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The Interdisciplinary Research Process

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Introduction

This book provides case studies of the performance of interdisciplinary research. It is hoped that these case studies will prove instructive both to students and other scholars as they perform interdisciplinary research. This introductory chapter does not provide a detailed overview of these case studies: Brief descriptions of each chapter are provided in the Preface, and a discussion of lessons learned and questions raised is provided in the concluding chapter. Rather, this chapter engages some broad questions regarding the very possibility of identifying superior strategies for performing interdisciplinary research. In doing so, it provides the rationale for the case studies that follow: It is both feasible and desirable to identify interdisciplinary best practices.

Is there a best way of doing interdisciplinary research? If so, what is it? Do practicing interdisciplinarians across different fields seem to follow some set of universal practices or strategies? These broad questions drive this chapter. The first section addresses a set of epistemological and practical questions regarding the possibility and advisability of an “interdisciplinary research process.” The second reviews efforts to develop such a process. In particular, it discusses the process outlined in Repko (2008)—in which the chapters in this book are grounded—and how this relates to other suggestions in the scholarly literature regarding an interdisciplinary research process. As various characteristics of the interdisciplinary research process are identified, later chapters that particularly exemplify them are noted.

Should Interdisciplinarians Identify Such a Process?

This section opens with a set of epistemological queries that have been raised regarding the feasibility and desirability of an interdisciplinary research

process: Does the structure inherent in such a process interfere with the freedom of interdisciplinarians to follow their curiosity? Should interdisciplinarians mimic disciplinary research practice? And is interdisciplinary research inherently revolutionary? It then moves toward more practical concerns: Would an interdisciplinary research process improve the practice of interdisciplinarity (in teaching as well as research) and perhaps even enhance the pursuit of quality interdisciplinarity within the academy?

Structure Versus Freedom

One of the main attractions of interdisciplinary research is that it allows researchers freedom from disciplinary constraints. Disciplines take their strength from a shared perspective that includes many elements: a shared set of topics that are addressed, a shared but limited set of theories and methods that are applied to them (and often a shared set of assumptions about how they are to be applied), a shared set of epistemological assumptions regarding what can be known and how, often shared ethical assumptions about what is “good,” and often shared ideological attitudes. It is these areas of agreement that allow specialized research to proceed so easily: Writers need not explain their theory or method or subject matter *unless they deviate in some way from what is expected*. These expectations are institutionalized in the discipline’s publication, hiring, and promotion decisions. Interdisciplinarians may (or may not) respect the power of specialized research but are always conscious that it has powerful disadvantages. The strong incentive to obey disciplinary preferences regarding theory, method, and subject matter means that disciplinarians *necessarily* ignore competing theories or methods, and they also ignore related phenomena that might cast an important light on the issues addressed by the discipline. Likewise, the very set of issues that are addressed may be arbitrarily curtailed due to theoretical or methodological preferences—as when economists turned away from the study of economic growth for decades because they lacked a compelling mathematical model of growth.

Interdisciplinarity, then, must embrace a freedom to explore *any* theory or method or phenomenon that the researcher(s) think appropriate to the question being asked. This might be proclaimed to be the basic nonnegotiable principle of interdisciplinary research. Because the best-known research methodologies in the Academy are those disciplinary methodologies that succeed only by limiting freedom, some interdisciplinarians naturally fear that any proposed “interdisciplinary research process” would inevitably also limit the freedom of interdisciplinarians. If so, interdisciplinarity could not fulfill its function as the antidote to restrictive disciplinary perspectives.

In the second section, then, it is important to hold any proposed interdisciplinary process to very high standards of academic freedom. A process that would limit interdisciplinarians in the same way that disciplinary methodologies limit disciplinarians would defeat the very purpose of interdisciplinarity.

The Role of Shared Methodologies

The idea of an interdisciplinary research process naturally reminds one of disciplinary methodologies. It would be undesirable to discipline interdisciplinarity in this way. Yet it can, at the same time, be appreciated that much of the strength of disciplines comes from these shared methodologies (and much of the rest comes from the way these are instantiated in disciplinary reward structures).

Do shared methodologies enhance the productivity of research? As noted above, they enhance communication within disciplines (while unfortunately limiting communication across disciplines). Researchers can easily explain to another member of their discipline what minor novelty they are attempting to introduce into the shared research agenda. Many scholars will find it both comforting and straightforward to follow a recommended research trajectory. It may be thought that those attracted to the academic life will be those who are determined to chart their own path. However, the scholarly requirement to add something new to the body of human understanding is not easily achieved, and many scholars find it professionally rewarding to follow what others do.

