Fruits, Salads, and Smoothies:

A Working Definition of Interdisciplinarity

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Abstract: Interdisciplinarity involves bringing together distinctive components of two or more disciplines. In academic discourse, interdisciplinarity typically applies to four realms: knowledge, research, education, and theory. Interdisciplinary knowledge involves familiarity with distinctive components of two or more disciplines. Interdisciplinary research combines distinctive components of two or more disciplines in the search or creation of new knowledge, operational procedures, or artistic expressions. Interdisciplinary education merges distinctive components of two or more disciplines in a single program of instruction. Interdisciplinary theory takes interdisciplinary knowledge, research, or education as its main objects of study. At any given historical period, the interdisciplinary richness of any two exemplars of knowledge, research, and education can be compared by weighing four variables: number of disciplines, the "distance" between them, novelty, and integration.

Although many have tried to define interdisciplinarity (e.g., Berger, 1972; Huber, 1992; Kockelmans, 1979; Mayville, 1979; Stember, 1991), it still seems "to defy definition" (Klein, 1990, p. 11). The most widely cited attempts break down interdisciplinarity into components such as multidisciplinarity, pluridisciplinarity, crossdisciplinarity, transdisciplinarity, and even metadisciplinarity. But these subdivisions, it seems to me, throw little light on the theory and practice of interdisciplinarity, in part because they try to grasp points along a fluid, multidimensional continuum (Blackwell, 1955). Moreover, because such definitions attempt to confer upon this term a precision it does not possess, they run the risk of missing its essential nature. At any rate, I have often tried to use the prevailing definitions in conversations with colleagues and students, with little success.

This brief note proposes a practical definition of interdisciplinarity which reduces some of the uncertainties surrounding this term and which focuses on its essential attributes. In my experience as an interdisciplinarian and as a teacher of interdisciplinary theory, this definition serves as a better foundation in theoretical and practical discussions of interdisciplinarity than anything that has so far been proposed in the English language. The definitional impasse which prevails now, I shall try to show, and some of the difficulties it created in all theoretical analyses of interdisciplinarity, may be overcome by recognizing the fluidity of this concept on the one hand, and its application to four realms on the other. Before we delve into the definition itself, two preliminary concepts must be characterized. First, a *discipline* can be conveniently defined as any comparatively self-contained and isolated domain of human experience which possesses its own community of experts. Every discipline has its peculiar constellation of *distinctive components:* such things as shared goals, concepts, facts, tacit skills (Polanyi, 1962), methodologies, personal experiences, values, and aesthetic judgments. Thus, aesthetic judgments of sound combinations, theorems about whole numbers, and chess opening gambits, are, respectively, distinctive components of music, mathematics, and chess.

Owing to the complex nature of any given discipline, in practical situations, these characterizations must be aided by current conventions, common sense, and intuition. Also, these characterizations are time-dependent, e.g., today's discipline may well have been yesterday's subdiscipline; by the 21st century, some distinctive components of contemporary educational research will be replaced by others.

For *interdisciplinarity*, I propose this minimalist definition: bringing together in some fashion distinctive components of two or more disciplines.

Four Interdisciplinary Realms

In academic discourse and practice, there are four realms to which the term "interdisciplinarity" is most commonly applied. *Interdisciplinary knowledge* involves familiarity with distinctive components of two or more disciplines. Interdisciplinary knowledge is a necessary, but not sufficient, condition for *interdisciplinary research*: combining distinctive components of two or more disciplines while searching or creating new knowledge, operational procedures, or artistic expressions. *Interdisciplinary education* merges distinctive components of two or more disciplines in a single program of instruction. *Interdisciplinary theory* takes interdisciplinary knowledge, research, or education as its main objects of study.

A few examples should make this quadripartite distinction clear. Bertrand Russell--at home in disciplines as far apart as philosophy, history, and mathematics--exemplifies an advanced state of interdisciplinary knowledge. Other notable twentieth-century erudites are Karl Popper, Aldous Huxley, Isaac Asimov, and Arthur Koestler. In previous centuries, erudition may have been more attainable, as witness the encyclopedic knowledge of Aristotle, Descartes, and Goethe.

In his time, Gregor Mendel's work with peas typifies interdisciplinary research (cf. Nissani, 1994). While teaching a rather narrowly circumscribed version of physics to high school students, Mendel was also studying the transmission of characters from one generation of plants to the next. At one point--the watershed mark in his research--he realized that the key to his biological observations was to be found in statistics. By combining his botanical data and simple laws of chance, he achieved a major breakthrough.

