2 Mapping the Drivers of Interdisciplinarity

Chapter Preview

Before delving into the research process, it is useful to first discuss why interdisciplinary research is so important and identify those factors "driving" it. The problems confronting humanity today are of such magnitude and complexity that new approaches to addressing them are needed. This has sparked renewed interest in interdisciplinarity as a mode of education and an approach to research. Because interdisciplinarity deals with "big questions and real problems," explains Carol Geary Schneider (2010), president of the Association of American Colleges and Universities (AAC&U), "interdisciplinarity is now prevalent throughout American colleges and universities" (p. xvi). In *College Learning for the New Global Century* (2007), the signature report from AAC&U's decade-long initiative on Liberal Education and America's Promise (LEAP), the authors call for making intentional integrative learning a defining feature of liberal education. Brint, Turk-Bicacakci, Proctor, and Murphy (2009) report that interdisciplinary teaching and research is now widely considered a prominent feature of the modern academy. The reason for heightened interest in interdisciplinarity, reports Julie Thompson Klein (2010), is because the word "is associated with bold advances in knowledge, solutions to urgent social problems, an edge in technological innovation, and a more integrative educational experience" (p. 2).

This chapter sets out the four primary drivers propelling the growth of interdisciplinarity in research and education. This discussion is followed by the interdisciplinary critique of the disciplines, a brief recounting of the origins of the disciplines and of interdisciplinarity, and the four key assumptions that anchor this diverse and rapidly evolving field. It concludes by identifying the cognitive abilities that interdisciplinarity fosters and the traits and skills characteristic of interdisciplinarians.

The Primary Drivers of Interdisciplinary Research and Education

The National Academies report *Facilitating Interdisciplinary Research* (2005) identifies four primary and overlapping "drivers" of interdisciplinary research and learning:

1. The inherent complexity of nature and society
2. The desire to explore problems and questions that are not confined to a single discipline
3. The need to solve social problems
4. The need to produce revolutionary insights and generative technologies

Each of these warrants extended discussion.

The Inherent Complexity of Nature and Society

The first driver of interdisciplinary education and research is the need to understand the inherent complexity of nature and society. The complexity discussed here is of two kinds: the complexity of real-world problems that involve natural systems or human society, and the complexity associated with the meaning of cultural artifacts, past and present, such as literature, visual art (e.g., films, paintings, and sculptures), and performance art (e.g., plays, dance, and musical compositions). Real-world problems concerning nature and society are typically complex, ill structured, and not readily solved.

Research in the natural sciences and even more so in the social sciences is increasingly interdisciplinary because the complexity of real-world problems often defies using a single disciplinary approach and requires crossing disciplinary boundaries. Examples of "grand challenge questions" that require scientists to cross disciplinary domains include the following: How did the universe originate? What physical processes control climate? What is the carrying capacity of the biosphere? Complex natural systems such as the Earth's climate cannot be understood comprehensively, they say, "without considering the influence of the oceans, rivers, sea ice, atmospheric constituents, solar radiation, transport processes, land use, land cover, and other anthropogenic practices and feedback mechanisms that link this 'system of subsystems' across scales of space and time" (National Academies, 2005, p. 30).

Human societies are also enormously complex systems. They are affected by myriad influences such as climate, geography, history, cultural traditions, conflict, and systems of sacred beliefs. Examples of high-priority problems that require expert insights from multiple disciplines include world hunger,

sustainable resource use, terrorism, and childhood development and learning. For many in the natural and social sciences, "it seems quite clear that the advancement of science in the twenty-first century depends on effective collaboration across disciplinary boundaries. This is so, first and foremost, because of the complexity of issues that must be addressed" (Calhoun & Marrett, 2003, p. v).

The humanities are likewise increasingly interdisciplinary, reflecting what anthropologist Clifford Geertz (1980) describes as the "blurring of the genres" (i.e., disciplinary knowledge domains). Each generation seeks its own understanding of cultural artifacts, as witnessed by the perpetual reinterpretations of Shakespeare's plays, the new biographies of major historical figures, and new forms of artistic expression. Here are examples of topics or themes that require drawing on insights from multiple disciplines in the humanities: How was the Cold War depicted in the films of the 1950s and 1960s? How is the concept of "the gaze" understood in the work of particular artists? How is the rescue motif expressed in hip-hop lyrics? To fully understand any problem, object, work, or system that is complex requires using multiple disciplines. Some problems span the natural sciences, the social sciences, and the humanities.

One aspect of real-world complexity is job complexity. Much of what we actually do at work is becoming more knowledge intensive. "Knowledge—an intangible—is a key ingredient in the success of a tangible product" (Oblinger & Verville, 1998, p. 10). This trend toward job complexity, says noted economist and former U.S. Department of Labor Secretary Robert B. Reich (1991), defines a new type of worker—the *symbolic analyst*—who works with intangible simulations to produce a tangible outcome (pp. 177–180). Research scientists are using simulation techniques to create theoretical molecules that have certain properties for the pharmaceutical industry. Real estate developers conceptualize and market a concept to investors and government officials that may ultimately be transformed into a physical environment. Financial analysts run simulations of how certain combinations of investments will perform under a variety of market conditions. Recent analyses of the future of industry and labor call for persons who can understand, use, and integrate knowledge and methods as well as collaborate with disciplinary teams across industry sectors and cultures (Levy & Murnane, 2004; National Academies, 2005).

For this reason, business is becoming increasingly interdisciplinary because it takes place within an increasingly complex environment that demands interdisciplinary skills to address this complexity. Jan Rivkin (2005), a professor in the Strategy unit of the Harvard Business School, writes that for managers

> integrative skills are crucial. Managers who possess them can spot the core of an innovative strategy, grasp the implications for other parts of the company, and build out the idea relentlessly until it comes to pervade a company's entire value chain. They see, for instance, how

> improvements in a retailer's information system have implications for store locations, store manager autonomy, pricing policy, and vender relations. (p. 42)

Another aspect of real-world complexity is the need to apply systems theory to complex problems. **Complex systems theory** concerns the properties of complex systems in general, including how an overall pattern of behavior is generated, its characteristics, and how it evolves over time or in response to changes in its environment. Examples of complex systems include the environment, the human body, and an urban transportation system. Virtually everything we do takes place within a system. Understanding how a complex system functions and the relationships between the various actors in the system is useful because it improves understanding of system outcomes. For example, if a government widens a congested road, systems theory is able to show that it is likely to become congested again even if the destinations of current drivers, employment patterns, location of entertainment and service venues, and other determinants of driving patterns have not changed (Mathews & Jones, 2008, p. 76).

A complex system that students are perhaps most familiar with is their college or university. Yet, as the American Council on Education reports, those entering a university with its many colleges, schools, and special programs are often unaware of how the many parts of the university relate to the whole (Oblinger & Verville, 1998, p. 78). After completing their general requirements, undergraduates typically specialize in a traditional discipline. As they proceed in their major they are prone to develop a **silo perspective**, meaning that they perceive the university and the larger world through the narrow lens of that major. What is often lacking is context—the context of the whole system—and the ability to view reality or a particular problem through multiple disciplinary or theoretical lenses. Those in an interdisciplinary field such as environmental science, however, are taught to relate the smallest parts of the system they are studying to the whole. Similarly, those in cultural studies learn to discover the meaning of a public space in the broad context of the culture that produced it. A hallmark of interdisciplinary research and learning is relating the particular to the larger whole by drawing on multiple disciplinary perspectives that are relevant to a specific problem.

The Desire to Explore Problems and Questions That Are Not Confined to a Single Discipline

Interdisciplinarity is also driven by the desire to explore problems and questions that extend beyond the confines of a single discipline (National Academies, 2005, p. 16). Interdisciplinarity fills gaps in knowledge created by inattention from the disciplines. From these gaps emerge interdisciplinary spaces and new knowledge formations such as cultural botany, geological

information systems, environmental and ecological studies, cognitive science, urban and public policy studies, forensic studies, crime and justice studies, literary cultural studies, sociological cultural studies, area studies of various kinds, word and image studies, cultural analysis, visual culture, ethnomusicology, popular music studies, jazz studies, American cultural studies, and ethnic studies of various kinds (Klein, 2005a, p. 78). Mattei Dogan and Robert Pahre (1990) call this process of gap filling **hybridization**, meaning the integration of specialties across disciplines. Klein (1996) describes hybridization and how interdisciplinarity relates to this ongoing process as follows:

> As older fields have divided into smaller units through fissioning, they have confronted the fragments of other disciplines. The deeper specialization goes, the greater the number of specialties, and the greater inevitability of specialists meeting at the boundaries of other disciplines. . . . Specialization produces narrower and narrower fields, nearly all of which correspond to the intersection of two disciplines. . . . Depending on the case, "interdisciplinarity" may be used as a symbol of crisis, the means of exploding an over rigid discipline, or the foundation for a new discipline. (p. 45)[1]

Noted biologist and philosopher E. O. Wilson (1998) says **consilience**—the "jumping together of knowledge" across disciplines "to create a common groundwork of explanation"—is the most promising path to scientific advancement and human progress (p. 8).