Disciplinary standards are closely allied to disciplinary methodologies. Economists are expected to use mathematical models and/or statistical analysis. Naturally, economists are then judged on their mastery and application of sophisticated mathematical techniques (which is easier to evaluate than their understanding of the economy itself). Should interdisciplinarians aspire to interdisciplinary standards? One of the problems faced by interdisciplinary teaching programs is a claim that interdisciplinarity infuses the Academy, and thus special interdisciplinary programs are no longer needed (Augsburg & Henry, 2009). Interdisciplinary research programs could face a similar critique. The best rejoinder would be to claim that one is doing a better form of interdisciplinarity. It is all too easy, after all, to do superficial “interdisciplinarity”: to read one book in sociology and repeat its insights with no understanding of how that book rests within the wider discipline. Disciplinarians, with their formalized (but disciplining) standards, can all too readily identify examples of superficial interdisciplinarity and then claim that interdisciplinarity is inherently inferior. Still, some interdisciplinarians may hesitate to proclaim standards precisely because they do not wish to limit freedom. A question to ask in the second section of this chapter is whether an interdisciplinary research process can support both standards and freedom.

Revolutionary Versus Normal Science

Thomas Kuhn famously argued in the 1960s that scientific understanding does not advance entirely through a gradual process of accretion of new bits of understanding, but rather that the history of science is punctuated by occasional revolutions during which some of the previous understandings are

replaced by quite novel understandings. The Kuhnian distinction between revolutionary and normal science was undoubtedly overdrawn and has now been supplanted in the study of science by more recent debates. These decades of discussion will not be reviewed here. However, the Kuhnian distinction has useful implications for the present discussion. Scholars closely following disciplinary methodologies would clearly fall within the “normal science” category. Interdisciplinary scholars are more likely to celebrate grand new syntheses that set scholars on entirely new research trajectories: These would qualify as “revolutionary science.” And scholars of scientific discovery note that such revolutionary insights tend to come from connecting ideas from different disciplines (Root-Bernstein, 1989). Is interdisciplinary research inherently revolutionary (as suggested by Pohl, van Kerkhoff, Hirsch Hadorn, & Bammer, 2008, p. 413)? If so, then an interdisciplinary research process might be less useful. Of course, even revolutionary insights come only to the prepared mind, and thus there may well be strategies scholars can follow in order to increase their chances of achieving revolutionary insights. If, though, interdisciplinarity can proceed as normal science, then some sort of shared process may be much more important.

For Kuhn, revolutionary science was exceptional; the vast bulk of scholars produced normal science. Scholars in the humanities might imagine that revolution is more likely in their realm. Still, unless the phrase is stripped of its intended meaning, revolutionary scholarship—that which truly breaks free from preceding theories and methodologies—must be rare. To identify interdisciplinarity with revolution is then to suggest that only a very small minority of scholars can be interdisciplinary. If interdisciplinary scholarship is to be established within the Academy, then it is necessary either to identify some third form of scholarship between normal and revolutionary or to identify how interdisciplinary scholars can slowly and gradually build upon the work of other interdisciplinary scholars.

Disciplines concur in having a guiding methodology but differ in the precise nature of that guiding methodology. Perhaps the answer for interdisciplinarity is likewise for different groups of interdisciplinary scholars to coalesce around quite different research agendas. There need be no common elements among these. Yet, it is noteworthy that there are common elements of disciplinary methodologies: Disciplines (among other things) accept only a minority of the theories and methods they might embrace and apply these to a subset of the (relationships among) phenomena that they might study. Should there also be common elements among interdisciplinary methodologies? And should these, then, be quite different from the common elements of disciplinary methodologies? In particular, should interdisciplinary methodologies be more open in terms of theory, method, and phenomena than are disciplinary methodologies? If so, is it possible to structure normal science around such openness? Many interdisciplinary scholars, especially in natural science, have argued that this is possible. This set of related questions should inform much of what is done in the second section of this chapter.

The case studies performed in this book can be seen as normal science. Authors follow a logical research strategy. Yet, this process does not at all restrain them from displaying creativity, nor from reaching novel conclusions. As Newell discusses in the concluding chapter, the authors of these case studies clearly saw themselves as contributing to an ongoing conversation.

