



**New York University**  
*A private university in the public service*

School of Education, Health, Nursing, and Arts Professions  
Program in Educational Communication and Technology

23 Press Building  
Washington Square  
New York, N.Y. 10003  
Telephone: (212) 598-3044, 3637

November 13, 1984

Dean George Gerbner  
Annenberg School of Communications  
3620 Walnut Street C5  
Philadelphia, PA

Dear George,

As you requested, I am enclosing a copy of the speech I delivered at the Opening Dinner of the Annenberg Conference on Science and the Media. I am currently adapting and amplifying parts of it for publication as I do not yet have any of these particular thoughts in print.

I am glad you were pleased with the outcome of the conference. I look forward to reading the reports of the Tuesday task groups when they are written up, as I was not there to hear the final reporting. With best wishes to Ilona.

Most cordially,

Cecily Cannan Selby  
Adjunct Professor

PRIORITIES FOR UNDERSTANDING  
Opening Dinner Address  
Annenberg School of Communications Conference on  
Science and the Media  
Cecily Cannan Selby  
October 21, 1984

To join the political context that the forthcoming presidential candidate debate lends to this evening, I will open with the political dimensions of my topic. Much of the nation, and probably all of us here, do believe that public understanding of technology --- and I will be distinguishing between technology and science --- is a political, as well as an economic and a social priority. Preparation of American citizens to live and work confidently and productively with technologies of ever increasing power is a key challenge for our nation.

A host of political issues can be summarized in the proposition: citizens must not become aliens within and thus alienated from their society. The citizen who has no confidence in his or her ability to deal with the escalating power of technologies will withdraw from the attempt. Such citizens will fear and resist change. They will feel like the subject of A.E. Housman's poem: "a stranger and afraid, in a world I never made". Confident productive citizens, not fearful strangers are a prerequisite of democracy. Powerful non-rational forces (such as cults and creationism) appear ever-present and ready to mobilize into anarchistic or authoritarian groups, those who choose to withdraw from dealing with change and technology.

Another political priority is to maintain and develop our scientific and technical leadership. The National Science Board Commission on Pre-College Education in Mathematics, Science and Technology which Wm. T. Coleman and I co-chaired in 1982/83 concluded that the nation must broaden the pool of students who are highly motivated for advance careers in science, engineering --- and teaching. The nation needs all the talent it can find. Thus ways must be found to search out and develop talent in previously underserved populations. In the underserved I would include students in privileged environments that breed an anti-technology bias with those more socioeconomically and geographically deprived of encouragement and development of "higher order" skills of observation and analysis. Indeed, our Commission report considered this need of such high priority that the first in our long list of recommendations was the following:

"Early and substantial exposure to mathematical and scientific concepts and processes is critical to later achievement. Early creative and stimulating experience is essential to truly equal opportunity and to effective and continuing study in these fields. Thus, the Commission recommends: Top priority must be placed on providing increased and more effective instruction in mathematics, science and technology in grades K-6."

Increased understanding of what such instruction should be and how it can be promoted will be required of parents, teachers, school boards, and legislators if improvements are to be made. To promote appropriate education for youth, community leadership itself must have a useful understanding of all subjects involved --- including mathematics, science and technology: another priority for public understanding.

To turn to economic issues, it is clear that the nation now needs, as never before, a technically skilled workforce to adapt to and advance with new technologies in the work place. As an industrial personnel officer said to me recently "today's worker needs to know more and do more than before". My military friends speak comparably of the broader range of skills, higher order skills, needed by today's military recruit. Rather than debate differing estimates of the proportion of skilled and unskilled labor projected for tomorrow's labor force, I prefer the approach of the N.Y.U. Institute for Economic Analysis utilizing the input-output strategies of Wassily Leontief. Studying Impacts of Automation on employment their report concludes "whether or not a smooth transition from the old to the new technologies can be realized depends to a large extent on whether the necessary changes in the skill structure of the labor force and its distribution between different sectors of the economy (and geographic sectors) can be carried out". Improvements must be made in the skills, in the understanding of technology, in the workforce across the country if we are to make the transitions essential to the nation's economic future.

Among social issues, consideration of human rights also prompt us to seek greater public understanding of science and technology. Jeremy Bernstein, physicist and journalist, makes an eloquent case for human curiosity as justification enough for such literacy.. Do not human beings, have as much right to satisfy their spirit and their curiosity through investigation of science and technologies, as through religion, the arts and philosophy? Rupert Brooke's poem "The Great Lover" includes within his list "These I have loved", "the keen unpassioned beauty of a great machine".

My curiosity was satisfied early as I was born into the world of science and the scientist. through my father. My childhood summers were spent in the stimulating scientific community of Woods Hole, Mass. Through living in this community, science was, to me, a world that encompassed Nobel Laureates walking by to the post office for mail, leaving at dawn on supply boats to collect sea urchins and squid for teaching and research laboratories open day and night with views of island and ocean outside the windows and vari-colored jellyfish in tanks and the technology of centrifuges and spectrometers inside. Lectures in evenings included the world of arts, and of politics; musical concerts were ever present. Church bells rang with song and time. Thus I grew up knowing and feeling Science as art, in culture and with religion.

