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Towards Breaking the Silence Between the Two Cultures:
Engineering and the Other Humanities

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Over the years, I have attended numerous meetings like this one at the Center for the Study of Higher Education. I have noticed that most of the attendees, and certainly the speakers, tend to come from the social sciences or humanities. Only rarely do I see anyone here from Berkeley's College of Chemistry or College of Engineering. I come from the College of Chemistry that includes Berkeley's Department of Chemical Engineering.

I mention this background to indicate that my remarks here are necessarily less abstract, less theoretical and less philosophical than those of most previous seminar speakers. My remarks are probably somewhat simplistic because, as a result of my engineering background, I tend to focus less on generalities and principles, giving more attention to possible solutions of limited practical problems.

About seven weeks ago, I was invited to attend a conference sponsored by the Berlin Academy of Sciences where "Sciences" is not confined to natural sciences but includes also humanities and social sciences. The topic of the Conference was "Sprachlosigkeit", a German word that roughly translated means inability to speak. The subtitle was "Silence Between the Disciplines". The German universities are worried about the increasing gulf between what is often called "the two cultures". This gulf is a problem everywhere, including Berkeley, but it is my impression that it is much worse in Europe than in America.

The International Conference in Berlin was attended by some big names including the presidents of the Humboldt University in Berlin, the University of Uppsala in Sweden and the Central European University of Budapest, as well as some distinguished academics from a variety of institutions including Harvard and Stanford, and the presidents of three major funding organizations: The Volkswagen Foundation, The German National Science Foundation and the Max Planck Society. The speakers were primarily from the humanities and social sciences but there also were two physicists, two biologists and one mathematician. I was the only speaker from Engineering.

Following Karl Pister's generous invitation to present a seminar here, I would like to tell you in a severely revised form some of what I tried to say at the Conference in Berlin.

When talking to colleagues in the Humanities and Social Sciences, one of my most difficult tasks is to persuade them that those who practice science and engineering are not confined to cold logic and bloodless experiments but that instead, science and engineering is a human enterprise, subject to all the paradoxes, inconsistencies and aesthetic judgments that characterize the human condition. When scientists and engineers are at their best, they suffer the same frustrations, self-doubt, and delights common to artists or novelists or literary critics, or to anyone who creates to extend knowledge and awareness. Like all other members of a university, scientists and engineers strive to make a better

world; in participating in this common activity, they necessarily operate within the borders set by our common human nature. I stress this common activity and this common purpose because ultimately, it is this commonality that provides the only sound basis for overcoming the alienation, this Sprachlosigkeit, that under another name, is known as the silence between the cultures.

I can best illustrate what I have just tried to say with a quotation and a cartoon. The quotation is a famous one, from Theodor Adorno: “Die erfolgreichsten Kunststücke sind die, die an ihren fragwürdigsten Stellen Glück haben.” (The most successful artistic creations are those that are lucky at their most dubious places.) Adorno was referring to painting, sculpture, literature and especially to music. However, what he said also holds for science and engineering.

To show how Adorno’s comment applies also to science, let me now show you a cartoon from the journal “American Scientist”:

All students of history know that without occasional miracles, there would be little progress. Along with all the other humanities, sciences and engineering could not succeed without them.

I would like to discuss three topics and again, I want to apologize for my simplistic views.

- I. Two structural reasons that contribute to poor communication between disciplines.
- II. Is Sprachlosigkeit necessarily bad? Why should we worry about it?
- III. Some modest proposals that may facilitate communication across disciplinary boundaries with emphasis on the Bronowski Project for engineering students.

Topic I

I shall be brief concerning Topics I and II. There is no need (nor is there sufficient time) to discuss why there is inadequate communication between the disciplines. Everyone here can easily list several reasons; many of them are obvious. Let me however, without details, call attention to two existential facts that inhibit conversation between what is often – but I think inaccurately – called the human and the natural sciences.