Interdisciplinarity and Training

At this moment in the history of the Academy, most scholars who would define themselves as interdisciplinary simply “do” interdisciplinarity. They have not taken courses on how to do interdisciplinarity. They may not have ever read an article or book focused on how to do interdisciplinarity. Importantly, they may never have reflected very much on what it means to be interdisciplinary.

The analogy with university teaching is too tempting. Most scholars were never taught how to teach. They just go out and do it. And most do it very well. Or at least most appear to do it very well, given that the standards by which university teaching is judged have evolved in a world where university teachers are not expected to reflect much on the nature of their teaching. Even at that, most universities in the developed world have established some sort of bureaucracy designed to help scholars teach. Increasingly, scholars do take courses on how to teach. At many universities, graduate students are now expected, even required, to take such courses. The age of the untrained university teacher may thus be slowly drawing to a close. Should the age of the untrained interdisciplinarian be far behind?

Disciplinarians are not generally taught their disciplinary perspective explicitly. Yet, the fact that they are taught just one or two types of theory and one or two methods provides a solid introduction to that disciplinary perspective. Interdisciplinarians lack even this introduction. Most practicing interdisciplinarians received disciplinary PhDs. Even those with PhDs from interdisciplinary programs will rarely have experienced course material about interdisciplinarity: maybe about the nature of some interdisciplinary theme (such as environmental studies, gender studies, or cognitive science) but not about interdisciplinarity itself. As with university teaching, one can look at the glass half full and say “this works” or look at the glass half empty and wonder whether it might work much better if interdisciplinarians reflected on the nature and purpose of interdisciplinarity and asked how interdisciplinary analysis might best be performed.

Strategic Interdisciplinarity

The place of interdisciplinarity within the Academy is still contested. To be sure, almost every university president extols the value of interdisciplinarity—at least as long as granting agencies continue to do so. However, longstanding

interdisciplinary programs have been cut at several institutions. As noted above, these cuts are often justified by claiming that interdisciplinarity now infuses the Academy. Among the many lessons drawn in Augsburg and Henry (2009) are that interdisciplinarians need to integrate their efforts with those of disciplinarians, and interdisciplinarians need to distinguish quality interdisciplinarity from superficial interdisciplinarity. An interdisciplinary research process might support quality interdisciplinarity within the Academy if it had two characteristics: standards such that superficial interdisciplinarity could be distinguished from quality interdisciplinarity, and a symbiotic relationship between interdisciplinary research and specialized research.

The last point—and the careful way it was worded—deserves further treatment. Interdisciplinarians differ in the way they view disciplines. Some see disciplines as the strong base from which interdisciplinary analysis proceeds. Others see disciplines as a problem to be overcome. Few, though, would doubt that specialized research—in which some group of scholars collectively applies a particular theory and method to a particular problem—will and should always have a place in the Academy. Interdisciplinarians can debate (or not) the ideal institutional structure for both specialized and interdisciplinary research. The point here is that a process for interdisciplinary research should specify how it draws upon (and, ideally, informs) specialized research.

It is sometimes suggested that students can only master interdisciplinarity after obtaining a solid grounding in one or two disciplines. The sense that interdisciplinarity is an optional add-on to a disciplinary education poses an obvious threat to at least undergraduate interdisciplinary programs. If it were accepted that there is an interdisciplinary research process, and that this is complementary to disciplinary methodologies, then it would make sense for students—perhaps disciplinary students as well as interdisciplinary students—to learn simultaneously about disciplines and interdisciplinarity. Interdisciplinary undergraduate programs (and general education courses) would have an obvious place alongside specialized (disciplinary) programs.

What Would an Interdisciplinary Research Process Look Like?

This section begins with a brief review of Repko (2008) and then discusses a few other recent efforts to identify interdisciplinary best practices. It will be argued that these efforts are complementary and point toward a consensus approach to interdisciplinary research.

Interdisciplinary Research: Process and Theory

Repko (2008) wrote the first book-length treatment of the interdisciplinary research process. Repko draws in turn on a variety of works by scholars of

interdisciplinarity: Klein (especially 1990), Newell (especially 2007), Szostak (2002, 2004), and Bal (especially 2002). He also draws heavily on works in cognitive science and social psychology. Most important, for each step in his recommended research process, Repko provides examples of application from the humanities, social sciences, and natural sciences. And for each step, he suggests a handful of strategies or guidelines that might usefully be applied. Repko proposes 10 broad steps:

1. State the problem or focus question.
2. Justify using an interdisciplinary approach.
3. Identify relevant disciplines.
4. Conduct the literature search.
5. Develop adequacy in each relevant discipline.
6. Analyze the problem and evaluate each insight into it.
7. Identify conflicts between insights and their sources.
8. Create or discover common ground.
9. Integrate insights.
10. Produce an interdisciplinary understanding and test it.