Evidence of increasing boundary crossing is the U.S. National Institutes of Health's (NIH) "road map" for research and funding in 2002. Its former director, Elias H. Zerhouni (2003), declared that the scale and complexity of today's biomedical research problems "increasingly demand that scientists move beyond the confines of their own disciplines." What is needed to understand the combination of molecular events that lead to disease are collaborative teams, new combinations of skills and disciplines, new techniques, and new technologies (p. 3).[2]

This commitment to interdisciplinarity is shared by the American Association for the Advancement of Science's CEO Alan I. Leshner (2004). In "Science at the Leading Edge," appearing in the magazine *Science,* he writes,

> Now many of our papers involve teams of scientists from many specialties, bringing diverse expertise to bear in an *integrated* rather than parallel way. The fact that interdisciplinarity characterizes so much of today's most exciting work may portend the demise of single-discipline science. . . . My greatest concern is that our scientific institutions are not well positioned to promote the interdisciplinarity that characterizes so much of science at the leading edge [italics added]. (p. 729)

Rita Colwell (1998), former director of the U.S. National Science Foundation, adds, "Interdisciplinary connections are absolutely fundamental"

because it is "at the *interfaces of the sciences* where the excitement will be the most intense [italics added]."

Perhaps the most fertile ground for the development of interdisciplinary fields in recent decades is at the interfaces among biological, behavioral, social, and health sciences. Other national scholarly associations—from the American Geophysical Union and the American Chemical Society to the American Institute of Biological Sciences and the American Political Science Association—are promoting interdisciplinary analyses and emphasizing interdisciplinary activities at the borders of their represented sciences and disciplines (Rhoten, 2004, p. 8).

Diane Rhoten (2004) finds that the transition to interdisciplinarity and consilience is not a smooth one. What is lacking, she says, is "*systematic* implementation" of interdisciplinarity by university management structures. "The fact is, universities have tended to approach interdisciplinarity as a trend rather than a real transition and to thus undertake their interdisciplinary efforts in a piecemeal, incoherent, catch-as-catch-can fashion rather than approaching them as comprehensive, root-and-branch reforms" (p. 6).

Still, there are notable examples of productive research at the interface of disciplines. One is the International Geosphere-Biosphere Programme (IGBP), "one of the largest interdisciplinary international research efforts ever undertaken." From its inception, "the program reflected all of the major drivers of interdisciplinary research. It begins with the complexity of nature, the interactions between the land mass, the oceans of air and water, and the life forms of Earth" (National Academies, 2005, p. 31). A second example is the Human Genome Project. This highly complex undertaking depended on extensive collaboration across many disciplines (p. 32).

Research at the interface of disciplines, however, is not limited to large public and private projects. Individual researchers are also producing important insights into a wide array of social problems. For example, Barry Blesser and Linda-Ruth Salter (2007) are pioneering the new interdisciplinary field of aural architecture, which involves integrating information from architecture, music, acoustics, evolution, anthropology, cognitive psychology, and audio engineering in the design of public spaces such as concert halls.

Interdisciplinarity is not new, of course. What is new is the determination with which these research initiatives seek to promote connected learning (DeZure, 1999, p. 1). Denise Caruso and Diana Rhoten (2001) remind us that "Great discoveries and shifts in conventional thinking have been traditionally attributed to researchers crossing disciplinary boundaries" (p. 6).

The Need to Solve Social Problems

Certain kinds of problems, increasingly those of general public interest, are not being adequately addressed by individual disciplines. Such high-priority problems include food safety, genetically modified plants and animals, access

to affordable education, terrorism, job creation, poverty, community development, and immigration. According to the National Academies (2005),

> Human society depends more than ever on sound science for sound decision making. The fabric of modern life—its food, water, security, jobs, energy, transportation—is held together largely by techniques and tools of science and technology. But the application of technologies to enhance the quality of life can itself create problems that require technological solutions. Examples include the buildup of greenhouse gases (hence global warming), the use of artificial fertilizers (water pollution and eutrophication), nuclear-power generation (radioactive waste), and automotive transportation (highway deaths, urban sprawl, and air pollution). (p. 34)

These complex social problems require drawing on expertise from multiple disciplines. Analyzing and solving such problems, argues Steve Fuller (1993), requires interdisciplinary study (p. 33). Daniele C. Struppa (2002) agrees: The need for interdisciplinary studies "is now stronger than ever because modern objects of investigation require an interdisciplinary approach" (p. 97).

It is often important not only to integrate across disciplines but also to draw on expertise from outside the academy. For example, community development projects in urban and rural areas typically involve workers from various disciplines and institutions who join forces around complex social issues of mutual concern such as poverty, health, peace, housing, the environment, and so forth (Korazim-Korosy & Butterfield, 2007, p. 2). One form of community development is international university-to-university partnerships. For example, three large public universities—George Mason University in the United States, the National Autonomous University of Honduras, and the University of Costa Rica—have established an ongoing relationship with community practitioners in each country to develop a coordinated community response to domestic violence in culturally diverse communities with large immigrant populations. So far, the cross-national, cross-cultural, and cross-disciplinary dialog has reframed domestic violence as a human rights issue and increased cultural awareness among community and university participants (p. 8).

The Need to Produce Revolutionary Insights and Generative Technologies

A fourth primary driver of interdisciplinary research and learning is the need to produce "novel and revolutionary insights" and "generative technologies" (National Academies, 2005, pp. 35, 39). **Revolutionary insights** are those ideas that have the capacity to transform how we learn, think, and produce

new knowledge. **Generative technologies** "are those whose novelty and power not only find applications of great value but also have the capacity to transform existing disciplines and generate new ones" (p. 35). Examples include the Internet, MRI, GPS mapping, the laptop computer, and the iPhone. "Innovation," asserts Carole L. Palmer (2010), "often comes not from the core of a discipline but from the margins where knowledge is more diffuse" (p. 176).

Producing transformative insights and technologies requires what Robert J. Sternberg (1996) calls "successful intelligence." Sternberg, one of the world's leading researchers and authorities on intelligence, says that successfully intelligent people think well in three different ways: creatively, analytically, and practically. **Creative intelligence** is required to formulate ideas and solutions to problems. **Analytical intelligence** is required to solve problems and to evaluate the quality of ideas. **Practical intelligence** is needed to apply the ideas in an effective way, whether in business or in everyday life. What makes for **successful intelligence**, says Sternberg, is balance among these three ways of thinking. It means knowing how and when to use these aspects of successful intelligence rather than just having them (p. 128). The problem with traditional education, he says, is that it appears to privilege analytical intelligence. This kind of intelligence may well be less useful to students in their working lives than are creative and practical intelligence. Education, says Sternberg, needs to be preparing students to live in a world where what matters is successful intelligence, not just inert, analytical intelligence. Outside of the academy, problems are of the real-world variety. For example, in a research lab, scientists do not work on problems whose solutions can be readily discovered simply and mechanistically by applying known formulas. Instead, they tackle problems whose solutions are yet unknown and must be found. Solutions to these real-world problems require different strategies that fall into the realm of **heuristics**, involving intuitive, speculative strategies that sometimes work and other times do not work (p. 172). Innovative companies such as Apple, Google, Microsoft, and Intel value people who are successfully intelligent. As one transformative product is being introduced to the market, another is already under development. Analytical intelligence is required to know the market for a product, but creative intelligence is what produces products in the first place and keeps them coming out (pp. 136, 141).

Interdisciplinary education fosters the development of all three components of "successful intelligence." Marc Spooner (2004) finds that the interdisciplinary research process, as it is generally conceptualized, facilitates the creative process by ignoring or removing or altering disciplinary constraints that otherwise would make interdisciplinary work impossible. In fact, says Spooner, the research process may itself be fruitfully understood as a form of creativity (p. 86). Many interdisciplinarians consciously target the development and interaction of the "thinking tools" identified by the literature on creativity. The creative thinking tools include observing, imaging, abstracting, recognizing patterns, forming patterns, analogizing, body thinking,

empathizing, dimensional thinking, modeling, transforming, and synthesizing (Root-Bernstein & Root-Bernstein, 1999). We will, therefore, explore the role of creativity in performing the integrative part of the research process in Chapter 9.

Producing transformative insights and technologies also requires the ability to think integratively. Since the late 1990s, authoritative voices in academia including the Boyer Commission's report, *Reinventing Undergraduate Education: A Blueprint for America's Research Universities* (1998), and the AAC&U's report, *Greater Expectations* (2004), have been advocating increased interdisciplinarity in undergraduate education. The Boyer Commission states,

> As research is increasingly interdisciplinary, undergraduate education should also be cast in interdisciplinary formats. . . . Because all work will require mental flexibility, students need to view their studies through many lenses. Many students come to the university with some introduction to interdisciplinary learning. . . . Once in college, they should find it possible to create individual majors or minors without undue difficulty. Understanding the close relationship between research and classroom learning, universities must seriously focus on ways to create interdisciplinarity in undergraduate learning. (p. 23)

Echoing the Boyer Commission, the *Greater Expectations* report calls for higher education to help college students become **intentional learners** who can "integrate knowledge from different sources" (AAC&U, 2004, p. 4). The report criticizes traditional academic departmental structures for atomizing the curriculum into distinct disciplines. Disciplinary approaches to learning and research, though necessary and valuable, sometimes impede integrative approaches to learning (p. 16).

Joel Podolny, former dean of Yale School of Management, also challenges disciplinary-based education by championing a new curriculum for the school. "We're replacing the disciplinary courses that mapped onto the functional silos in organizations with new courses that are actually organized around key constituencies that a manager needs to engage in order to be effective," he writes. The reason, he adds, is this:

> Effective leaders need to be able to own and frame problems . . . then work across organizational boundaries in order to solve those problems. The curriculum in the past was broken down by these disciplinary silos and because of that, got in the way of effective management and leadership. . . . The real value to be added is in working across those silos. (*Businessweek*, 2006)

Capping the new integrated curriculum is a course called "The Integrated Leadership Perspective" that brings together all the different perspectives.