Johannes Kepler's first law provides another well-known example of interdisciplinary research. For a long time Kepler tried to fit Mars' orbit about the sun into a circle. The breakthrough in this case took place again at the moment when Kepler *recognized* that the points fell on an ellipse, not on a circle. That is, by combining Apollonius's work on conic sections with Tycho Brahe's data on Mars, Kepler was able to come up with the first law of planetary motion (Koestler, 1959).

Certain subjects can be best taught through interdisciplinary education. For instance, industrialized societies need elementary school teachers, landscape planners, materials researchers, and physicians whose jobs involve the bringing together of diverse disciplines. It is universally agreed, therefore, that their education must have a strong interdisciplinary component.

On other occasions, the motivation for interdisciplinary education is different. One interdisciplinary undergraduate program, for instance, attempts to develop "a holistic understanding informed by materials from various disciplines." Instructors in this program share the beliefs that most courses should draw "on the perspectives or world views of more than one discipline" and that "incorporation or integration of disciplinary perspectives into a larger, more holistic perspective is the chief distinguishing characteristic of interdisciplinarity studies" (Newell, 1992, pp. 212-3). Such a program might, for instance, discuss freedom sequentially from different disciplinary angles, then integrate these angles into a meaningful whole (Newell, 1992). But regardless of motivation, interdisciplinary education combines distinctive disciplinary components in a single course or program of instruction.

Interdisciplinary theorists study interdisciplinary knowledge, research, or education. They study such things as the psychological processes of integrating information from two disciplines, roadblocks to meaningful communication between linguists and biologists, or the pros and cons of teaching science and literature in a single course. An interdisciplinary theorist may or may not be an interdisciplinarian in the other senses described here--in the same manner that a philosopher of science may or may not be a scientist. This manuscript, Klein's book (1990), and a 1992 issue (#3) of *The European Journal of Education*, exemplify interdisciplinary theory.

Criteria for Ranking Interdisciplinary Richness

I have suggested already a working definition of non-theoretical interdisciplinarity: the bringing together of distinctive components of two or more disciplines in a single mind, research endeavor, or instructional program. However, this definition tells us little about the extent of interdisciplinarity in any given exemplar; that is, whether one scholar, research endeavor, or educational program is more interdisciplinary than another. Among other things, such ranking may clarify the nature of interdisciplinarity and resolve a long-standing controversy in interdisciplinary theory.

Because rankings in all three realms are based on similar criteria, I shall explore the interdisciplinary rankings of research activities in some detail first, and then merely touch upon the rankings of knowledge and education. To rank the interdisciplinarity richness of any given research, we need to refine our definition by placing all research along a fluid continuum, ranging from the two imaginary poles of pure disciplinary work to a grand synthesis of all human knowledge.

Experience suggests that this discussion can be best approached in a roundabout way, by means of a homely metaphor of mixing fruits. Let us fancy that we wish to determine the amalgamation quotient of fruit mixtures. When an apple, an orange, or a strawberry is served alone, this quotient is obviously zero. But connoisseurs sometimes wish to mingle fruits. One criteria in determining the amalgamation quotient of our particular dish would be the *number* of different fruits involved. A mixture involving apples and oranges is less amalgamated than one involving apples, oranges, and plums. A second criterion would be *distance*: mixing Mackintosh and Winesap apples would result in less amalgamation than the mixing of oranges and grapefruits, and still less than the mixing of oranges and cherries. Third, there is the *novelty* of the mixture itself. In Western societies now, for instance, mixing bananas, apples, and grapes is not as creative, and unusual, as the mixing of guavas, kiwis, and blueberries. Fourth, and perhaps most important, is the degree of blending or *integration*. The various fruits can be served side by side, they can be chopped up and served as a fruit salad, or they can be finely blended so that the distinctive flavor of each is no longer recognizable, yielding instead the delectable experience of the smoothie. Note that the amalgamation quotient says nothing about quality: in some circumstances, a plain mango will surpass all the smoothies in the world; in others, only a fruit salad will do.

In a similar manner, at any given historical point, the interdisciplinary richness of any two exemplars of knowledge, research, and education can be compared by weighing four variables: the number of disciplines involved, the "distance" between them, the novelty and creativity involved in combining the disciplinary elements, and their degree of integration.