This research process in particular is similar to those advocated by Szostak (2002) and Newell (2001). One can identify five common groups of steps in these three approaches. The first steps involve identifying an interdisciplinary research question. The second set of steps guide the researcher to identify relevant phenomena, theories, methods, and disciplines. The third set of steps involve evaluating disciplinary insights. The fourth set of steps focus on finding common ground across disciplinary insights. The final steps require reflection, testing, and communication of results.

At the level of these broad steps, it would be hard to maintain that the process interferes with freedom: Scholars are still encouraged to employ *any* scholarly (or, indeed, nonscholarly) theory or method and draw connections across *any* set of phenomena. Indeed, Repko (2008) provides potentially exhaustive tables of phenomena, theory types, and methods that interdisciplinary scholars might want to embrace. It might be objected that the linear nature of the process is restrictive: What if one wants to revisit Step 1 while performing Step 6? Repko and other advocates of such a process take pains to emphasize its iterative nature: Researchers are indeed encouraged to revisit earlier steps as they perform later steps, alter the question as new information is uncovered, embrace additional theories and methods as the limits of the first ones chosen become apparent, and so on. Seeing it in this iterative sense, one might worry not that the process is too restrictive but that it provides little structure. Yet, it does provide a checklist of tasks that the interdisciplinarian

should ideally perform. The value of revisiting earlier steps is highlighted in many of the case studies that follow, notably that of Connor (Chapter 3).

Concerns with structure may reappear at lower levels of granularity. The Repko (2008) book contains a host of suggestions for how to best pursue each step. Again, though, the intent has been to survey all useful strategies. For example, Repko discusses a common interdisciplinary approach: From the guiding question, one first identifies relevant disciplines and then looks within these for relevant insights. Yet, he also highlights an alternative approach (pioneered in Szostak, 2004) whereby the interdisciplinarian first reflects on relevant theory types and methods and only then progresses to identify relevant disciplines. These approaches are quite distinct, yet both lead to an appreciation of different insights within their disciplinary contexts. Likewise, several distinct strategies for evaluating disciplinary insights, integrating them, and then identifying a common ground are provided. With respect to evaluation, Repko discusses how to evaluate the theories applied, methods used, phenomena considered, data employed, epistemological assumptions engaged, relationship between insight and perspective, and potential biases of researchers; he also urges researchers to use insights generated by one community as a device to evaluate insights generated by another. As for building common ground, Repko first surveys a variety of critical thinking strategies identified by cognitive scientists before suggesting several broad techniques for achieving common ground: redefinition (semantic adjustment of terms or assumptions); extension (of a theoretical idea to a new domain); organization (identifying hidden commonalities across fields and establishing how these are related); and transformation (seeing differences of kind as differences of degree instead). Each of these strategies might be useful in some circumstances but not others. If other interdisciplinarians wish to suggest further strategies, these could be added to the lists proffered by Repko. Of course, any suggestion that “you may want to try X” may divert attention from strategy “Y.” Still, it would be unfortunate if the only way to avoid such a potential bias were to eschew giving interdisciplinarians any advice on how to proceed. Arguably, then, an interdisciplinary research process can provide a useful structure while remaining flexible enough to embrace all viable research strategies.

Of course, some interdisciplinarians might object to the outcome. They may find the idea of “common ground” disquieting, most likely if they wish to see some grand theory triumph over all alternative explanations. Yet, even here it is possible that common ground may take the form of one overarching theory. Most important, a scholarly methodology should be designed to encourage inquiry rather than to guarantee that a particular form of outcome is generated.

One may worry that no single researcher, and even most interdisciplinary teams, could adequately perform each of Repko’s (2008) steps. Yet, the process can hardly require researchers to do the impossible. It can, however, guide them to reflect on what they have missed. If, for example, time constraints

(coupled with the interdisciplinary-unfriendly nature of library catalogues) have forced a less-than-exhaustive literature survey, interdisciplinarians can usefully reflect on what might have been missed. In this way, the recommended process may serve as a support for a cumulative interdisciplinary scholarship. Subsequent researchers can fill in the gaps in previous research. The case studies in this book establish that one researcher can, indeed, do a very good job of performing most, if not all, steps in the Repko process; yet, most chapters also point to further research that other interdisciplinarians could perform that would further enhance our understanding of the question at hand.