The vital need for **integrative thinking**—the ability to knit together information from disparate sources—is a subject of Howard Gardner's *Five Minds for the Future* (2008). Gardner is one of the most influential public intellectuals in the world, a MacArthur Fellowship recipient, and the Hobbs Professor of Cognition and Education at the Harvard Graduate School of Education. The "synthesizing" or integrative mind—the mind able to synthesize and communicate complex ideas—is one of the five minds, according to Gardner, that the fast-paced future will demand. "Against all odds," says Gardner,

> individuals seek synthesis. . . . [The] most ambitious form of synthesis occurs in *interdisciplinary work* [italics added]. Biochemists combine biological and chemical knowledge; historians of science apply the tools of history to one or more fields of science. In professional life, interdisciplinarity is typically applied to a team composed of workers who have different professional training. In a medical setting, an interdisciplinary team might consist of one or more surgeons, anesthesiologists, radiologists, nurses, therapists, and social workers. In a business setting, an interdisciplinary or cross-functional team might feature inventors, designers, marketers, the sales force, and representatives drawn from different levels of management. The cutting-edge interdisciplinary team members are granted considerable latitude on the assumption that they will exit their habitual silos and engage in the boldest forms of connection making. (pp. 53–54)

The rapidly changing workplace also highlights the need for integrative thinking. "Workplaces need people educated, generally, in a wide range of disciplines, who know how to integrate knowledge across those disciplines and know how to apply that knowledge to complex problems and issues" (Henry, 2005, p. 11). Because the pace of job destruction and job creation is increasing, students entering the workforce today will need to not only change jobs several times in the course of their working life but also change careers. This means that students need to be flexible and possess a wide range of knowledge and skills that can be adapted and enhanced as their jobs and careers change. Today's employees are expected to question failing practices and offer creative ideas to improve processes and products. Interdisciplinary learning provides students with the competencies to integrate information and synthesize new solutions rather than merely provide formulaic responses based on narrow disciplinary thinking (Gregorian, 2004, pp. 12–14).

The Interdisciplinary Critique of the Disciplines

These authoritative and influential voices clearly emphasize the value of interdisciplinary-based inquiry as a much needed supplement to disciplinary-based research and education. But what is it *exactly* about the disciplines

and the disciplinary approach to research and learning that concerns advocates of interdisciplinarity? The answer to this question is found in the discussion of the interdisciplinary critique of the disciplines. This critique touches on seven weaknesses of **disciplinary specialization**, the focus on a particular portion of reality that is of interest to the discipline.

Specialization Can Blind Us to the Broader Context

Disciplinary specialization can blind us to the broader context. This criticism is expressed in a bit of dialogue found in *The Little Prince* by Antoine de Saint-Exupéry (2000)[3]:

> "Your planet is very beautiful," [said the little prince]. "Has it any oceans?"
>
> "I couldn't tell you," said the geographer. . . .
>
> "But you are a geographer!"
>
> "Exactly," the geographer said. "But I am not an explorer. I haven't a single explorer on my planet. It is not the geographer who goes out to count the towns, the rivers, the mountains, the seas, the oceans, the deserts. The geographer is much too important to go loafing about. He does not leave his desk." (pp. 45–46)

Specialization—that is, "not leaving [one's] desk"—can leave unanswered the larger, more important, and practical issues of life. The fable of building a house for an elephant referenced in Chapter 1 makes the same point. Interdisciplinarians believe that specialization alone will not enable us to master the pressing problems facing humanity today. The more specialized the disciplines become, the more necessary interdisciplinarity becomes.

Specialization Tends to Produce Tunnel Vision

Interdisciplinarians argue that many (but not all) problems can best be understood by being examined from various disciplinary perspectives and then integrated to produce more comprehensive understandings. They point out that disciplinary experts are prone to tunnel vision when it comes to examining important issues. For example, the experts who advocated the damming of the Columbia and Snake rivers system were certain that building a series of hydroelectric dams would not harm the many salmon species that spawned in the rivers' tributaries. But the experts were wrong. Today, despite the extensive building of fish ladders and other costly efforts to mitigate the effects of these dams, several species are on the verge of extinction, and an industry that employed tens of thousands of workers is in ruins. In this world

of specialists, even highly educated persons can be unaware of the social, ethical, and biological dimensions of a policy or an action. Indeed, one may know a great deal about a particular subject but know little about its consequence (Dietrich, 1995).[4]

Disciplinarians Sometimes Fail to Appreciate Other Disciplinary Perspectives

Interdisciplinarians fault the disciplines for sometimes failing to appreciate other disciplinary perspectives. For example, before the terrorist attacks of 9/11, few experts on Middle East policy paid much attention to the central role that religion plays in the region—in particular its role as a motivating force behind much of the organized violence against Western interests there. But since 9/11, scholars are taking a fresh look at how religion, in interdisciplinary combination with other perspectives, informs our understanding of terrorist organizations such as al-Qaeda. The need is to develop a more comprehensive understanding of such terrorist organizations in hopes of learning how to understand them and neutralize their appeal.

Some Worthwhile Topics Fall in the Gaps Between Disciplines

In their critique of the disciplines, interdisciplinarians argue that some problems are neglected because they fall between disciplinary boundaries. An example of a new integrative field is strategic organization, which is an effort to bridge the disciplinary divide between strategic management, usually housed in sociology departments, and organization theory, usually housed in management departments (Baum, 2002, p. 21). According to Giles Gunn (1992), important dimensions of human experience and understanding lie unexplored in the spaces between disciplinary boundaries or the places where they cross, overlap, divide, or dissolve (p. 239). These gaps between the disciplines are being filled by new knowledge formations such as sociobiology and biochemistry that are allowing researchers to address new questions and pursue new topics (Klein, 2000a, p. 16).

Creative Breakthroughs Often Require Interdisciplinary Knowledge

The interdisciplinary critique of the disciplines extends to the need for creative breakthroughs when addressing complex problems. **Creative breakthroughs** often occur when different disciplinary perspectives and previously unrelated ideas are brought together (Sill, 1996, pp. 136–149).[5] Noted British

scientist and novelist C. P. Snow (1964) states, "The clashing points of two subjects, two disciplines, two cultures—of two galaxies, so far as that goes—ought to produce creative changes. In the history of mental activity that has been where some of the breakthroughs came" (p. 16). For example, Moran (2010) reports that "interdisciplinarity has produced some of the most interesting intellectual developments in the humanities over the past few decades" (p. 180). Those who wish to speed up the production of knowledge and the solution to pressing problems should promote, or at least tolerate, an interdisciplinary approach.

The Disciplines Are Often Unable to Address Complex Problems Comprehensively

A further problem with the disciplines is their inability to address comprehensively, much less solve, complex problems such as global warming. One might examine global warming from a biological perspective and hypothesize about the effect of increased production of carbon dioxide, a greenhouse gas, on ocean temperatures and coral reefs. One might examine it from an economic standpoint and hypothesize about the effects of climate warming on, say, the supply of freshwater for agriculture and food prices in particular regions. Or one might examine it from the perspective of domestic politics and conclude that partisan political considerations and interest group lobbying are to blame for inaction on the problem.

All these disciplinary contributions may be valuable, but none of them provides the truly comprehensive perspective on the problem that policy makers and the public really need. On too many issues of public importance, the disciplines tend to talk past each other. Disciplinarians act as though the part of the problem they analyze is the whole problem, and simply ignore other aspects.

Most interdisciplinarians do not seek the end of the disciplines, for reasons already discussed in Chapter 1. They believe, however, that although the disciplines are useful for producing, organizing, and applying knowledge, too much specialization narrows and distorts one's view of the world.

The Disciplines Are Products of a Bygone Age

Critics of the disciplines say that they are products of a bygone age that was very different from today's world of increasing complexity and rapid social change. After all, they "were forged in relation to particular historical and social contexts, intellectual problems and achievements, and available methodologies" (Calhoun & Marrett, 2003, p. v). The structure of the disciplines and their silo approach to learning and problem solving reflects the form and the level of knowledge achieved in an earlier histori-

cal period. Consequently, it is unreasonable to expect that the disciplines *by themselves* will be capable of providing the comprehensive understandings of, or solutions to, contemporary issues and social problems. There is, then, no reason why the disciplines should continue to enjoy a monopoly on knowledge production.

Conversely, the rise of interdisciplinary research and learning reflects the need to ask new questions, try new approaches, produce new technologies, and develop new intellectual orientations (pp. v–vi). We can never entirely dispense with the disciplines as means of organizing knowledge, says Moran (2010), but we can use them to create new intellectual configurations of knowledge (pp. 181–182). Critics of the disciplines readily admit that interdisciplinarity *by itself* is no panacea for the world's problems. Rather, they believe that a symbiotic relationship between the disciplines and interdisciplinarity holds the promise of producing creative breakthroughs that would otherwise not be possible using traditional approaches.

The Formation of the Disciplines and the Origins of Interdisciplinarity

These concerns about specialization and fragmentation and the drive for integration of knowledge are not new but have a long history extending from ancient Greco-Roman times. The following brief history of the origins of interdisciplinarity shows that they arose in response to a series of cultural and educational challenges that required alternatives.