- 1- Time pressure. Meaningful conversation requires leisure. With ever-increasing demands on faculty to “produce,” and in response to the tyranny of accountants with their insatiable hunger for ever more evidence to satisfy accountability, faculty time and energy are saturated. With the pressure of work, much of it “busy” work, we are exhausted.
- 2- Physical proximity. Campus architecture has promoted ghettos where scholars in one discipline are geographically isolated from those in another. Faculty in say, physics, are in the Physics Building while faculty in say, history, are in the History Building, sufficiently far away to avoid contact between those in one building with those in the other. Interdisciplinary conversation can be stimulated by arranging our campus such that professors in different fields share stairways, elevators, conference rooms and parking spaces.

Regrettably, physical segregation also limits communication for students. In their living and social arrangements there is an unfortunate tendency for students in a given discipline to share apartments and to attend social functions with other students in the same discipline. We know that students often learn as much, or more, from other students than from lectures. In the residential colleges at Oxford and Cambridge, undergraduates from all disciplines mingle naturally because every college has an admission policy to assure disciplinary diversity. Similarly, the college fellows, at high table and in the fellow's lunch-room, sit at the next vacant seat, no matter who came before or who comes next.

There is a famous rule by one of the twentieth century's greatest physicists, Niels Bohr: A profound truth is one whose opposite could also be a profound truth. The classic example is the sentence: Life exists on Mars.

Here, in connection with leisure and proximity, I am thinking of the proverb: Familiarity breeds contempt. According to Bohr's rule, this is a profound truth because its opposite can also be true: under the right circumstances, leisure and proximity, familiarity can bring trust and common purpose.

In a short digression, you may be amused, as I was, by the contemporary popularizer of physics, Jeremy Bernstein, a contributor to the New Yorker Magazine, who has generalized Bohr's rule: A trivial truth is one whose opposite can also be a trivial truth. An example is a headline that appeared about 12 years ago concerning the elder President Bush. The headline said: President Bush does not eat broccoli.

Before turning to Topic II, I would like to make two short comments, one philological comment concerning leisure and one surreal comment concerning proximity.

What is the root of the word "scholar"? The dictionary tells us that it comes from the Latin "schola" which also gives us "school", a place where scholarship is practiced. However, Professor Thomas Rosenmeyer from Berkeley's Department of Classics, tells me that the Latin "schola" has a Greek root; it comes from "schole" (accent on the e). What is the translation of "schole"? "Schole" means leisure. – The Greek root indicates that scholarship requires an opportunity to read, to think, to discuss, to reflect, an opportunity that is increasingly rare.

Because physical proximity encourages communication and because physical proximity is encouraged by common needs and interests, I have a preposterous suggestion: On the university campus, let us have one, and only one, giant washroom. Of course, this suggestion is only a fantasy but I am thinking of a large lobby, a friendly living room with soft chairs, blackboards, and a coffee machine, with some recent magazines and, of course! the NY Times and a few other respected periodicals. Attached to this lobby, we have men's toilets on one side and women's toilets on the other. The essential point is, to enter and exit, everyone MUST pass through the lobby. This fantasy follows from my conviction that the best way to combat Sprachlosigkeit is to build on interests and needs common to ALL faculty.

Topic II

Let me now briefly turn to Topic II. Does poor interdisciplinary communication really matter? Why can the university not continue to prosper if we retain our present bifurcated ways? Like essentially everyone here, I believe it does matter and unless we learn to improve, that is, to find more common ground, our universities will decline. My reasons may be somewhat different from those given by others but regardless of such differences, our common goal is to preserve the integrity of the university such that it can fulfill its unique - and I believe essential - contribution to society. No doubt, there are more, but here are five reasons why interdisciplinary communication is important:

1. Major problems in society are inevitably multi-disciplinary. Alleviating poverty, alienation, health, violence, in short, promoting a meaningful life, cannot be achieved by any one intellectual discipline alone.
2. There is much evidence to show that, in any discipline, knowledge grows not at the discipline's center, but at its boundaries where it intersects with other disciplines. While there is some risk in the adoption of concepts and methods from one discipline to another, there is also much opportunity. Scholars in the sciences and scholars in the humanities should engage in mutual conversation because such conversation makes all participants better scholars.
3. The university's obligation and accountability to society require a unified academic institution. A divided UNiversity is not faithful to its name. Only a united UNiversity is in a strong position to obtain public support.
4. Most important, the university has an obligation to its students: to provide an education that goes beyond mere competence in one discipline. Students properly expect to learn how their chosen discipline is related to other disciplines and to the world wherein they will be practicing their chosen discipline. In other words, our teaching effectiveness is much improved - and our lectures are more alive - when we enlarge the scope and horizon of our specialized subject by presenting it not in isolation, but in a liberal context.
5. Finally, it is my belief - indeed my faith - that when I am in meaningful conversation with colleagues from the humanities, I become not only a better scholar and a better teacher; I also become a better person, a better human being: I become wiser; I become more tolerant of other points of view; I become a better citizen of my university; indeed, I become happier when my intellectual and emotional capacities grow; when I learn something new, something different from what I hear from my fellow engineers. At Berkeley we have some giants in the humanities. Listening to their views and concerns provides for me a rich reward of academic life.

If we confine our conversation to our immediate colleagues, we limit our personal and intellectual growth. I can best illustrate by recalling a passage from the novel "Nice Work" by the contemporary English novelist David Lodge. This novel concerns the interaction between a middle-aged, hard-nosed engineer in industry and a young woman named Robyn, a deconstruction-oriented lecturer in literature at a British university. The engineer and Robyn live in different worlds. In an early scene, Robyn has broken up her intimate relation with a young man who is also a literature critic in academia. Robyn decides to teach at another university for a change of scenery. She rents a cozy

apartment with the hope of establishing some new male companionship. However, Lodge tells us, she did not succeed because “all the young men in the university were either married, homosexual or scientists.”

Topic III.

I now turn to my third and most difficult topic: What can be done?

To encourage inter-cultural faculty, I have two suggestions. The first suggestion is not new but as yet, it has not been extensively applied. The second is perhaps, in part, novel. I have no illusion that these suggestions will “solve” the problem but I am hopeful that they can contribute toward a solution. These suggestions are:

- 1- Interdisciplinary research and education.
- 2- Curricular reform toward broadening course content.

Interdisciplinary research and education require common interests. It is encouraged by the ever-increasing fuzziness of borders that, in the past, separated one discipline from another. Humanists, social scientists, natural scientists and engineers learn to communicate when they are together involved in a joint intellectual enterprise. I have in mind research projects, seminars and courses that require input from several disciplines. Here are a few examples:

1. Bioethics: What rules and procedures should govern research in molecular biology and in the practice of genetic medicine?
2. Environmental Law: What are the ethical, social, economic and technical factors that should guide legislation for assuring a healthy and aesthetic environment?
3. Overpopulation and Allocation of Resources: How can we provide a livable world for our grandchildren? What are the scientific, religious, sociological, economic and political considerations that should guide our plans for the world of tomorrow?
4. City Planning, Architecture and Transportation: How can we rearrange our congested urban lifestyle to be more efficient and more consistent with human values?
5. Computers for Visual Art and Music
6. Emergence: What is the philosophical basis for understanding complexity in natural science, linguistics, political organizations, economic cooperation, etc? How can we transcend reductionism?

Surely any one of us could add to this illustrative list. The essential point here is that the demanding problems for intellectual progress are multi-dimensional. This multi-dimensionality should be reflected in our research programs, seminars and courses. Significant efforts along these lines are already in place but as yet, they are limited; much more needs to be done. At Berkeley, we have an impressive number of interdisciplinary courses and seminars but to my best knowledge, these are primarily for graduate students. We need to extend such courses and seminars to our undergraduate curricula. We do some of that but not enough and what we do tends to be “extra” to be outside the

mainstream of our educational programs. Toward that end, our university administrations, funding agencies and professional societies must exercise leadership, the courage to embrace change and to enforce its implementation. Of course, there are exceptions but in general, while professors are often liberal in politics, in university matters, they tend to be conservative and resist change. Further, our universities are so overzealous in democracy and sharing of power, with so many committees and administrative barriers, that meaningful reform through faculty initiative is unlikely or best, limited. If change is to come, it must come from the top. At present, our university presidents and deans tend to be overwhelmed by fundraising, lawsuits, bureaucracy and public relations. Understandably, but regrettably, their primary goal is to keep peace. If there is one thing I have learned in more than 40 years of university experience, it is this: there is no substitute for academic leadership.

