"Only Connect": Bridging the Institutionalized Gaps between the Humanities and Sciences in Teaching

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"Only Connect": Bridging the Institutionalized Gaps between the Humanities and Sciences in Teaching

by Gerald Holton

Academe today is characterized by two contrary movements. On one side we hear and experience the continuing strengthening of “Interdisciplinary Research.” It is most notable in the Natural Sciences, where that research style flourishes where exciting new problems arise at the borderlines between established disciplines. Also, when basic research attempts to deal with societal problems—as illustrated in Chapter 10, under the convenient label “Jeffersonian Science”—it almost inevitably requires a coordinated attack involving several established disciplines.

On the other hand, much of teaching and administration in academe can still be identified by the catch words “Silence between the Disciplines.” Evidence may be found aplenty in scanning the course catalogues of universities, the way most appointments and promotions are handled, not to speak of the barriers within most intellectually social life is carried on among the faculty.

While hoping that the spirit of interdisciplinarity will spread from the research laboratories and find a stronger place in the rest of academic life, I turn to the question how the perceptions and realities of silence between the disciplines came about, and what one may do about it in the classroom.

Historically, such a cultural dysfunction is fairly new. Would the intelligentsia and the educators of earlier times not have been astounded by that proposition? Would, say, Hermann von Helmholtz—physicist, biologist, physician, philosopher, and true Kulturträger—would he and his circle know what we are talking about? Or earlier, Alexander von Humboldt? Or earlier still, Madame Germaine de Stael, or Voltaire, or Émilie du Châtelet (herself a mathematician, physicist and philosopher)? Influential ideas on education, in their different ways, from Aristotle to Pestalozzi, from Friedrich Schleiermacher to Alfred North Whitehead, from Francis Bacon to John Dewey, Robert Maynard Hutchins, James Bryant Conant and others, were designed to prevent that interdisciplinary silence. So is the silence we are discussing here perhaps a by-product of some 20th-century historical, cultural, and social tendencies?
I

That conception is probable. Some saw it coming early. The American historian Henry Adams, writing his Autobiography in 1905, warned there that the course of history in the new 20th century would move away from the vestiges of cultural unity—a unity which he assumed to have been based on the centuries-long hold of religion in the West—and tend toward fragmentation and disunity, multiplicity, toward a state symbolized for him by the violent forces in the newly discovered radioactive elements.

In a less elegant but more concise way, the narrowing of attention on the particular, narrow but fascinating task at hand was encapsulated in a remark by the molecular geneticist in America, Dr. Eckart Wimmer (New York Times, July 19, 2002): "Every minute you don't work, you lose out on science."

Perhaps the most profound attempt to define the source and tragic costs of a dysfunction among the specialties was made many decades earlier. In May 1935, a distinguished German philosopher, no longer allowed to lecture and publish in his own country, was invited to speak at the Kulturbund in Vienna, and later in Prague. His lecture was later expanded in a book with the title "Die Krisis der europäischen Wissenschaften und die phaenomenologische Philosophie." That author was, of course, Edmund Husserl. He developed that material in his famous book of that title (published posthumously in 1954). Much of it has relevance for our topic, not only for education, but also for the current debate about the emergence of elements of a national identity. Indeed, the title of Part I of Husserl's book is nothing less than this: "The Crisis of the Wissenschaften as Expression of the Radical Life-Crisis of European Humanity."

Husserl was painfully aware of the "profound malaise among the educated," "a deeply felt lack of direction for man's existence as a whole—a feeling of crisis and breakdown," and not merely because of the then prevailing political conditions, not merely because of what he called the "irrationalism" among the educated. In a letter at that time he warned of the "complete upset [in] the international community [of] a harmonious unity of the life of nations, with its source in the rational spirit." To Husserl, the schism between the Wissenschaften, the lack of a widely shared culture, seemed to doom the rise of what he
called "the primal phenomenon of spiritual Europe"—a vision of Europe in which Hasserl significantly included the United Kingdom and the U.S.A.

What had come to full fruition, in this view, was the long-range damage unwittingly introduced by Galileo's method of science. For that method had begun to inject, as already prophesized by John Donne in 1611, the schism in what Husserl called a coherent "Weltanschauungsphilosophie." This schism not only manifested itself in the centrifugal forces that tore, Husserl said, "the total worldview of modern man" into "split disciplines." The separate specializations even caused the methods used in those fragments to ape the positive sciences that seemed "so unimpeachable within the legitimacy of their methodological accomplishments." Thereby the Geisteswissenschaften had become powerless to deal with the most fundamental questions of all, "the questions which are decisive for a genuine humankind."