By the time of the ancient Greeks, knowledge had accumulated to such an extent that Plato's Academy, founded in 387 BC, offered instruction in gymnastics, music, poetry, literature, mathematics, and philosophy. The purpose of this experience was to promote the physical, moral, and social development of the "whole person," a concept foundational to integrative values in modern humanities, liberal education, general education, and many interdisciplinary studies programs (Hirst, 1974, pp. 30–31; Nussbaum, 1985, pp. 6–7).

Aristotle, the great philosopher, began the practice of dividing knowledge into subjects. He established a clear hierarchy of the different academic subjects with the theoretical subjects of theology, mathematics, and physics on top; the practical subjects of ethics and politics in the middle; and the productive subjects of the fine arts, poetics, and engineering at the bottom. Aristotle found this structuring of knowledge necessary but regrettable because it violated the fundamental notion of the unity of all knowledge. To integrate these subjects, he placed philosophy as the universal field of inquiry at the top of his hierarchy, as a way to bring together all the different branches of learning (Moran, 2010, p. 4). Significantly, this **classical division of knowledge** remained intact until the nineteenth century, when a new scheme of disciplinarity arose.

The Origins of the University and the Disciplines

The twelfth century (1100–1200 AD) saw the development of a new institution that was to play a major role in the ascendancy of European civilization and the development of the disciplines: the **university**. The modern university is an institution of higher learning that provides teaching and research and is authorized to grant academic degrees. It evolved from the medieval cathedral schools and "rested on the conviction that there was an essential and universal unity of knowledge and through Christianity, that faith was the highest order of knowledge" (Briggs & Micard, 1972, p. 186). The first recorded appearance of the word *university* is in a letter of Pope Innocent III in 1208 or 1209 (M. Bishop, 1970, p. 266). The first universities appeared in Bologna, Paris, and Oxford, where groups of students and teachers (or masters) would meet, often in rented halls or rooms. Interestingly, the original meaning of the word *university* does not refer to either "universe" or "universal" but rather refers to the totality of a group, as in a group of students (Haskins, 1940, p. 14; Rashdall, 1936, pp. 4–5).

By the thirteenth century and until at least the end of the eighteenth century, university students tended to study a core curriculum of the liberal arts, divided into the trivium (logic, grammar, rhetoric) that addressed things qualitatively and the quadrivium (arithmetic, geometry, astronomy, and music) that addressed things quantitatively (Moran, 2010, pp. 4–5). This curriculum served as the basis of and preparation for the professions. Students went on to specialize in theology, medicine, or law much as students today choose to "major" in a subject. These studies corresponded to modern courses in the arts and sciences (M. Bishop, 1970, p. 267).

The term *discipline*, introduced as *disciplina* by the Romans, was applied to these professions because of the perceived need to relate education to specific economic, political, and ecclesiastical ends (Klein, 1990, p. 20). Interestingly, medieval scholars largely excluded contemporary cultural developments as well as the mechanical arts, including agriculture, navigation, war, weaving, and the theater arts (Saffle, 2005, p. 14). Not until the twentieth century would these fields be absorbed into the academic curriculum of the Western university. The university and the disciplines became an engine of knowledge production that far outstripped any other method of learning devised by any previous civilization.

The Impact of the Enlightenment and Scientific Revolution on the Disciplines

The production of knowledge and disciplinary specialization accelerated during the late seventeenth and eighteenth centuries. Two movements hastened this process. The first was the **Enlightenment**, a Europe-wide intellectual movement that emphasized the progress of human knowledge through the

powers of reason and provided justification for the movement known as modernism. The second was the **scientific revolution** that occurred at about the same time and that emphasized greater specialization (i.e., reductionism) and heightened research activity (i.e., empiricism), initially in the sciences and then in all the disciplines. The significance of the Enlightenment and the rise of modern science is that they challenged the idea of the unity of knowledge. The early division of the empirical or natural sciences dates from this period.

Not everyone, however, saw greater disciplinary specialization as a positive development. In the early 1700s, the Italian thinker Giambattista Vico called for a new approach to learning. He claimed that the ascendancy of science and mathematics in the curriculum had led to a neglect of broad education in favor of specialized knowledge. He argued that the "human sciences" such as history, philosophy, and law can achieve knowledge and understanding "from within" and, in fact, were superior to the natural sciences, which can only describe the external phenomena in nature (Moran, 2010, p. 7). Nevertheless, Vico's call for less specialization and a more comprehensive approach to learning largely fell on deaf ears.

The Consolidation of the Disciplines in the Late Eighteenth and Early Nineteenth Centuries

Between 1750 and 1800, the disciplines consolidated their hold on the teaching and production of knowledge by embracing three new revolutionizing techniques: writing, grading, and examination. These practices were introduced in three new teaching settings: the seminar (beginning in the German universities around 1760), the laboratory (beginning in the French *Grandes Écoles* before the Revolution), and the classroom (beginning in Scotland around 1760).

Disciplines also began publishing disciplinary journals and hiring their own PhDs, making it difficult for scholars to cross disciplinary lines. Combined, these practices and settings enabled the disciplines to strengthen their position and accelerate the production of new knowledge (Hoskin, 1993, pp. 275–277). These practices and settings have been so successful that today they are used the world over.

The Professionalization of Knowledge in the Late Nineteenth and Early Twentieth Centuries and the Rise of the Modern Disciplines

The academic disciplines of today and the modern concept of disciplinarity are largely the product of developments in the late nineteenth and early twentieth centuries (Klein, 1990, pp. 21–22; Lattuca, 2001, p. 23). This period saw the formation of disciplines in the physical and natural sciences

such as biology, chemistry, and physics, though the division process was under way between the mid-seventeenth century and the late eighteenth century. By the middle of the nineteenth century, the social sciences were fragmenting into anthropology and economics, followed by psychology, sociology, history, and political science. Though the humanities include the oldest subjects, the humanities were the last to assume modern disciplinary form (Easton, 1991, p. 11).

Along with the rise of scientific specialties came increased competition for university resources, so universities began to organize themselves around the disciplines. These new disciplines were accompanied by new professional societies in the United States. National organizations emerged in history in 1884, economics in 1885, political science in 1903, and sociology in 1905 (Hershberg, 1981, p. 23). Disciplinary journals allowed isolated specialists to keep abreast of the latest research and also gave them a forum for presenting their own research. Specialists did not need to consider perspectives other than those of their own specialty (Swoboda, 1979, p. 62).

As the modern university took shape, disciplinarity was reinforced in two major ways, according to Klein (1990). First, industries demanded and received specialists from the universities. Second, the disciplines recruited students to their ranks (pp. 21–22). The trend toward specialization, especially in the sciences, was further propelled by increasingly more expensive instrumentation, elaborately equipped laboratories, and highly trained personnel. "Although the 'Renaissance Man' may have remained an ideal for the well-educated baccalaureate, it was not the model for the new professional, specialized research scholar" (Hershberg, 1981, p. 23).

The proliferation of academic disciplines raised concerns about overspecialization, in particular how these new disciplines were connected to issues of power and self-interest. Late-nineteenth-century German philosopher Friedrich Nietzsche and early-twentieth-century Spanish philosopher José Ortega y Gasset saw the new disciplines as symptoms of a more general phenomenon: the growing interdependence of government, business, and education. Driving this interdependence was an economic system that increasingly depended on the availability of specialists and professionals. Under this system, the disciplines and the universities served two vital functions: They trained persons for careers in government and business, and they gave these new professions legitimacy and status by providing them with academic credentials (Moran, 2010, pp. 11, 12).

The Emergence of Interdisciplinary Studies and Interdisciplinarity

Once the disciplines were established, it was only natural that interest in interdisciplinarity began to develop. For this to be successful it had to appeal to university administrators. It is also notable that pressure for interdisciplinarity

came on the teaching side long before it came on the research side. On the teaching side, the notion of interdisciplinarity and the emergence of interdisciplinary studies can be seen as a response to two broad developments in the United States in the twentieth century. The first concerns the general education movement that dates from the early decades of the century. The second concerns the cultural revolution of the 1960s and the resulting reforms in higher education.

The General Education Movement

The **general education movement** that arose after World War I was a response to several problems besetting American culture and education at the time, including the lack of national unity and the eroding cohesiveness of general education (Boyer, 1981, pp. 4–5). The belief animating the general education movement was that these problems could be solved by reemphasizing the arts and the values associated with classical humanism that emphasized wholeness of knowledge and of human nature. These arts and values are "general" in four ways: (1) They apply to all subject areas; (2) they embrace all basic skills; (3) they affect the formation of the whole person; and (4) they provide guidance for all humans (McKeon, 1964, pp. 159, 171–172).

At the heart of the general education movement and of liberal humanism was the implicit notion of interdisciplinarity. There were two differing conceptions of interdisciplinarity at work: **traditional interdisciplinarity** and **pragmatic interdisciplinarity**. The former focused on the classical and secular ideals of culture and liberal education. The latter focused on historically situated problems of society (Hutcheson, 1997, pp. 109–110). What both conceptions held in common, though, was the notion that general education is "the place where all the parts would add up to a cohesive whole" (Klein, 2005a, p. 31). The magnet holding these diverse pieces together was thought to be a common core of great books and ideas based on two millennia of Western cultural development. Requiring students to study this common core of knowledge, advocates believed, would stem the rising tide of "materialism, vocationalism, empiricism, relativism, specialism, and departmentalization" (Graff, 1987, p. 162). Thus, one of the first motivations for interdisciplinary studies in the United States was to unify knowledge (C. Anderson, 2001, pp. 456–457).