The Ecology of Team Science

Though Repko (2008) provides the only textbook treatment of the interdisciplinary research process, a handful of other scholars have, in recent works, also shed important light on interdisciplinary research. These authors, representing a broad range of research fields and hailing from at least three continents, share insights broadly consistent with those of Repko.

Stokols, Misra, Moser, Hall, and Taylor (2008) focus on the particular needs of interdisciplinary teams. They note that the effectiveness of interdisciplinary teams varies a great deal. Team size matters (though the optimal size varies by project); homogeneity of team members along various social dimensions matters (homogeneity encourages conversation but limits novelty); personality of team leaders matters (though firm advice on what qualities are best is lacking at present); and personality of team members also matters (openness, methodological flexibility, and willingness to devote time to listening appear to be important). In terms of process, they emphasize the need to develop “shared conceptual frameworks that integrate and transcend the multiple disciplinary perspectives represented among team members” (p. S97). That is, the process of integration needs to start early: Whereas Repko (2008) stresses integration of insights to form a common ground understanding, Stokols et al. urge some integration of disciplinary perspectives in order to allow participants to work toward a later integration of insights. It may, though, prove more difficult in practice to integrate perspectives than to integrate insights. When interdisciplinary research extends beyond the Academy (which the authors appreciate is important for some types of research but not others), then some sort of educational function may also be critical: Scholars need to learn how to communicate to the public, and members of the public need to learn about scholarly research. Academy-community collaboration also requires careful identification of common goals, distribution of power and control, and organizational support.

Stokols et al. (2008) do not distinguish the social from cognitive aspects of interdisciplinary team research. Interdisciplinary teams work best when there are many informal opportunities for team members to interact. They also

work best either when team members have strong personal incentives to pursue team goals or, alternatively, when team efforts are evaluated entirely at the team level; cases in which team members face a choice between pursuing individual versus team glory are generally problematic. Teams work best when there is both a high level of trust and a shared dream. Teams operating at a distance need not only to utilize the best communications technology but to appreciate that special steps are necessary to create a feeling of social cohesion at a distance. For team interdisciplinary research, then, one might want to encourage very early steps in the research process that set up the right incentive structure, select the right sorts of leaders and team members, create mechanisms for interaction, and establish the right physical and technological infrastructure.

The case studies in this book are each performed by one or two authors. The special challenges of team research were thus not confronted directly. Yet, as Klein points out in Chapter 10, the strategies for team building advocated by Stokols and others are generally complementary to the strategies for individual research advocated by scholars such as Repko. These case studies are thus useful, not just for the individual interdisciplinarian but also for the interdisciplinarian involved in some sort of team research project.

Integration and Implementation Sciences

Bammer (2005) suggests the creation of a new academic field focused on integrating the insights of specialized researchers and applying the holistic insights gained. Her main motivation is the recognition that interdisciplinarians too often “reinvent the wheel,” discovering over and over good strategies for performing interdisciplinary research. She also speaks at some length to the strategic advantages of providing an institutional home for interdisciplinarity (see above), and she appreciates that such a home will only be provided and respected if there is some set of core strategies and skills associated with integration. She notes that both academics and policy makers interested in interdisciplinary analysis do not know where to turn for advice. This book—and Repko (2008)—can be considered a response to such a call for advice on how to perform interdisciplinary research.

Bammer (2005) suspects that interdisciplinarians will be called upon to deal with “complex” problems: those that involve not only interactions among many phenomena but significant nonlinearities in how some phenomena influence others. Newell (2001) had made a similar argument; those who responded to him in that volume of *Issues in Integrative Studies* generally concluded that complexity was often, but not always, at play in the problems addressed by interdisciplinarians. Bammer herself notes that there is a big difference between how “complexity” is used by complexity theorists and how it is used in common parlance; it could be that the latter usage more closely captures the essence of interdisciplinary questions. Bammer’s suggestion that

