the assumptions we hold about reality.

2. **What is the relationship between the *knower* (i.e., the scientist, the inquirer) and the *known* (i.e., reality, that which is *knowable*)?[22]** The answers to these questions articulate the *epistemology* of the paradigm. Epistemology builds on ontology by putting the nature of reality into practice for developing knowledge. It requires us to reflect on how researchers should engage in inquiry to develop knowledge that will be considered legitimate and valuable. For example, should the researcher assume the position of a detached observer of an objective reality or should the researcher recognize him- or herself as a participant of reality and assume an insider perspective?

3. **How should the researcher go about finding out knowledge?[22] What is the nature of the research approach that will enable the scholar to develop new knowledge?[23]** These answers articulate the *methodology* of the paradigm.

Box 1
Sample Case[a]

Lee was a resident assigned to monitor a postop patient. The patient had a periodically low respiratory rate and lower-than-normal pulse and blood pressure. Narcan was ordered on an "as needed" basis, to be given in doses of 0.2 mg intravenously. In checking the patient's vitals, Lee decided it was time to administer an intravenous (IV) dose of Narcan.

Once Lee injected the vial of Narcan into the IV port, Lee noticed it was labeled "2 milligrams per 1 milliliter (ml)"—the entire vial should not have been injected. Feeling panicky, Lee reported the mistake to an attending and rushed back to the patient's side to monitor the vital signs. Lee was surprised to find that the patient's vitals had come up to normal rates, and the patient was actually much more alert. When Lee reported this change to the attending surgeon and anesthesiologist, they told Lee to continue to monitor the patient closely, remarking that it may have been just what the patient needed.

Lee felt hugely relieved, but was still overwhelmed and very upset. In most cases, giving 10 times a normal dose of any medication could have led to extremely serious consequences and even death. Still, Lee managed to remain outwardly composed and took the time to complete an incident report. At the end of the day, when Lee finally sat down to rest, the incident played over and over again. Lee did not sleep.

[a]This sample case is used throughout the Philosophy of Science Invited Commentaries to illustrate each research paradigm.

Methodology is a set of guidelines and principles that put an epistemology and an ontology into action in a given research project. When properly aligned, a study's methodology constructs data that are considered valid and support drawing reasonable conclusions within a given paradigm. Methodology generates knowledge reflective of the ontological and epistemological foundations of the paradigm.

Each article in the series also addresses an additional question suggested by Heron and Reason,[24] not part of Guba's triumvirate:

4. **What are the *values* and/or *value judgments* that shape this research approach?[25]** These answers articulate the *axiology* of the paradigm. They force us to consider why and how specific kinds of research came to be valued and deemed worthwhile.

To illustrate these terms, consider the concept of *competence*, which is at the forefront of many medical educators' minds given the recent focus on competency-based approaches to medical education. A range of ontologies, epistemologies, methodologies, and axiologies characterize the more than 4,500 articles addressing competency-based medical education published in our field since the late 1960s. We can see a variety of perspectives on what competence is, a breadth of ideas about how to study it, subtle differences in the way scholars describe and investigate it, a temporal evolution of the concept from the 1960s to now, and a range of questions about its underlying values and effects (see Table 1). These questions demonstrate the breadth of assumptions that underpin different philosophies of science.

Following the ontology/epistemology/methodology/axiology structure, each article in the series offers definitions of key terms related to the paradigm in question and illustrates how the paradigm shapes research by applying it to the same fictional case scenario (see Box 1). Since all articles in the series address the same scenario, readers will see how scholars working from different paradigms can approach the same topic of research in different ways.

Researchers who wish to work in new paradigms can review these primers to understand the foundational premises that determine what research is and how it should be practiced in each paradigm.[22] We hope that the Philosophy of Science series will help researchers collaborate across the many paradigms present in HPE and so reap the benefits of the multidisciplinary edge effect.

In conclusion, we contend that harnessing the productivity of the multidisciplinary edge effect requires HPE researchers to be paradigmatically nimble. We offer this series of Invited Commentaries on the Philosophy of Science as a means of helping scholars develop this agility.

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