The Cold War Era and Interdisciplinarity

After World War II, a second general education reform movement emerged, triggered by the 1945 Harvard report, *General Education in a Free Society.* The report called for a new general education curriculum based on the sciences and writings of the European humanist tradition. Against the backdrop of fascism and communism, proponents intended the curriculum to provide a common core of knowledge, beliefs, and values centered on the

ideals of freedom and democracy—in short, a national ideology opposed to communism in the Cold War era (Bender, 1997, pp. 20–21).

At the same time, criticism of the disciplines intensified and focused on two themes. The first was the enormous power that the disciplines had accumulated since the turn of the century. Influenced by Friedrich Nietzsche, French philosopher Michel Foucault argued in the 1960s that the disciplines are not just a way to produce knowledge; they are a sophisticated mechanism for regulating human conduct and social relations. He found the examination to be the "quintessential practice that epitomizes both the modern power of knowledge and the modern practice of meticulous disciplinary control" (Hoskin, 1993, p. 277).

The second criticism focused on the deepening isolation of the disciplines from each other. Tony Becher (1989) uses the anthropological metaphor of **tribes** to describe the disciplines, each having its own culture and language:

> Men of the sociology tribe rarely visit the land of the physicists and have little idea what they do over there. If the sociologists were to step into the building occupied by the English department, they would encounter the cold stares if not the slingshots of the hostile natives. . . . The disciplines exist as separate estates, with distinctive subcultures. (p. 23)

Echoing Foucault, Moran (2010) complains that the disciplines exercise their considerable power by "permitting certain ways of thinking and operating while excluding others" (p. 13).

University Reforms in the 1960s and the Emergence of Interdisciplinary Studies

This critique of the disciplines was strengthened by the confluence of three major developments in the United States in the 1960s: the Vietnam War, the student revolution, and dramatic changes in social mores. Combined, these served as a catalyst from which emerged new thinking about how the academy should relate to society (Mayville, 1978, p. 3). This new thinking called for radical university reforms, one central element of which was the elimination of the traditional academic disciplines in favor of holistic notions of training that were closer to the practical problems of life (Weingart, 2000, p. xii). The disciplines and the scholarship that they produced had failed to explain, or had ignored, the great social movements and ideological struggles that characterized the period. These included the civil rights, anti-imperialist, antiracist, and women's rights movements. To that generation of students and young faculty, "The disciplines seemed increasingly irrelevant or even obstructionist to their quest to understand, address, and solve the great issues of the day" (Katz, 2001, p. 520). By contrast, *interdisciplinary studies* became a programmatic, value-laden term that stood for reform, innovation,

progress, and opening up the university to all kinds of hitherto marginalized publics (Weingart, 2000, p. xii). The radicalism of the 1960s produced new fields such as African American studies, women's studies, and ethnic studies, and new definitions of culture and politics.

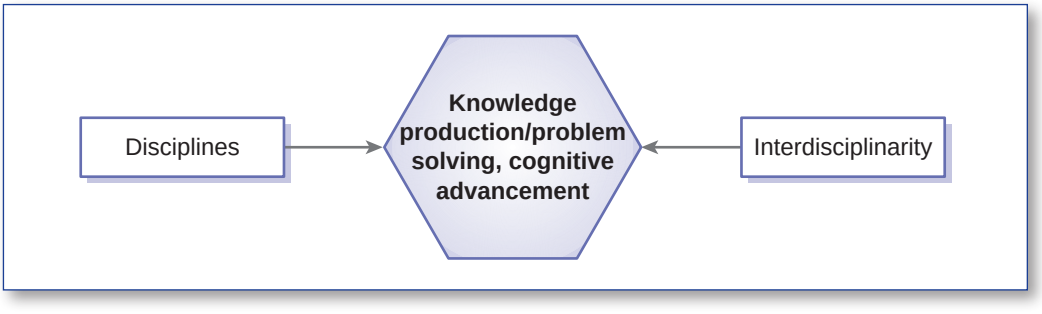
But by the late 1970s, when the social struggles had subsided and mundane academic routine had returned to the universities, the call for interdisciplinarity became much less urgent. "What had seemed progressive only a few years earlier appeared outdated, if not quaint" (Weingart, 2000, p. xii). Yet under the surface calm, young interdisciplinarians such as William H. Newell and Julie Thompson Klein were persistently questioning what constituted legitimate subjects of inquiry, and by their work, they began slowly to reconfigure the contours of knowledge and the methods through which such knowledge was produced (Katz, 2001, p. 520).

Interdisciplinary Studies Becomes an Academic Field

In 1979, a group of 50 interdisciplinarians led by Newell decided that they needed to have their own professional organization and journal and formed the **Association for Integrative Studies (AIS)**. Its purpose was to study interdisciplinary methodology, theory, curricula, and administration. In 1982, AIS launched a peer-reviewed journal, ***Issues in Integrative Studies***. Within a decade, AIS, under Newell's leadership, became a national voice for interdisciplinary studies and a professional home where several hundred interdisciplinarians could work together to develop the potential of the field.

The founding of AIS converged with a broader development that reflected a fundamental change in the way knowledge is produced. There is, observes Peter Weingart (2000), "a growing pluralism both in the locations of knowledge production and in the patterns of initiation, production, and use of knowledge as well as its disciplinary combinations" (pp. xi–xii). This development is uneven and does not affect all the disciplines in the same way. For example, in the natural sciences, the disciplinary boundaries seem to be more

Figure 2.1 Complementary Ways to Produce Knowledge and Solve Problems



fluid than in the social sciences. Inside the university, where the disciplines command great respect, the goal of knowledge production is to *understand*. However, outside the university, where the goal is to generate practical knowledge in order to *solve practical problems,* the disciplines command less respect and "are even frowned upon as obstacles to innovation or as providing a skewed perspective" (p. xii).

Finally, as disciplinary boundaries are becoming more permeable and as the number of new fields and specialties grows by the day, interdisciplinarity is becoming a fairly common experience. This development, however, does *not* signal the beginning of the end of the disciplines and their replacement by interdisciplinarity. Rather, it shows the limits of the disciplines and the need for interdisciplinarity.

The interdisciplinary research process presented in this book offers a way to apply basic research from relevant disciplines to two types of problems: complex, real-world problems that concern society and science and the need for meaning making that is the focus of the humanities. Both the disciplines and interdisciplinarity are needed and should be viewed as complementary rather than contradictory ways to produce knowledge and solve problems, as shown in Figure 2.1.

Assumptions of Interdisciplinarity

The interdisciplinary approach to research and learning distinguishes this academic field from the disciplines. All disciplines, interdisciplines, and fields of study are based on certain assumptions that provide cohesion to the field. In this regard, interdisciplinary studies is no different. There are at least four assumptions that anchor this diverse and rapidly evolving field, though the extent of agreement on each of them varies.

The Reality Beyond the Academy Requires an Interdisciplinary Approach to Research and Education

Interdisciplinarity reflects the reality that is beyond the academy. It is, according to a recent study by the Carnegie Foundation for the Advancement of Teaching, uniquely able to "address real-world problems, unscripted and sufficiently broad to require multiple areas of knowledge and multiple modes of inquiry, offering multiple solutions and benefiting from multiple perspectives" (Huber & Hutchings, 2004, p. 13). The term *interdisciplinary* is appropriately applied to knowledge of complex problems. A disciplinary approach might suffice to fill gaps in knowledge, and improvements in databases and search engines might suffice to address the fragmentation of knowledge. It's complexity that necessitates an interdisciplinary approach.

The Disciplines Are Foundational to Interdisciplinarity

Speaking for many interdisciplinarians, Deborah DeZure (1999) says, "Interdisciplinarity is not a rejection of the disciplines. It is firmly rooted in them but offers a corrective to the dominance of disciplinary ways of knowing and specialization" (p. 3). We need academic specializations: groups of scholars who share preferences for certain theories, methods, and phenomena of study. But we also need interdisciplinarity to broaden the context and establish links to other ways of constructing knowledge. Indeed, interdisciplinary study, grounded by definition in the disciplines, is both complementary to and critical of them at the same time (Newell, 1992, pp. 212, 220).

Some interdisciplinarians, though, share an **antidisciplinary** view, preferring a more "open" understanding of "knowledge" and "evidence" that would include "lived experience," testimonials, oral traditions, and interpretation of those traditions by elders (Vickers, 1998, pp. 23–26). However, there is a problem with this approach. Without some grounding in the disciplines relevant to the problem, borrowing risks becoming indiscriminate and the result rendered suspect. Moreover, those who reject the knowledge claims of the disciplines altogether may be uncertain how to make knowledge claims other than on grounds of life experience. In academic work, says Klein (2005a), it is still necessary to develop disciplinary adequacy or minimum understanding of the cognitive map of each of the disciplines, interdisciplines, and schools of thought relevant to a particular problem (p. 71). How to achieve adequacy in the disciplines relevant to the problem is the focus of Chapter 7.