One may quarrel today with some aspects of his analysis. But in my opinion, the net result is correct to this day: Settling for the "split disciplines" would impede the ability and duty of intellectuals and other educated persons to attend properly to their main task—which is to contribute, in the various necessary ways, to the health of "a genuine humankind."

II

If we now set out, in the face of Husserl's pessimism, to build at least into the educational process some of those much-desired bridges between the disciplines, certain tested models of the past come to mind. How about re-instituting, in liberal arts education, the trivium and quadrivium, used for centuries, ranging from logic to astronomy and music? One might call it the encyclopedic solution, meant to assure that future Henry Adamses and Eckhart Wimmers will find common ground and harmonious converse.

Variations of this encyclopedic solution persisted into the 19th century. For example, in a letter of September 7, 1814, Thomas Jefferson, during his retirement at Monticello, wrote to Peter Carr, who had evidently inquired of just such an educational program. Jefferson obliged, giving a detailed list of subjects for the instruction of those
who "aspire to share in conducting the affairs of the nation"--the persons Plato had called the magistrates. Here, much abbreviated, is Jefferson's list":\footnote{Pp.1349-50 in Jefferson's *Writings*, The Library of America, 1984. (For related lists, see pp. 462-63 and 1422-25.)}

Languages (including of course Latin and Greek); history, ancient and modern; *belles lettres*, even with special help to be given to the "deaf, dumb, and blind."

Mathematics, including fluxions, or calculus; physics; chemistry; mineralogy; biology; zoology; anatomy; the theory of medicine; and meteorology.

Philosophy, including ethics, the law of nature and nations, government, political economy. And so forth. But all this is just a start. For those who were to graduate on to a professional school, they would have to add such subjects as architecture, gardening, painting, sculpture, law, theology, and much more.

Why so many subjects to study? Because, first and last, Jefferson believed, as did many after him, that only a people widely educated in a spirit of free inquiry could govern itself and flourish in a democracy. Today, one would add that such an education prepares one to deal better with the complex social problems.

The same Jeffersonian spirit, though less exhaustive, animated later educational experiments, such as those in Contemporary Civilization at Columbia University, and the Great Books Programs (Chicago; St. John's College).

Leaving aside other efforts to find common ground among the disciplines—for example, by the Vienna Circle under Moritz Schlick, its Berlin counterpart under Hans Reichenbach, and the *International Encyclopedia of Unified Science* of Otto Neurath, I turn to one in which I participated some decades ago, with all the enthusiasm of a young faculty member. The idea for it came from the top. Harvard's President at the time was James Bryant Conant. While holding prominent positions in Washington during World War II, he had been startled by the fact that young soldiers with little knowledge about the values characterizing a free society had been sent into bloody battle to preserve it.

At his instigation, a Harvard faculty committee published a plan in 1945, significantly called "General Education in a Free Society" (the famous Red Book), a manifesto meant for all secondary schools as well as universities. (That makes this example less parochial.) At Harvard and many other places, General Education initiated,
for the first two years of college, a series of courses, each a one-year course intended to present a serious overview of the main achievements in knowledge and sensitivity—at least one in the natural sciences, one in the social sciences, and one in the humanities. The subtext of the whole program was chiefly to turn out a citizenry that would have the rudiments of education in each major field; that would be aware of and treasure the heritage of our civilization; and that would, by providing "a common learning for all Americans as a foundation of national unity," meet the "supreme need of an America education," namely, "a unifying purpose and idea."

Indeed, while it lasted, the whole program could boast of many grand courses that attempted to lay out the unities behind each major department of knowledge, and provided a "shared experience" for the student body. The faculty, too, faced with this new and ambitious task, had to subject itself to a serious expansion of its initial interests. And to signal to the faculty his seriousness, Mr. Conant himself, while president, undertook to teach one of those General Education courses.

III

But after some years, the initial enthusiasm waned. Even a program led by distinguished intellectuals such as Conant, Erik Erikson, David Riesman, Paul Tillich, and George Wald succumbs eventually to what Max Weber called the routinization of the charisma. The spirit of fragmentation reasserted itself in the faculty, driven chiefly by the professional embrace of sub-specialization. A rebellion against General Education at Harvard and elsewhere, led first by some scientists, urged a return to concentration on current knowledge in specific specialty fields, rather than the broader, historical and humanistic approach initially launched by Conant. In time, the revised program developed into ever-narrower courses, on the way to a new mandate called the Core Curriculum—one also widely copied throughout America. As one of my colleagues remarked at the time, it was a "departmental takeover" of the General Education program.