interdisciplinary researchers cope with the emergent properties of complex systems could thus be treated not as a mandatory practice but as a mandatory question to be asked: Are there emergent properties to be addressed in the system of causal links being investigated? Notably, the Repko-like process pursued in Szostak (2009) and in his chapter on economic growth (Chapter 6) has exactly such a step. Bammer worries that there are several competing approaches to complexity analysis. She argues convincingly that these might well be integrated into a coherent set of strategies. Integration is, in part, possible because different approaches deal with different kinds of complexity: Some emphasize equilibria, others stress cycles, still others focus on change in some direction, and many speak of stochastic outcomes (these are, notably, the different sorts of time-path that every theory should specify, as identified in Szostak, 2004). It should thus be possible to develop a menu of complexity theories and methods that are applied to different situations. Yet, integration is also possible because many similar elements appear in quite different approaches to complexity: concerns with hierarchy of phenomena, boundaries between phenomena, networks and flows, and feedback loops among phenomena. Note that several case studies, but most explicitly those of Szostak (Chapter 6) and Keestra (Chapter 8), show how mapping the relationships between variables can be invaluable; those two chapters also address issues of hierarchy.

Bammer (2005) argues that interdisciplinarity will also involve both academic teams and interaction with nonacademics. But as Stokols et al. (2008) have stated, the size of teams and degree of community interaction vary widely depending on the question being addressed. As noted above, strategies for organizing teams and interacting with the public should be developed by interdisciplinary researchers, but some interdisciplinary projects may not require one or both of these. Bammer discusses how interaction with nonacademics can be useful at various stages of the research process: identifying research questions, identifying relevant theories and methods, identifying problems with these, identifying practices that seem to work, and testing policies and procedures. Bammer devotes particular attention to the last of these. If interdisciplinary researchers will investigate complicated systems of relations among diverse sets of phenomena, then there is likely to be a great deal of uncertainty surrounding any policy recommendations that might result from interdisciplinary research (indeed, Bammer identifies uncertainty as one of the hallmarks of interdisciplinary research). These recommendations must thus be explained carefully to policy makers and the public, and they must be carefully tested in practice. The idea that academics can simply produce ideas to be taken “off the shelf” by policy makers will be especially inappropriate for interdisciplinary research. Rather, academics, policy makers, and the public should work together in testing policy recommendations (Funtowicz & Ravetz, 2008 make a similar point). Although several chapters address the policy implications of the analysis performed, Henry and Bracy (Chapter 9) discuss most fully how testing might proceed. Connor (Chapter 3) is notable for showing how policy implications can influence scholarly discourse itself.

Bammer (2005) also usefully extends her gaze beyond the confines of an individual research project in two important respects. First, she cites Klein (1990) on the value of encouraging specialized researchers to pursue questions identified by interdisciplinary researchers. Within a team of researchers, it may be possible to encourage specialized research of this sort. More often, though, one key aspect of interdisciplinary research is to identify questions or research strategies that are understudied by specialized researchers (this is also a step performed in Szostak, 2009). This sort of symbiotic relationship between integrative and specialized research deserves emphasis: Integrative research not only builds on specialized research but also informs it (and not just about questions but about relevant phenomena, theories, and methods). Second, Bammer urges interdisciplinarians to engage seriously with information scientists in developing better systems for organizing human understanding. One of the main barriers to interdisciplinarity is that scholars simply do not know where to look for relevant information. In a particular project, this means, most obviously, that greater care must be taken with the literature search than is generally the case for specialized research. Yet, interdisciplinarians should not lose sight of the wider goal of suggesting how information could be better organized to serve further research (Szostak, 2008).

Types of Interdisciplinarity

Julie Thompson Klein has, in a variety of publications, developed typologies of different types of interdisciplinarity. Given the vast array of different types of interdisciplinarity identified, does it make sense to speak of one interdisciplinary process? As with the analysis of Stokols et al. (2008) above, one possibility is that different types of interdisciplinarity can be seen as representing different choices within an overarching research process. If so, then an understanding of the overall process would help researchers and others evaluate whether the choices made in a particular research project were appropriate.

Klein describes a spectrum of types of integration. Partial integration involves an ad hoc and temporary borrowing of tools and approaches from one discipline for use by researchers based in another. If this borrowing becomes more sophisticated and enduring, one can speak of supplementary integration. Full integration (or better yet, unifying integration) occurs when the ideas from one discipline are so absorbed into the other that some new synthesis emerges. Although Klein's focus in these comparisons is on the emergence (or not) of interdisciplinary research fields rather than the structure of individual research projects, it is nevertheless true that individual researchers face a choice regarding the degree of integration to be pursued in a particular project. The analysis above has generally stressed relatively full sorts of integration. One of the earliest steps in the Repko (2008) process is an evaluation of whether the research question is appropriately interdisciplinary. If the answer is affirmative, then partial integration, while better than nothing, will likely not yield as useful an understanding as will full integration.