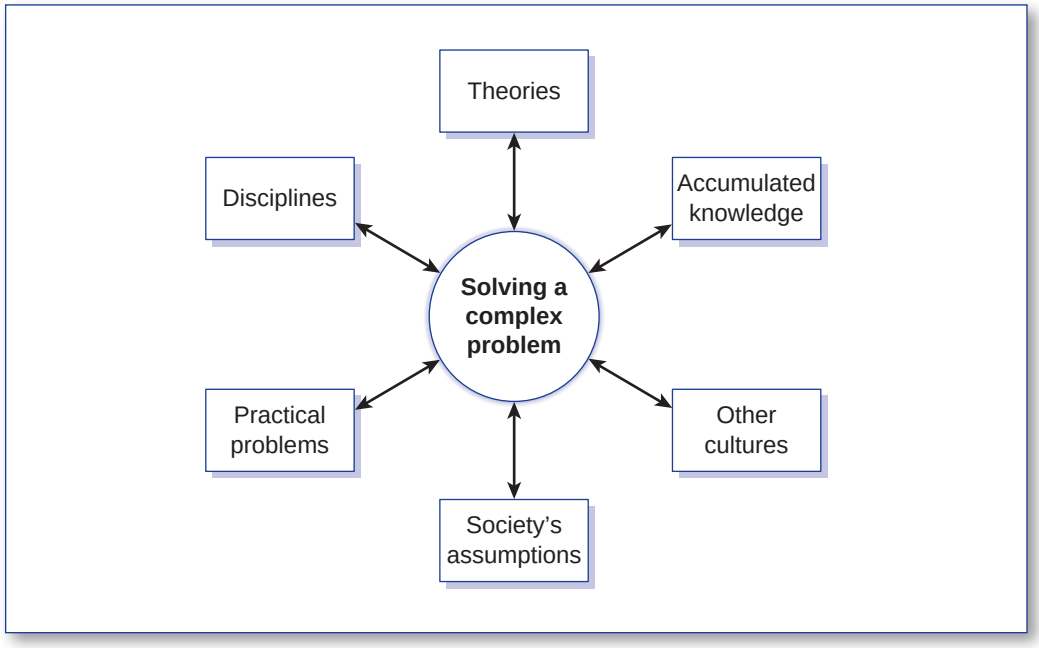
The Disciplines *by Themselves* Are Inadequate to Address Complex Problems

Disciplinary inadequacy is the view that the disciplines by themselves are inadequate to address complex problems. Disciplinary inadequacy stems from several factors, beginning with the pressing need for an integrated approach to increasingly complex social, economic, and technological problems. This was one of the findings of the first authoritative national report on interdisciplinary studies published in 1991 by the AAC&U. It confirmed a widely held belief that knowledge is becoming increasingly interdisciplinary. The reasons cited include new developments in research and scholarship, the formation of new hybrid fields, the expanding influence of interdisciplinary methods and concepts, and the pressing need for integrated approaches to complex social, economic, and technological problems (Klein & Newell, 1997, pp. 395–396). Wolfram W. Swoboda (1979) uses even stronger language: "Individual specialties on their own, it is now clear, simply do not have the breadth of perspective nor probably the willingness to assume responsibility for offering extensive and intensive solutions to social problems" (p. 83).

Disciplinary inadequacy stems from a second factor, namely, the claim that the disciplines provide all that is needed to make sense of the modern world. This is so, states Ananta Kuma Giri (2002), observing that there comes a point when disciplinary certainty has to be abandoned in order "to discover the unexpected truths of reality in the borderland" (p. 110). The disciplinary approach fails, she argues, because "whatever categories and concepts we use to make sense of reality, they are not adequate to provide us a total picture" (p. 110). Stanley Fish (1991) notes, "As soon as disciplines are fully established they come quickly to believe in the priority of their own concerns" (pp. 101–102). He complains that the disciplinary boundaries that characterize the university "are not natural but historical" (p. 105). "The problem with disciplinary thinking," says Giri (2002), "is that it fails to realize that its claim to universality needs to be relativized by recognizing the significance of other disciplines in gaining multiple perspectives about the world to which both one's as well as another's discipline contribute" (p. 106).

A third factor explaining disciplinary inadequacy is that the world is undergoing a **paradigm shift**. This refers to a profound and transformative change in the philosophical and theoretical framework that dominates a discipline or an approach to knowledge formation. Accelerating globalization of cultural, technological, economic, and demographic flows is rapidly and profoundly transforming the institutions that produce and disseminate knowledge (Friedman, 2001, p. 504). Interdisciplinarity can aid in this process.

Figure 2.2 Cognitive Decentering



Underlying the calls for an interdisciplinary component to liberal education is the recognition that interdisciplinary study encourages "breadth of vision and the development of the skills of integration and synthesis so frequently demanded by the problems of a culture in the midst of a profound transition" (Newell & Green, 1982, p. 23). Many of the challenges of integrating across disciplines are similar to those involved in integrating across cultures.

As society and its problems become more complex, the traditional academic disciplines will not always be able to prepare students for the complex challenges they will face in the professions (McCall, 1990, p. 1319). Professional education in particular needs to grapple with these social changes (which naturally affect how we conceive law, health, education, etc.). A value inherent in interdisciplinarity is the necessity of preparing future professionals to confront the complex behaviors and problems they will certainly face in a profession.

Disciplinary Perspectives Are Partial and Biased

The insistence on integration by interdisciplinarians rests on the assumption that disciplinary perspectives are partial and biased (Szostak, 2007b, p. 34).[6] Academic disciplines provide their own unique perspective on a given problem, as illustrated in the fable of the blind men and the elephant (see Chapter 4). For example, although "power" is a concept relevant to virtually all the social sciences, each discipline has its own definition of power, and each definition is undergirded by certain assumptions, methods, and so forth that are unique to each discipline. To gain a more balanced and comprehensive understanding of "power" as it relates to a problem, interdisciplinarians must develop adequacy concerning the perspective of each relevant discipline (Hursh, Haas, & Moore, 1983, pp. 44–45).

The ability to do this is called **cognitive decentering**, which is the intellectual capacity to consider a variety of other perspectives and thus perceive reality more accurately, process information more systematically, and solve problems more efficiently. The term *decentering* denotes the ability to shift deliberately among alternative perspectives and to bring each to bear upon a complex problem. This type of thinking allows the student to make connections between disciplines and theories, between practical problems and accumulated knowledge, and between a society's assumptions and those of other cultures, as shown in Figure 2.2.

Above all, cognitive decentering enables interdisciplinarians to evaluate the usefulness of various disciplines to understanding complex problems. The importance of this thinking process is evident in everyday decision making, as well as in scientific pursuits. For example, the cognitive process described above is essential in the search for solutions to such problems as energy depletion, environmental pollution, health care delivery, and urban decay, or in considering aesthetic qualities of line, color, form, and texture from the standpoint of music, art, dance, or theater (Hursh et al., 1983, pp. 44–45).

Cognitive Abilities Fostered by Interdisciplinarity

Interdisciplinary learning fosters the development of at least five cognitive or mental abilities. These include the ability to (1) develop and apply perspective-taking techniques, (2) develop structural knowledge of complex problems, (3) create or discover common ground between conflicting insights, (4) integrate conflicting insights from two or more disciplines, and (5) produce a cognitive advancement or more comprehensive understanding of the problem.

Develop and Apply Perspective-Taking Techniques

Research in cognition and instruction shows that repeated exposure to interdisciplinarity results in students being able to apply perspective-taking techniques. **Perspective taking** or the use of multiple perspectives involves viewing a problem, a topic, or an artifact from alternative viewpoints—including disciplinary-based viewpoints (Baloche, Hynes, & Berger, 1996, p. 3). The difference between disciplines and their perspectives is the subject of Chapter 4.

A core feature of the interdisciplinary research process presented in this book is perspective taking and the ability to draw on disciplinary concepts and theories in order to develop a more comprehensive understanding of a problem, text, or system.

Develop Structural Knowledge of Complex Problems

A second cognitive ability that interdisciplinary learning fosters is the development of structural knowledge of complex problems. Students are challenged to assess critically the relationships among the relevant disciplinary perspectives "and evoke a deeper cognitive analysis of the core theme" of the course (Ivanitskaya, Clark, Montgomery, & Primeau, 2002, p. 99). For example, students studying the roots of animosity between Palestinians and Israelis will need to acquire factual knowledge of their history and religion. But to develop "a deeper cognitive analysis" of the problem, they will need to study how each discipline understands and approaches the problem and how these various perspectives interrelate (p. 99). For this reason, this book emphasizes the importance of mapping the problem that is the focus of study.

Create or Discover Common Ground Between Conflicting Insights

A third cognitive ability fostered by interdisciplinary learning is the ability to create **common ground** between conflicting disciplinary insights or theories

(the subject of Chapters 11 and 12). The ability to create common ground is preparatory for performing integration and constructing a more comprehensive understanding of the problem. The research of cognitive psychologist Herbert H. Clark (1996) shows that the activity of establishing common ground is a normal and basic feature of human communication. If it is possible for humans from differing social and other contexts to establish common ground to communicate, then, reasons cognitive psychologist Rainer Bromme (2000), it should also be possible to establish common ground between cognitive constructs such as disciplines and other knowledge formations. Clark's development of common ground theory and Bromme's theory of cognitive interdisciplinarity have important implications for interdisciplinary research and learning. Chiefly, they support the view of interdisciplinarians who argue that integration is fundamental to the notion of interdisciplinarity and that creating or discovering common ground is what makes integration possible. As a result, a growing number of interdisciplinary programs (undergraduate as well as graduate) are applying these theories to their teaching of the interdisciplinary research process. They believe that if interdisciplinarians are self-conscious about process, they should be able to do proactively what people normally do reactively.