At the time, on the very first page of our College's Catalogue of Courses, the announced proud aim of these Core courses is that they "do not define intellectual breadths, as in the mastery of a set of great books...[but] rather seek to introduce students to the
major approaches to knowledge [italics in original] in different specialties": in short, not primarily the pursuit of knowledge, but attempts to demonstrate different ways of thinking.

In practice, this high-sounding purpose presents some problems for a would-be builder of bridges across the separated elements of our culture. For example, under the heading "Literature and Arts," our students are asked, depending on their concentration, to select as few as one out of nearly sixty different, one-semester (13 weeks) courses. These have titles which range from "Fairy Tales" to "Dante," from "American Jazz" to "Recollecting the Way of Life in Pompeii." For many students, such a course would be their only required contact with literature and the arts during their four years of college. Individually, some of these courses may be very well done; but the program as a whole hardly allows for enough depth, scope, and time to nourish a life-long interest.

As to the natural sciences, for which the new Core Course legislation specifically outlawed any historical components, there is a similar large spectrum of mainly narrow one-semester offerings, from which every student not heading for a science career must select two. The result is that a little less than 6% of our non-science students' total educational experience in college is reserved for science and technology. To be sure, this paltry fraction is still better than at most other colleges in the U.S. today, which have largely dropped all structured systems, and let each student assemble his or her own program. Indeed, at present, only 30% of all colleges in the U.S. require even a single hour of science for graduation—building on a largely dismal secondary school education, about which the less said here the better.

In short, in U.S. college education, there has been a visible abandonment of the quasi-encyclopedic approach of the mid-20th century. It is not too much to say that the metaphor of the Bridge has been replaced by that of the College Cafeteria. That also fits with the postmodern current, still strong in American academe, which is directed against any canon, and assigns equal authority to each fragment of interest, be it the epics of the Trojan War or, at one well-known college, alternatively a course, in its Music Department, on "Humming."

The result therefore, in most American higher education today, is the institutionalization of the silence between the disciplines, beginning at the college level. Rarely is the faculty challenged to go beyond its main professional preoccupation; and
rarely do two students share some, if any, of the intellectual experience of their four years of college. Gone are the four characteristics which, according to Daniel Bell's analysis,\(^2\) were common to the General Education programs of half a century ago, as well as the earlier ones at Columbia University and Chicago, and their many imitators:

1) Some attempt at consensus, "instilling in students a sense of common tastes, though not necessarily a single purpose."

2) Some attempt at awareness of tradition, of the history of Western Civilization, "its moral and political problems, the travails of the idea of freedom," and with it instilling some "idea of civility."

3) Going beyond specialization: A bridging attempt, parallel to the track of offering thorough pre-professional training, to widen the specialists' view to encompass "humanitas."

4) Integration. As a balance to the "staggering expansion of knowledge produced by specialization," an emphasis in those General Education and similar courses on "the broad relationship of knowledge, rather than [focusing only] on a single discipline," based on "the underlying assumption...of the need of an interdisciplinary approach."

I know of only a mere hand-full of college programs in the USA which still believe in those guiding principles.

IV

At this point you may wonder whether I can offer any positive response to the problems I have sketched. But even now, some versions of the earlier, honorable models I have cited can flourish in proper hands. There are also other pedagogical approaches, both for secondary schools and colleges or universities, to ameliorate that institutionalized silence. I shall describe briefly three personal experiments in designing such courses, necessarily centered on physics—although (and this is important here) the same principle is worth experimenting with in any field.

1. As in all my examples, one has of course to insist on conveying a sound knowledge of the main subject matter. But the easiest policy to expand on it is to diverge at the right moment from teaching—for example--pure physics, and add key elements of

some of the neighboring natural sciences—astronomy, astrophysics, chemistry, biophysics, and certain aspects of technology (ranging from transistors and radar to magnetic resonance imaging). Such an extension, demonstrating the lack of silence between at least segments in the natural sciences, is by no means artificial. For example, a Physics Department such as mine at home has, on its senior faculty, a large spectrum of scientists with diverse but overlapping interests—including those who have joint appointments with other Departments, in molecular biology, chemistry, electrical engineering, astronomy, mathematics, applied physics, chemical biology, and the history of science. In short: at the level of research, interdisciplinarity is now the key to some of the best new achievements.