If, however, a research question is largely disciplinary, then partial integration may be all that is required. Van der Lecq (Chapter 7) and Henry and Bracy (Chapter 9) explore how partial integrations can be further integrated to generate a more holistic understanding.

One can also speak of different means of integration. Sometimes, integration is primarily semantic: The meanings of concepts are adjusted to carry a similar meaning across communities (Klein [Chapter 10] notes that there are a handful of strategies for achieving semantic consensus). Van der Lecq (Chapter 7) and Tayler (Chapter 2) pay particular attention to this strategy. Sometimes integration occurs by adjusting the assumptions of theories so that they are complementary. Repko (Chapter 5) is particularly notable in this regard. Sometimes integration involves placing competing theories within an overarching framework. Connor (Chapter 3), Szostak (Chapter 6), and Keestra (Chapter 8) do this in quite different ways. As should be clear by now, these different integrative strategies can be seen as complements.

As with Stokols et al. (2008) above, Klein (1990) appreciates that research groups operate in quite different ways (see also Pohl et al., 2008, p. 415). Sometimes the group engages in cooperative learning, with all group members involved in regular conversations about how to proceed. At other times, group tasks are divided among members on the basis of expertise, with members working largely independently for long periods. In still other cases, group leaders take on much of the responsibility for integrating ideas produced by group members. The suitability of these different approaches to different circumstances can be judged in terms of how well they generate particular results: Do they identify relevant disciplines, theories, methods, and phenomena? Do they evaluate these different theories? Do they integrate them?

Transdisciplinary Perspectives

While the *Handbook of Transdisciplinary Research* edited by Hirsch Hadorn et al. (2008) has no chapter devoted to the articulation of an interdisciplinary research process, there is support for the idea in many chapters. “Transdisciplinary research needs concrete paradigms to help researchers understand problems in context and to structure the research accordingly” (Hoffman-Riem et al., 2008, p. 7). Pohl et al. (2008) suggest, “A paradigm is critical for integration to improve its scientific profile” (p. 413). They are confident that a broad research process can be identified by comparing successful research programs: “We can start to identify a number of forms of collaboration and integration that appear more or less consistently in transdisciplinary research” (p. 415). They note, in particular, that it is difficult to assess interdisciplinary research projects in the absence of some sense of how these should proceed. Messerli and Messerli (2008, p. 60) argue that transdisciplinary projects may have difficulty gaining research funding in the absence of well-defined research practices that lend themselves to peer review. Bergmann and Jahn (2008, p. 98) provide a more practical rationale:

Integration must occur throughout the entire project, and this is best achieved with some guiding model that allows planning and regular evaluation. This process must be general enough to be universal but differentiated enough to identify key questions that research planners must grapple with in particular cases.

Wiesmann et al. (2008, pp. 436–437), among many others, emphasize that any interdisciplinary research process must be iterative. Because the guiding question is chosen interactively, it will inevitably be refined as research is undertaken and even as policy recommendations are devised. Decisions about what disciplines to engage are inevitably revisited as research proceeds. Teamwork increases the need for an iterative approach because the development of shared theories, models, or outputs is inherently a circular process. As noted above, several of the case studies in this book speak to the value of revisiting earlier steps.

Teamwork is emphasized by all authors in the *Handbook*. Successful teamwork processes “require carefully structured, sequenced, and selected negotiations and interactions” (Wiesmann et al., 2008, p. 437). This takes time, requires mutual acceptance of team goals, and depends on encouraging mutual respect. If independent specialized research is undertaken within the broader project, this must be carefully planned so that it is known in advance when and how this will ideally be integrated into the broader project. As with Stokols et al. (2008), teamwork implies additional steps at the start of the research process.

Bergmann and Jahn (2008) argue that research questions must themselves emerge from a team effort: The team is motivated by some shared societal concern or problem but must then identify well-defined research questions that can be pursued by scholars. Developing the question and creating the team may themselves be symbiotic processes. Messerli and Messerli (2008, pp. 53–54) observe that environmental (and social) problems often occur in clusters or syndromes, and thus guiding questions must often be multifaceted. The next task involves identifying the key disciplines and the key differences in their approach to the research question (this step may lead to a revision of the team and/or question). Després, Fortin, Joerin, Vachon, Gatti, and Moretti (2008, p. 329) identify four broad types of knowledge that must be gathered together: “scientific” knowledge about how the world works, “practical” knowledge about what is possible, “ethical” knowledge about desirable goals, and (for some projects) “aesthetic” knowledge of what is beautiful. The case studies in this book all address “scientific knowledge”; those with a significant policy component also address “practical” insights; ethical issues are addressed most clearly in Tayler (Chapter 2), Repko (Chapter 5), and Szostak (Chapter 6); Bal (Chapter 4) investigates aesthetic knowledge to the greatest extent.