Clark Kerr has pointed out that the university has three major constituencies: administrators, faculty and students. To bring about major change in the culture of the University, Kerr tells us that it is necessary to have support from at least two of these three constituencies.

There is little doubt that students want change. And there is little doubt that faculty resist change. Therefore, the key to change lies with administrators.

When I think of the top university administrators I have known here and elsewhere, I find that they have many, very many, fine qualities. But changing the university culture does not receive the priority that it deserves.

Topic III

After this long prologue, I now at last want to come to my main subject: to present some suggestions for curricular reform with particular reference to undergraduate engineering education.

Following many years of teaching undergraduate chemical engineers, I remain saddened and sometimes shocked by our students' ignorance. Our students are intelligent and hardworking but outside of their own discipline, they know very little. The kind of elementary cultural knowledge that you and I take for granted is often totally absent. The traditional concept of Bildung is in serious decline. In Germany, those whose knowledge is restricted to one area are called Fachidioten (subject idiots). I fear that too many of our engineering students fall into that category.

Is it necessary for engineers to have cultural awareness, to have some understanding of history, politics, literature and so on, in short, to be familiar with the social context wherein engineering is practiced? Clearly, the answer is a resounding YES. In our ever-more complex world, the interaction between technology and society demands that engineers must know more than natural science and its applications.

Since World War II, much attention has been given to teaching science to non-scientists in what we may call the "Physics for Poets" tradition. My concern here is the inverse: of course it is important to teach science to non-scientists but equally, it is important to teach humanities and social science to scientists, especially to applied scientists and engineers.

In essentially every university in the United States, the undergraduate engineering curriculum includes a few courses in the non-science area. These courses are usually electives and all too often, students choose a low-level course where the intellectual content is minimal. Further, the number of such courses required for graduation is small and in some cases, credit is given for courses in business administration or technical writing. Such courses may be valuable but they do not address the student's need to learn something about the broad culture where engineering operates. Engineering students get little advice on what courses are best and all too often, in the eyes of the engineering faculty, the so-called "humanities-and-social-science requirement" carries no prestige and tends to be regarded as little more than a nuisance.

There is a marked absence of integration. First, engineering professors are often not interested in having their students enrolled in humanities and social science courses and second, humanities and engineering professors who teach these courses have little interest in teaching engineering students. Third, and perhaps most important, undergraduate engineering students have difficulty in relating what they learn in classrooms devoted to "culture" to what they learn in classrooms devoted to science and engineering. Students receive essentially no help toward integrating their educational experience.

Another negative effect is the prevailing pernicious accounting system where departmental budgets are based on student course enrollment. Every department wants its students to take courses within its department to maximize its own budget and to support its arguments for additional faculty.

With the help of Anne Maclachlan and Michael Starkey, we are in the very early stages of trying to establish what I call the "Bronowski Project," in memory of Jacob Bronowski (1908 - 1974), an applied mathematician at the Salk Research Institute in San Diego who wrote eloquently about science and culture and who created a highly successful television series called "The Ascent of Man", a historical survey that showed how science and humanities, together, advanced Western Civilization. The essential element of the Bronowski Project is an effort to bring into existing well-established engineering courses some relevant material from humanities and social science. (repeat)

Why bring "culture" into existing engineering courses? Why not, instead, use separate courses? Because experience has shown that introducing courses like "Science and Society" into the engineering curriculum is often not useful first, because the engineering curriculum is already badly over-crowded; second, because engineering faculty are unlikely to give the necessary moral and financial support to such courses and third, because it is often difficult to find respected professors in humanities and social science who are interested in contributing to engineering education.

The goal of the Bronowski Project is to prepare educational materials that engineering professors can use in their own regular lectures. (repeat) Here educational materials means reports or examples or case studies, where there was or is a significant interaction between engineering and culture. Each report is about 4 pages with a list of some selected references and some suggestions for discussion topics and for homework assignments. In a given engineering course, the professor might devote say, ten minutes of a lecture to a cultural related topic; we anticipate, we hope, that he or she may do so perhaps once or twice a month.