2. I turn to a second type of course that aims to prepare students for an appreciation of the other aspects of our culture, while at the same time teaching, say, good science, and show it to be the result of a more general on-going human adventure. This second type of course involves adding to the first exemplar an ordering of the sequence of successive science topics of the course in the historical sequence of its actual developments. It permits tracing the evolution of a science through painfully achieved advances; through frequent struggles with errors, conjectures and refutations; through the complex interplay between theory and experiment. Moreover, it inevitably brings in some philosophical, social and other cultural factors that helped (or interfered with) scientific advances.

When inserted at particular points in the course, this approach, too, does not add greatly to the time burden. But it does add an element that for many students is humanly interesting, alerts them to the "cultural soil" that nourishes science, and is also helpful in the students' own complex struggles with initially counter-intuitive scientific concepts. Let them see how some of those giants experienced troubles similar to their own. For example, Isaac Newton himself early on poorly understood the concept of inertia to be a vis insita, an inseminate force in the moving object—as if a little person inside the body kept pushing it to keep it moving. (So do many students initially, today.)

Such an introduction of the history of science into science courses is fairly new in pedagogy, although there exists a small group that has published texts in this spirit. But at least in the U.S.A., this enlarged approach has been strongly supported by our National

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3 For examples of this mode of teaching, see G. Holton, Introduction to Concepts and Theories in Physical Science (1952 and later editions), and G. Holton and S. G. Brush Physics, the Human Adventure: From Copernicus to Einstein and Beyond, 2001).
Academy of Sciences, in a major report (of 1996) on proper science teaching standards, first of all at the secondary (high school) level. I quote from the booklet *National Science Education Standards* (p. 107): "In learning science, students need to understand that science reflects its history and is an on-going, changing enterprise. The standards for the history and nature of science recommend the use of history of science in...science programs, to clarify different aspects of scientific inquiry, the human aspects of science, and the role science has played in the development of various cultures." The Academy's volume then shows in detail how this might be done.

Another significant benefit derived from including the historical aspects of science in such a course is that it demonstrates by example *commonalities* which persons engaged in scientific work often have with that of creative people on the other side of that famous gap—with poets, composers, artists and others. The commonalities I refer to are the frequent use, during the nascent stages of scientific work, of metaphors, analogies, and themata, of the visual imagination, and of occasional daring leaps of the imagination, unsupported by prior experience or current consensus.

3. My last example of a bridging-type of course exploits cross-cultural potential even more seriously--and therefore is to me the most interesting. This type of discipline-centered course devotes from time to time a lecture period, after appropriate reading assignments, to the interaction among the Wissenschaften, and relates scientific advances to social and other cultural trends and products. Examples can be readily found in the first and second industrial revolutions, based respectively on steam and electricity; in the effects by and on physical science of the electronic deluge; in the occasional, fascinating interactions between science and literature as well as with philosophy; and in the ethical problems scientists can face in their work.4

That approach to teaching ameliorates a grave difficulty with most other programs. The difficulty is this: In practice, as a student sees it, even the most inspiring set of general survey courses, each covering a major field, offers essentially a two-dimensional array which has the silence between disciplines built in from the start. Each of these courses presents its topics like a string of pearls, arranged in some logical order (Fig. 1, at end). In

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the total program consisting of several courses, these separate strings hang side by side, touching one another barely, if at all. Next to the string of topics covered in a science course, there may be—in another building—a course on literature, with its own cascade of linked jewels, each jewel standing for a week's presentation; and next to that hangs another filament bearing the successive kernels in social science; and so on. But while it may have served its purpose some time ago, that two-dimensional, quasi-encyclopedic model of teaching no longer corresponds to the reality and necessity of the world today. The total scope of culture is now not two-dimensional, but multi-dimensional, a kind of web or patchwork of overlapping and diverse elements, some complementary to one another, some even contradictory.

V

To illustrate this point, let me conjure up the idea of a dinner party among friends—for, as J. Robert Oppenheimer once wrote, while we can't share all knowledge, "We can have each other to dinner. We ourselves, and with each other by our converse, can create, not an architecture of global scope, but an immense, intricate network of intimacy, illumination, and understanding."

At such an imaginary future party, one might seat a physicist who is also deeply interested in philosophy and a passionate reader of military history. Next to a sociologist who happens to be also a major connoisseur, a collector of Japanese prints. Next to him is a cellist whose undergraduate degree was in biochemistry; and her neighbor is a Judge on the Judicial Court, who is always eager to hear the latest news in science, not only because a larger and larger portion of the caseload before him involves scientific and technological matters.

What binds them together is not that they fully share one common culture, or that each is ready to recite a sonnet of Shakespeare and the Second Law of Thermodynamics. However, within such groups there are sufficient overlaps of significant elements of knowledge and expertise, of taste, above all of open curiosity. Together, they form a multi-dimensional array.