Integrate Conflicting Insights From Two or More Disciplines

A fourth cognitive ability fostered by interdisciplinary learning is the "capacity to integrate conflicting insights from two or more disciplines" (Boix Mansilla, 2005, p. 16). Brain research, says Kathy Lake (1994), "points to interdisciplinary learning [and] thematic teaching" (p. 6). For example, students in an interdisciplinary program are more likely to recall a particular historical period if they have integrated insights from the visual arts, musical expression, cinema, poetry, and philosophical and political events of the period. Of course, the extent and quality of integration achieved will depend on the level of the course and the instructor's command of the interdisciplinary research process. This book argues that integration is a hallmark of interdisciplinary education and research.

Produce a Cognitive Advancement or More Comprehensive Understanding of the Problem

Interdisciplinary learning also develops a fifth cognitive ability: using integrated knowledge to produce what Boix Mansilla (2005) calls "a cognitive advancement," or what the research model presented in Chapter 3 calls "a more comprehensive understanding." A **cognitive advancement**, explains Boix Mansilla (2005), is the ability to explain a phenomenon, solve a problem,

create a product, or raise a new question "*in ways that would have been unlikely through single disciplinary means* [italics added]" (p. 16). Interdisciplinary integration, she says, is a means to an end, not an end in itself. This "end" or result or product of integration is a "cognitive advancement" or a more comprehensive understanding (p. 16). How to construct this advancement or understanding is the focus of Chapter 13, and the core premises that underlie the concept of cognitive advancement are identified and explained in Chapter 14.

Reflection on What Interdisciplinary Education Offers

What interdisciplinary learning offers is a way "to harvest the depth of disciplinary knowledge while *also* moving dialectically across disciplines, noting areas of commonality, areas of difference, and providing a holistic framework for further analysis" (Henry, 2005, p. 13). It seeks to empower students by enabling them to bring together the multiple truth claims of disciplinary experts, acknowledge the contingency of their claims, and recognize the potential of integrating them in order to enhance understanding. Interdisciplinary learning also seeks to empower students by cultivating certain traits and skills that are essential for problem solving, decision making, and research.

Traits and Skills of Interdisciplinarians

Interdisciplinary studies is a systematic method of training one's mind and developing one's character. "The effect, if not the purpose, of interdisciplinarity is often nothing less than to alter the way we think about thinking" (Geertz, 1980, pp. 165–166). From the extensive literature on interdisciplinary studies, it is possible to identify no fewer than 15 traits and skills common to interdisciplinarians. Traits are distinguishing qualities of a person, whereas skills are cognitive abilities to use one's knowledge effectively and readily in performing a task.

Traits

Enterprise. The interdisciplinarian is like an entrepreneur in the sense that both are willing to see connections and possibilities that others do not see. And they are willing to assume risk in order to achieve the objective. The interdisciplinarian, like the entrepreneur, sees connections that disciplinarians do not see and the possibility of constructing more comprehensive understandings of complex problems. Cognitive psychologist Rainer Bromme (2000) compares crossing a disciplinary boundary to "moving about in

foreign territory" (p. 116). Interdisciplinarians enjoy venturing into unfamiliar places and entertaining new ideas.

Love of Learning. Those drawn to interdisciplinary studies are intensely interested in the world they live in and welcome opportunities to view the world and its problems from differing perspectives (Trow, 1984, p. 15). Since interdisciplinarians often find themselves in new situations, they must also know how to learn and adapt. They need to know what information to ask for and how to acquire a working knowledge of the terminology, concepts, and analytical skills required to understand a given problem (Klein, 1990, p. 183).

Reflection. Learning is a process of cognitive and emotional transformation. Interdisciplinarians are interested in understanding the knowing process. Reflection occurs when students evaluate sources of information, demonstrate lines of reasoning from conflicting perspectives, evaluate complex problems or objects, discuss controversial issues, or justify an important decision. Reflection also occurs when students examine, perhaps in a reflective paper, their responses to an emotionally charged question (C. Myers & Haynes, 2002, pp. 191–192). Consequently, those engaged in interdisciplinary learning develop a strong self-concept (Bromme, 2000, pp. 116–118).

Tolerance for Ambiguity and Paradox in the Midst of Complexity. Interdisciplinarians accept ambiguity and paradox in the midst of complexity. They must be able to see all sides of an issue, reconcile conflicting perspectives by creating common ground among them, and live with ambiguity to the extent that reconciliation proves impossible (Bromme, 2000, pp. 116–118; Hursh et al., 1983, pp. 44–45). Ambiguity can be unsettling, especially for those who demand quick and clear-cut solutions to problems or have deeply held biases. But ambiguity is a fact of life. Real-world problems are often so complicated that it is impossible to know everything that one needs to know to understand them, let alone solve them. Interdisciplinarians accept that understanding any complex problem is an ongoing process, and that complete understanding of it is often elusive. Accepting that there is always something more to know keeps interdisciplinarians from becoming too settled in their understanding of a problem. They remain open to new perspectives and new insights.

Receptivity to Other Disciplines and to the Divergent Perspectives of Those Disciplines. **Receptivity to other disciplines** means being open to information from any and all relevant disciplinary perspectives. This, in turn, means being willing, even eager, to learn about divergent fields of knowledge, gaining both an intuitive and an intellectual grasp of them (Newell, 1992, p. 215). Receptivity to divergent perspectives means recognizing the possibility

(or reality) of multiple causes, and being alert to unintended consequences, or to small changes that have large effects. Defined in this way, receptivity to divergent perspectives opens up the possibility of new understandings and surprising insights into complex problems. Receptivity to other disciplines and to their perspectives is essential to developing a more comprehensive understanding of any problem. Understanding a discipline's perspective involves not simply knowing what knowledge the discipline offers, but a willingness to deal with its perspective on its own terms, appreciating its assumptions, epistemology, concepts, theories, and methods (Armstrong, 1980, p. 54; Gunn, 1992, p. 239). In other words, the interdisciplinarian needs to be ready, willing, and able to walk in the shoes of the disciplinarian. Chapter 4 emphasizes the primary importance that interdisciplinarians attach to knowing the commonly used elements of the major disciplines in the sciences, the social sciences, and the humanities. But that knowing must be preceded by receptivity.

Willingness to Achieve "Adequacy" in Multiple Disciplines. Being receptive to multiple perspectives is one thing; successfully understanding them is another. The disciplines have each developed a daunting array of skills and knowledge, and at first glance it seems impossible to comprehend fully, let alone master, any one or two of them in a single lifetime. However, there is a difference between achieving mastery and achieving adequacy in a discipline. Disciplinary mastery means learning a discipline thoroughly in order to practice it, whereas **disciplinary adequacy** means merely comprehending how that discipline characteristically looks at the world in terms of its perspective, phenomena, epistemology, assumptions, concepts, theories, and methods (Klein, 1996, p. 212). The interdisciplinarian needs only to achieve adequacy, meaning knowing the discipline's defining elements and important insights relevant to the problem. How adequacy is achieved is the focus of Chapter 7. This knowledge allows one to have a basic "feel" for the discipline and an understanding of how it approaches the problem. Interdisciplinary learning develops the ability to know the limitations and biases of a discipline, to discover the benefits and perspectives of a discipline, and to understand how a discipline works simply by forcing us to see one discipline in light of another (Carlisle, 1995, p. 10).

Appreciation of Diversity. Appreciating diversity means, simply, having respect for people holding different views, or who are devoted to different faith traditions and different cultures, or who are of different ethnic or racial backgrounds. Interdisciplinarians, acutely aware of their own biases, acknowledge that different points of view are necessary to produce new understanding or new meaning (Newell, 1990, p. 71).

Willingness to Collaborate. Interdisciplinarity is often a collaborative process. No one person, no matter how thoroughly trained, will ever

have a complete understanding of any given problem or issue. This includes the interdisciplinarian investigating it. The interdisciplinarian typically draws upon the insights of disciplinary experts. An expert interdisciplinarian is one who is able to address an issue either by working alone or as part of a team. Willingness to work with others applies especially to interdisciplinarians engaged in technical and scientific research that most commonly involves teamwork. Effective participation in interdisciplinary teams is not so much a matter of individual traits as it is of learned behavior. People develop intellectual skills, such as dialectical and metaphorical thinking, and patterns of group communication skills that permit them to learn from and be taught by other members of the team (Newell, 1998, p. 551).

Humility. Humility is the one learned behavior that all scholars, including interdisciplinarians, surely need when faced with a problem that exposes the limits of one's training and expertise (Newell, 2001, p. 22). While disciplinarians can take comfort in knowing all there is to know about some sliver of reality that is their specialty, interdisciplinarians cannot hope to achieve this level of mastery of every facet of a complex problem. Instead of experiencing pride of mastery, the interdisciplinarian is humbled by knowing how much the relevant domains of knowledge do not know about the complex problem. Practitioners of interdisciplinary studies bring to their craft a humility that comes from knowing what they do not know. Those involved in interdisciplinary investigations quickly discover that they do not know and cannot know everything about the research question. But by using the interdisciplinary research process, they can at least move toward knowing more about the question than they would otherwise be able to learn using a purely disciplinary approach. "Through this process students discover the need for further learning, and they develop respect for different views" (Wentworth & Davis, 2002, p. 17). Interdisciplinarity, according to the Organisation for Economic Co-operation and Development (OECD), "is first and foremost a state of mind" (1972, p. 192).