To illustrate, let me mention two examples that I have used in my own undergraduate course. The first concerns how the development of quantum mechanics by Niels Bohr was stimulated by his early interest in Kierkegaard. Of course the students never heard of Kierkegaard. In about 10 minutes, I outline some of Kierkegaard's views and how these, in part, influenced Bohr's Copenhagen interpretation of quantum mechanics.

A second example concerns how the invention of the Haber process for synthesizing ammonia a few years prior to World War I enabled Germany to continue the war after its supply of nitrates, imported from Chile, was exhausted in 1915. When the war started in August 1914, the German generals were convinced that the war would be over in six months. The British navy prevented German imports of nitrates needed for the manufacture of ammunition; however, ammonia can easily be converted to nitrates. In 1915, when the end of the war was not in sight, the German government initiated a crash program to scale-up what was essentially a laboratory procedure toward industrial-scale chemical plants for making large amounts of ammonia. Without the industrial-scale Haber process, the history of 20th century Europe would be quite different.

I teach chemical thermodynamics. Whenever I spend a few minutes to indicate relations between chemical thermodynamics and its cultural context, student attention rises dramatically. Feedback from students is nearly unanimous: with few exceptions, students approve with enthusiasm; they are grateful for a rare faculty effort to integrate their education.

A few years ago, at a conference on engineering education at the University of Rochester, a thoughtful undergraduate gave a concise summary of the limitations of the prevailing engineering curriculum. He said: In our engineering courses, there are too many scales but not enough music.

The Bronowski Project is now only in an early planning stage. We hope to establish an advisory board containing faculty from a broad variety of disciplines to suggest possible topics for reports to be written by supervised research assistants. Carefully edited reports will be published in paperback and will be made available on the Internet.

It is not at all clear that the Bronowski Project can succeed. I expect that the strongest moral support for this project will come not from faculty, but from students.

There is an obvious key question: If we can supply engineering professors with a large choice of engineering-related cultural reports, will engineering professors use them? I cannot be certain, but interviews with numerous engineering colleagues suggest that many will do so. In general, engineering professors want to expand the horizons of their students but they cannot do so alone. The purpose of the Bronowski Project is to provide the help they need.

Regrettably - I suspect this holds for most disciplines - many engineering professors are uncomfortable when asked to lecture about something where they are not expert; they are reluctant to expose their own inadequacies. Many professors are insecure in the classroom when the topic of presentation or discussion departs from their own areas of specialization. This insecurity discourages the professor from putting his field into context and that, in turn, explains, in part, why so many students have difficulty in relating what they learn in one course to what they learn in another, even when these courses are in the same department.

The Bronowski Project is a modest effort to help engineering professors to look beyond the horizons of their areas of specialization. We all know the stereotype of the absent-minded professor who cannot transcend the borders of his or her own narrow intellectual concerns. This stereotype was effectively described in one of the short stories of the Italian novelist Ignazio Silone: A professor's wife talks about him and says: "Oh, he knows everything. But that's all he knows."

The Bronowski project is a modest attempt to counteract the professor's insecurity, to make it easier for him or her to include some context in his or her regular lectures.

In addition to pertinent episodes from history, we hope to include some reports that present critiques of technology. I am here thinking of carefully selected passages from writers like Lewis Mumford, Jacques Ellul, Max Weber, Bruno Latour, or Hans-Georg Gadamer. It is not clear whether or not engineering professors will consent to include such materials in their courses but I am hopeful that some will have the courage to do so. For the truly courageous engineering professor, we plan to include a report on Heidegger! We also plan to include some materials from literature and art, perhaps something by Keats on negative capability, or some short poems by William Blake or W. H. Auden, or a few paragraphs from the diary of Paul Klee. The purpose here is to show engineering students that there are other ways - in addition to that of science and technology - for viewing the world around us.

One goal of the Bronowski project is to suggest to engineering students that there are alternatives to technology, that there are other ways to attain understanding of our world. To stimulate that suggestion, I occasionally digress from my canonical lecture by citing a provocative quotation and then, for only a few minutes, I discuss what the quotation means. Some examples are shown in Figure 9. For some, indeed for many, engineering students, these quotations come as a shock, an entirely new dimension in their education.