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5 In *Daedalus*, Winter 1958 issue, p 76.
To make this more visible, imagine a crossword puzzle, in which each series of letters in the words on each of the horizontal lines stands for the various active interests of one person. But each such line of letters intersects, orthogonal to it, with one or more other vertical lines. Together, these vertical lines also represent the several active, life-long interests of other educated persons. It is this overlapping at intersections of lines, this intercalation of a variety of different elements—rather than one common unity—which is at the heart of our modern culture. While it is a fragile compromise, it keeps a culture from decaying into a Tower of Babel. Nobody escapes his or her individual limitations, but everybody in such a group can know and feel enough to be a member of an intellectual network. Indeed, perhaps deep down this has always been so.

The imaginary dinner party I just spoke about is, as you may have guessed, a metaphor for what I hope modern pedagogy, and especially the third type of education, can do to encourage the production of more communities of different specialists with greatly enlarged horizons, whether in academe or other professions, in industry, in governance, and so forth.

To approach such a goal, the traditional way in which we have taught our disciplinary courses is patently insufficient. The traditional course values only training, not orientation. What I am recommending, especially in the third type of course, is what I call a connective approach to the teaching of science, and indeed of each field, not least as intellectual preparation for the student's later life. For historically, most basic findings developed not linearly, but as part of a constellation of an interdisciplinary network.

VI

I end with an example for classroom use, in this spirit, of just one topic for a week or two, the Newtonian synthesis, based on the works of Kepler, Galileo, Descartes, and their contemporaries (Fig. 2). We can show that Newton's ideas were much influenced by debates on the nature of physical knowledge that go back in time to the ideas of the Greeks (line A). Conversely, the success of seventeenth-century physics had a striking impact on later philosophy (F), on Immanuel Kant, on the conceptions of the separation of primary and secondary qualities, and on the mathematization of reality that haunts parts of sociology and philosophy to this day.
Again, among the giants on whose shoulders Newton knew he was standing were Greek mathematicians (C) such as Euclid and Apollonius. In turn, Newton's mathematics made that field flourish later (D). The philosophers of the Age of Reason were of course also deeply influenced by Newton's physics (F), as was, in his way, the founder of a branch of chemistry (G), John Dalton. Turning to political science, one can refer to the explicit acknowledgment of the debt to Newtonian science in the "balance of power" imagery that was used in drawing up the Constitution in revolutionary America (H). Other connections, such as to literature, when Newton swayed the Muses, and to art, can be referred to easily, bolstered by reading assignments. And those links between science and other fields were not unilateral, but worked the other way, too. For example, Einstein's formulation of the relativity theory can be shown to have benefited from his reading in Hume, Kant, Ernst Mach, Spinoza, and Goethe.

There are many other potential examples to use in such a course, based on the presentation both of sound discipline as well as of connective links to the rest of our cultural tradition. In the end, such a course has presented not only that string of pearls, all of them within one field, but at the very least a good glimpse of a tapestry of cross-connections among many fields. Moreover, it can prepare students for the possible need to do interdisciplinary work in real life.

One might now be thinking that only a new Erasmus could run such a course. That is not correct, for two reasons. First, each instructor interested in this approach need not assume his or her version of the course—and they can all differ—has to be given fully developed the first time. The instructor can build up segments, year by year—as many whom I know have done. Second, just as in a typical research laboratory, much of the work, with some guidance from the top, is done by students, so here too, instructors do not act alone. They give the class just enough background to legitimize such an approach, to interest students, and then assign them papers that will lead to further exploration on their own. To this end, one aids them by supplying lists of references and other materials, prepared for this purpose.

To be sure—unless helped by subsidized tutorials--it takes courage for instructors to prepare themselves to convey that antidote against silences between the disciplines. It
would be my hope that the academic institutions might institute programs to help selected, interested teachers or institutions to experiment with developing such courses, for example, by providing publications and teacher training.

What I have proposed, and I have tried in class and teacher training, is not going to repair quickly what Husserl bemoaned as the loss of that supposed "harmonious unity of the life of nations." But students taught in such courses may emerge attuned to the more modern, more practical view of culture as an assembly of different, partial portions of the whole—a mosaic rather than the icon of one great, commanding edifice such as the cathedral at Chartres, which haunted the imagination of Henry Adams.

The time has long come to repair our comfortable, old-style curriculum, and attack its inherent, institutionalized silence between the disciplines. For behind the mere question what to talk about in our next set of lectures, there loom, since antiquity, and never more than now, "the questions which are decisive for a genuine humankind."