While the meanings of the first three criteria can be readily grasped from the illustrations below, a few words may be in order regarding the more important and complex criterion of integration. In explicating this concept, I shall closely follow Roland Case's (1991) excellent treatment. By "integration" we mean uniting or meshing discrete elements. Integration can be partial, as, for example, when parallels are drawn between elements which remain separate; or complete, as, for example, when separate elements are fused into a single entity. To be meaningful, integration must satisfy the condition of coherence: the blending of elements is not random, but helps to endow our knowledge, research, or instruction with meaningful interconnections and greater unity.

I shall now illustrate the reasonableness and utility of the foregoing discussion by applying it to a few concrete research programs.

The interdisciplinary extent of the labors of a contemporary astronomer tracing the path of a newly discovered asteroid is comparatively low, although even her efforts are influenced and informed by a variety of disciplines. For instance, she may be employing optical instruments (optics); she must take into account atmospheric conditions (climatology); and her labors may be motivated by the desire to know the potential consequences of a future collision between earth and an asteroid (ecology, politics, etc). All the same, our four criteria suggest that her research can be safely placed near the disciplinary pole of the interdisciplinarity continuum. The number of disciplines here is small, they are for the most part related, their merging in a study of this particular problem is by now fairly routine, and the discrete disciplinary components used here can be hardly said to fuse into a single whole.

In the 1950s, morphological descriptions of a single human ulcer ranked even lower in interdisciplinary extent. Such descriptions involved fewer and closer disciplines, hardly any creative combinations, and little integration. By contrast, one might imagine, the re-discovery of the link between psychological stress and stomach ulcers fell farther along the interdisciplinary continuum. Here, insights from the two traditionally distinct disciplines of psychology and physiology were involved. The two disciplines were only occasionally brought together before (e.g., Galen in Moulton and Schifferes, 1945), so the merging of relevant concepts from both required insight. In this case, too, the effort led to the blending of two concepts: thanks to this research, the term "stomach ulcers" evokes in the modern mind both the physiological symptoms and their frequent psychological causation.

Compare Mendel to a modern geneticist who routinely carries out statistical tests of significance. The research program in either case involves the same two disciplines of biology and statistics. Today, the merging of the two for the purpose of testing significance is a routine operation but in 1860 the two were rarely combined. So, judging by the second criterion of distance, Mendel's work was richer in interdisciplinary content. It was richer by the third criterion as well, for it takes little imagination to carry out a test of significance today, but in Mendel's time it took uncanny insight to see that some laws of chance applied to inheritance in peas. Finally, both research programs appear equally integrative, as both assume, for instance, randomness as one essential attribute of living entities.

As a final example, compare the chromosome theory of inheritance (Carlson, 1966) to Torricelli's sea of air hypothesis (Conant, 1951). In both cases, the work was carried out within subdisciplines of a larger discipline (biology in one case, physics in the other). The number of subdisciplines and the perceived distance between them in both cases is roughly the same: genetics and cytology on the one hand, hydrostatics and aerostatics on the other. It is difficult to rank creativity, but it seems that both cases call for a similar imaginative leap, since neither pair was often brought together. The extent of integration, on the other hand, seems greater in the biological case than in the physical one. In physics, the recognition of similarity between pressure under water and on land served for the most part as a heuristic device: it did not lead to a permanent integration of two subfields or concepts. In biology, the juxtaposition of chromosomes and genes altered and enriched the two original subdisciplines. It also led to the establishment of a new borderline subdiscipline, cytogenetics, which is devoted to investigating problems that concern both its parent subdisciplines. And, as a result of this work, key definitions in both subdisciplines changed. By 1920 at the latest, a gene for a geneticist became "a factor of heredity located on the chromosome," while a chromosome for a cytologist became "a nuclear organelle which embodies the factors of heredity." It follows that the chromosome theory was richer in interdisciplinary content than the sea of air hypothesis.

Scholars may again be ranked along the same fluid, four-dimensional continuum. One might be concerned primarily with one's own discipline; one might occasionally incorporate in one's work or teaching some limited insights or methodologies from another field; or one might be a true Renaissance Scholar, not only at home in a number of areas in the arts, sciences, and humanities, but in a position to meaningfully integrate them in one's mind, research, or teaching. A similar distinction holds for education, ranging from strict (and imaginary) disciplinary instruction to the novel, comprehensive (and equally imaginary) integration of all disciplines in a single instructional session.

Finally, interdisciplinary rankings tell us little about quality or fruitfulness: in either scholarship, research, or education, excellence and second-ratedness can be found anywhere along the interdisciplinary continuum.

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