The educational effectiveness of these quotations comes not so much from their content but from the context of their delivery. If these or similar quotations are presented by a professor in the humanities, engineering students have a polite but condescending tendency to dismiss them as coming from an outsider, someone who is a member of a different club. But when they hear them for me, a member of their own club, they sit up and take notice. In this connection, I have a powerful advantage over a humanities professor because, for engineering students, I have credibility.

Although most engineering students have never heard of Descartes, they are inevitably Cartesians. The limited goals of the Bronowski project cannot include a sustained challenge to their Cartesian prejudice but perhaps, it is possible to suggest to engineering students that there are competing philosophies – I am thinking of philosophers mentioned in Isaiah Berlin's book "Against the Current", for example, Vico, Hamann, Bergson - that influence a substantial fraction of "modern" Americans and Europeans to have deep skepticism about science and technology. The Bronowski Project cannot properly present these philosophers but it can alert engineering students to a significant intellectual dimension that is not included in their engineering education.

The Bronowski Project is not perfect; no doubt, there will be problems. But the advantages are clear:

1. Essentially no cost. No new courses, no new faculty are needed. Requirements for graduation are not affected.

2. Because the reports on cultural material are relevant to his or her regular lectures, and because this cultural material is presented by the engineering professor, it is taken seriously; it carries prestige. Because the cultural material is presented as context for the technical material of the regular engineering course, the students benefit from an integrated educational experience.

Ten years ago, the Bronowski Project would have had little chance. Today, the chance of success is better because faculty in the applied sciences are now much more sensitive to the importance of cultural factors in the acceptance and development of technology. Engineering professors are aware of increasing evidence that resistance to technology is rising all over the world. If engineers are to be effective in their work, they must understand the roots, the varieties and the appeal of that resistance.

In a sense, the Bronowski Project is an inversion of a well-known proverb: If Mohammed will not go to the mountain, let the mountain go to Mohammed. The Bronowski Project will not bring the entire mountain. It will bring some mountain samples, well digested and edited to ensure accessibility by young minds that are often quite ignorant but, for the most part, open to new aspects in the spectrum of knowledge.

While the Bronowski Project is an attempt to help engineering professors to include some cultural context in their regular courses, we can imagine an analogous science project - let's call it the "Leonardo Project"- where reports on relevant scientific topics are made available to professors in the humanities and social sciences for inclusion in their regular courses. I recognize that, thanks to radical postmodernism and the excesses of deconstruction, some professors in the humanities may at once reject this idea. But I expect that many humanists may be willing to try to bring some science to their lectures when they can obtain help to do so. I have little experience here and I am anxious to hear opinions from some of the audience who know much more than I do about how humanists and social scientists feel about science and its role in the education of non-scientists.

Finally, I want to return briefly to what I said earlier: a unified UNiversity, that is, a university where all segments blend together, is necessary not only for intellectual progress but equally important, because of our obligation to students, to those who come to us during the best years of their lives, to those who entrust their education to our care.

A long-standing American tradition is based on a sharp division between undergraduate and graduate education: In America, different from Europe, undergraduate education has some specialization but also emphasizes broad education while graduate education is severely specialized. The Bronowski Project is directed at undergraduate education; it is a modest effort to provide some educational breadth for undergraduates in engineering.

To emphasize the importance of educational breadth for excellence in scholarship, I now want to close with a remark made by Jaroslav Pelikan, a distinguished church historian at Yale University

and former president of the American Academy of Arts and Sciences. I do not recall the exact quotation but the essence of Pelikan's remark is this:

The difference between bad scholarship and good scholarship is the result of what a student learns in graduate school. But the difference between good scholarship and great scholarship is the result of what the student learns as an undergraduate, that is, from general education in fields other than the field of specialization.

In Berkeley and elsewhere, can we give new life to the classic educational concept Studium Generale? The Bronowski Project may provide a start toward that goal in the spirit of St. Augustine: Non nova sed nove. Not new but in a new way.