Several authors speak of identifying subquestions for disciplinary research. Wiesmann et al. (2008, p. 436) stress the symbiotic relationship between specialized and integrative research. Bergmann and Jahn (2008) alternatively

celebrate the advantages of having interdisciplinary subgroups pursue subquestions: It is then much easier to achieve integration at the level of the project as a whole. In either case, it is essential that the relationship between the guiding question and subquestions be carefully specified at the outset, though of course the relationship may change as research proceeds. It is also essential that there be regular interactions between subgroups: Integration cannot just be left until the end (p. 94). Several chapters in this book show how even individual researchers can benefit from identifying and addressing subquestions.

The focus on integration will vary by project: Sometimes developing shared understandings of concepts is critical, in other cases it is theories that must be integrated, in other cases models, in still other cases policy developments (Pohl et al., 2008, p. 416). As noted above, some of the cases in this book focus on concepts while others stress theories; a handful of chapters, including Tayler (Chapter 2) and Henry and Bracy (Chapter 9), address how policies might be integrated.

Wiesmann et al. (2008) speak to the difficulty of evaluating interdisciplinary research projects. They cannot be evaluated fairly against the standards of any one discipline. As noted above, this is one major advantage of developing a shared understanding of the ideal interdisciplinary research process within the community of interdisciplinarians. The exemplary research projects included in this book provide a standard against which similar projects might be compared.

Because interdisciplinary research is motivated in general by social problems, researchers will usually want to generate both scholarly contributions and practical policy advice. These are two quite different sorts of output. Bergmann and Jahn (2008, p. 96) argue that they require different types of integration. Scholarly audiences may be most interested in integration at the level of theories and methods. Policy makers will seek integration of diverse policy proposals. Ideally, of course, the first sort of integration should support the second. Bergmann and Jahn feel that very few interdisciplinary research projects succeed on both counts. The chapters in this book by Tayler (Chapter 2), Connor (Chapter 3), Szostak (Chapter 6), and Henry and Bracy (Chapter 9) each strive in their own way to address the concerns of both scholars/students and policy makers.

Conclusion

In this brief overview, there has been little time to comment at length on the evidential basis for these various arguments regarding process. Briefly, though, it might be noted that the works cited reflect a balance between a deductive approach (looking at scholarship on interdisciplinarity, cognitive thinking, social psychology, and organization, and deducing what should work best) and an inductive approach (looking at interdisciplinary research projects and seeing what works and what does not). In good interdisciplinary

fashion, research from a variety of fields and a variety of theories and methods have been drawn upon in each of the works cited above. The inductive and deductive approaches are increasingly being combined as researchers apply recommended processes in their research; they can then reflect on how well these worked. As noted at several points above, the case studies in this book serve both to highlight the value of the interdisciplinary research process and to clarify its nature.

It would be straightforward to integrate the processes reviewed above. The team-building steps advocated by Stokols et al. (2008) or contributors to Hirsch Hadorn et al. (2008) could be added to a Repko-like process. So too could Bammer's (2005) stresses on emergent properties, discussions beyond the Academy, and implementation. Likewise, the development of subquestions and reintegration of these into the overall project can be seen as a further option available to interdisciplinary researchers. Several chapters in this book pursue such a strategy. Moreover, these various amendments could be treated iteratively: Although one wants a cohesive team from the start, one may revisit teambuilding strategies as the research process unfolds. The different approaches to interdisciplinarity identified by Klein (1990), Pohl et al. (2008), and others can be seen as choices within this iterative process; the appropriateness of particular choices can be judged in terms of how well the research process achieves its goals.

Potentially, at least, this integrated research process meets the objections raised in the first section: It provides structure without interfering with freedom, it facilitates normal research by interdisciplinarians, it encourages use of the widest range of theories and methods and phenomena, it encourages standards grounded in this sort of flexible structure, and it strengthens the case for a role for interdisciplinarity within the Academy that is clearly symbiotic with specialized research. Teams of interdisciplinarians, including nonacademic participants, should thus be able to achieve success employing the interdisciplinary research process, just as have the researchers pursuing case studies in this book.

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