Skills

Ability to Communicative Competently. Interdisciplinarity is a highly interactive field requiring **communicative competence**, which is the ability to comprehend and translate terminology that is discipline-specific. Each discipline has not only its own set of skills and knowledge but also its own technical language that it uses to describe its assumptions, concepts, and theories. Though discipline-specific terminology is effective "shorthand" for experts to use to communicate with each other, it is often incomprehensible to those outside the discipline. This places an

additional burden on the interdisciplinarian, who must grasp this terminology and make it accessible to others, regardless of their field of expertise (Klein, 1996, p. 217).

The variety of disciplinary perspectives involved in interdisciplinary research often necessitates the building and coordination of teams of individuals with different training and expertise. An interdisciplinarian must possess keen interpersonal relations skills and be able to engage in productive communication with people who hold a variety of interests, beliefs, and mind-sets, even if some of these sharply conflict.

Interdisciplinarity facilitates communication across disciplinary boundaries. This communication is possible because, despite the differences in jargon, there is overlap among the assumptions, concepts, theories, and methods used by the disciplines as well as underlying recurring patterns in both natural phenomena and human behavior that are perceived across disciplines. In many cases, each of the disciplines is saying something similar about the nature of the world, only in a different language.

Ability to Think Abstractly. **Abstract thinking** is a higher-order cognitive ability that enables one to understand and express an interdisciplinary understanding or meaning of a problem symbolically in terms of a metaphor, or to compare a hard-to-understand and complex phenomenon to a symbol that is simple, familiar, and easy to understand. Abstract thinking is an essential skill for many professions and is particularly desirable for the interdisciplinarian, especially when working in the humanities. To achieve the objective of a more comprehensive understanding, the interdisciplinarian has the goal of integrating different disciplinary insights into the problem and, ideally, should be able to express this understanding or meaning symbolically such as using a metaphor. Abstract thinking is an important skill in the interdisciplinarian's toolbox. However, "abstract thinking represents '*an* end, not *the* end' of the thinking process" (Seabury, 2002, p. 47).

Ability to Think Dialectically. In many ways, dialectical thinking is the opposite of disciplinary thinking, but it is an important skill of the interdisciplinarian and a method that underlies interdisciplinary work. **Dialectical thinking** is the ability to view issues from multiple perspectives and to arrive at the most economical and reasonable reconciliation of seemingly contradictory information and positions. It is a method of determining the truth of any assertion by testing it against arguments that might negate it. Composition expert Anne Berthoff (1981) believes that there is a natural dialectic of the mind, "a dialectic of sorting and gathering, of particularizing and generalizing" (p. 105). Indeed, one writer goes so far as to state that dialectical thinking "is *the* underlying method of interdisciplinary work" (W. Davis, 1978). Rather than viewing differences, tension, and

conflict as barriers that must be overcome, the interdisciplinarian views these as part of the integrative process.

Ability to Think Creatively. Interdisciplinarity requires creativity. The creative idea is a "combination of previously unrelated ideas, or looking at it another way, a new relationship among ideas" (G. A. Davis, 1992, p. 44). As applied to interdisciplinary work, **creativity** is a process that involves rethinking underlying premises, assumptions, or values, not just tracing out the implications of agreed-upon premises, assumptions, or values. Creativity involves iterative (i.e., repetitive) and heuristic (i.e., experimental) activity (Spooner, 2004, p. 93). Creating common ground among conflicting insights, for example, may well involve iterative and heuristic activity. The techniques and methods useful in creating or discovering common ground, engaging in integration, and producing an interdisciplinary outcome are identified in Part III.

Ability to Think Holistically. **Holistic thinking** involves thinking about the problem as part of a complete system. According to Irene J. Dabrowski (1995), "A holistic perception of reality—*seeing things whole*—requires interdisciplinary focus [italics added]" (p. 3). Aspects of holistic thinking include inclusiveness that accepts similarities as well as differences, comprehensiveness that balances disciplinary breadth and disciplinary depth (disciplinary specialties privilege depth over breadth), ability to associate ideas and information from several disciplines and connect these to the problem, creativity that is dissatisfied with the partial insights available through individual disciplinary specialties and that produces an interdisciplinary understanding, and metaphorical thinking that visually expresses the resultant integration.

Reflection on Traits and Skills of Interdisciplinarians

Some of these skills and traits, such as holistic thinking, typically receive greater emphasis in interdisciplinary contexts than in disciplinary contexts. These skills and traits are arguably desirable for anyone who wishes to lead a meaningful and productive life in any field of endeavor.

Chapter Summary

The drivers of interdisciplinary research and education are formidable and are unlikely to be reversed. What began as a fad in higher education has become a fixture of the modern academy. The interdisciplinary critique of the disciplines is based on seven problematic characteristics of the disciplines, but these limitations in no way justify abandoning them. An

examination of the origins of interdisciplinarity and interdisciplinary studies shows that the historical curriculum of European and North American universities was a common core of undergraduate studies deeply rooted in the humanities and the ideals of the generalist model. By the late nineteenth century, however, the generalist model was challenged by a combination of cultural, economic, and educational factors that led ultimately to the modern system of disciplinarity. The negative impacts of knowledge fragmentation, in turn, led to calls for reform of the general education curriculum at the end of both world wars and the rediscovery of interdisciplinarity. The social and political upheavals of the 1960s led to a concerted effort to inject interdisciplinarity into academic culture beyond the confines of general education through the establishment of interdisciplinary courses and programs. This effort continued, though with less intensity, into the 1980s and 1990s. By the turn of the new millennium, the increasing importance of interdisciplinarity was established, and there is now far more agreement on what interdisciplinarity is, what it assumes, and why it is needed. Students are benefiting from the traits and skills inherent in interdisciplinarity research and learning. The commonality undergirding these developments is the growing recognition of the importance of integration to interdisciplinary studies and its ability to produce new knowledge. The integrative process draws on the disciplines and their insights to address problems and questions that require an interdisciplinary approach. This approach is the core feature of the interdisciplinary research model, which is the subject of Chapter 3.

Notes

1. Klein draws from the seminal report *Interdisciplinarity: Problems of Teaching and Research in Universities* resulting from the seminar organized by the Centre for Educational Research and Innovation (CERI) and issued in 1972 by the Organisation for Economic Co-operation and Development (OECD), pp. 44–45.

2. For a more detailed discussion of science and funding priorities for research, see Stuart Henry (2005), "Disciplinary Hegemony Meets Interdisciplinary Ascendancy: Can Interdisciplinary/Integrative Studies Survive and If So, How?" *Issues in Integrative Studies, 23,* pp. 13–15.

3. Source: Harcourt: Excerpt from THE LITTLE PRINCE by Antoine de Saint-Exupery, copyright 1943 by Harcourt, Inc. and renewed 1971 by Consuelo de Saint-Exupery, English translation copyright © 2000 by Richard Howard, reprinted by permission of Houghton Mifflin Harcourt Publishing Company. Egmont: From *The Little Prince* by Antoine de Saint Exupery © Editions Gallimard 1943 and 1971. English translation © 2000 Richard Howard. Published by Egmont UK Ltd London and used with permission.

4. According to Rick Szostak (personal communication, January 2, 2011), the economic methodologist Thomas Mayer has long criticized economists for this. He notes that if A causes B, which in turn causes C, and economists understand how A causes B only, they will just assume that B affects C in the desired manner.

5. Examples of interdisciplinary breakthroughs may be found in R. S. Root-Bernstein and M. Root-Bernstein (1999), *Sparks of Genius: The 23 Thinking Tools of the World's Most Creative People*.

6. Szostak (2007b) adds, "Interdisciplinarians can, do, and should debate just how partial and biased disciplinary insights are and just how optimistic one should be about the possibility of enhanced scholarly understanding" (p. 34).

Exercises

Trends in Education and Research

2.1 Authoritative voices inside and outside the academy have identified several drivers of interdisciplinary education and research. Concerning the profession or academic program you plan to enter, what aspects of it are being impacted by this powerful trend?

Silos

2.2 Consider this situation: A government program was launched to solve a particular social problem. It was well funded and professionally staffed. However, the program produced unintended consequences and ultimately failed to solve the problem it was designed to remedy because it approached it with a silo perspective. Identify a situation with which you are familiar in which a government agency (at any level) attempted to solve a problem but failed because it approached the problem with a silo perspective. How can silo perspectives be identified and corrected in large organizations?

2.3 Why does the development of generative technologies typically require crossing disciplinary domains?

Successful Intelligence

2.4 How does interdisciplinary education foster the development of what Sternberg calls "successful intelligence"? How might interdisciplinary education be improved in this regard?

Privileged Status

2.5 The chapter has made the case for reducing our dependence on disciplinary modes of knowledge production. How is the process of knowledge production inside and outside the academy already challenging the privileged status of the disciplines?

Fundamental Change

2.6 The origin of the university, the development of disciplines, and the emergence of interdisciplinarity are among the most significant developments in human history because they concern how knowledge is produced, applied, and passed on to succeeding generations. What fundamental changes are now at work that are transforming knowledge production, application, and transmittal?

Assumptions

2.7 How are the assumptions of interdisciplinarity reflective of the contemporary human condition?

Decentering

2.8 Consider the profession you plan to enter. How might your ability to engage in cognitive decentering be an asset when dealing with difficult people or a complex situation?

Cognitive Abilities

2.9 Reflect on the discussion of the five cognitive abilities fostered by interdisciplinarity. How might these abilities transform the way you approach problem solving and decision making?

Inventory

2.10 Of the several traits and skills that are associated with interdisciplinary education, which of these do you currently possess?