However, we know that mine was far from a common early introduction to science. In the language of the sociologist it was an "elite" experience, the type of background shared by most men and women of my own and previous generations who elected research science careers. That my "early advantage" led to early academic opportunity and later research experience with superb mentors at the cutting edge of biophysical studies of the cell becomes not surprising, but an advantage that our Commission recommendation, alluded to earlier, seeks for many many more.

Just how significant was my introduction to science, has come home to me over the years as I have sought to convey to others my students, my friends, even my own children, what I, at least, perceive science to be. What we know best is often most difficult to describe --- and certainly why we love them. Many of you here tonight will agree it is particularly difficult to communicate what we know and feel about science, and because it is difficult we often overdo it. When we do, we can rightly be criticized for evangelism, chauvinism and even xenophobia.

We may agree with Dr. Lewis Thomas that part of the common ground science shares with other fields is "bewilderment" --- but the public thinks we are the people who deliver answers. We may believe, with Alfred North Whitehead, that "inert" ideas are not only uninteresting, but dangerous, while our students may believe that what we love most are facts. They would certainly be surprised to hear me quote Cyril Smith, MIT Professor of Metallurgy, say that technology is more closely related to art than to science --- partly because "the technologist like the artist must work with unanalyzeable complexities". It is Physics that gave us the Uncertainty Principle and Relativity --- but the Scientific Method is so often misperceived as a certain route to absolutes. The Technologist is often perceived as inferior to the Scientist, whereas, as Derek DeSolla Price points out "Much more than is commonly believed, the experimenter's craft is the force that moves science forward". He describes, as essential to the development of early 20th Century Physics... "A band of ingenious craftsmen with brains in their fingertips".

As such barriers to cross-cultural understanding have appeared to increase over the years, I have become more and more convinced of the need for in-depth re-examination of our message, in both teaching and in public information. This need is now urgent as our personal or collegial missionary zeal to open the minds and hearts of more people to the joys and beauty of science and technology has become a mission of national importance.

National attention has given priority to these needs, because, as our Commission concluded "At a time when we would like our total population to have some skills and understanding in mathematics, science and technology, we have been most successful in discouraging general interest and achievement in these subjects". Student participation and accomplishment in these subjects decreased significantly during the 1970's.

If we are not "turning on" more students to the study of mathematics, science and technology and thereby not promoting our two-fold goals of scientific and technological literacy for all and excellence for a more socioeconomically broadly based student population, our message must be at fault; it must be very confused. Tonight, I would like to deal with some of these confusions. Not being clear to ourselves, we cannot be to others.

The overriding confusion I find is between science and technology. Through using the terms sometimes interchangeably, but almost always together, we are breeding continuing misinterpretation of each field. They are fundamentally different; related but different.

Let us look first at Technology. Since the dawn of human history man and woman have extended their physical and mental capacities through technologies they have developed. First the power of arms and backs were extended with a bow and an arrow, then the power of legs with a wheel, a chariot, a stirrup. The power of the senses was extended through the development of the reed, the violin, the lens, the electric light. In the middle of the nineteenth century she (I am happy to remind this audience of Ada, Lady Lovelace the first computer scientist!) initiated new technologies (building on earlier innovations like the abacus) to extend the capacity of her mind. The overwhelming escalation of technological power in our time arises from combining computer capability with virtually all the other technologies, be they wheels or rockets, lenses or musical instruments, lasers or typewriters. Man and woman, the technologist, has always organized and controlled the resources of the natural world to do work and make things. Now, through the computer, power for such organization and control, will increase exponentially until, through the emergence of new constraints (and I believe they will emerge) the next plateau is reached.

Defined in this way, what are the characteristics of technology? Above all men and women are central to technology because they made it all! Human beings are thus at the center of the study of technology; they make it and use it. The study of women and men's works, their technology, can illuminate the study of humanity. Should not, then, understanding and investigation of technology belong to all? Fascination with it certainly does. Those of us watching children, (and for me, now with grandchildren, I have more time to watch than I did with my own) know that children are natural technologists and perceive cause and effect relationships very readily.

Not building, in school curricula, on children's experiential and intuitive sense of how the world works, we close doors in their minds and in their relationship with school: we frustrate children's natural instincts for learning. Technological understanding could be an easy early learning objective rather than a later difficult goal.

I suggest one reason public understanding of Technology has been so elusive is that we haven't started with the very young. Technology was not included in the liberal arts education of our early schools and colleges, as they were established in the European classical tradition. In the mid-nineteenth century, the Morrill Act, (Land Grant colleges) and the various vocational education legislations of this century served to provide technological education for future farmers and blue collar workers but not for the future college student or for middle class managers and professionals.

My case tonight is that this is not an appropriate separation for today's society. It should be redressed. The Jeffersonian & Jacksonian educational traditions must be melded: perhaps to create a recombinant form. Through doing what technology itself does so well --- opening minds and senses to increased powers of perception, the goal should be to reach the imagination of the general public at all levels of education, and for all populations. I believe that this is possible, if we start with Technology. To explain, why I make such a claim, let us look at the nature of Technology.

Technology is interdisciplinary, all fields of study use it so it can integrate all fields. It is needed and developed by the arts, by medicine, by manufacturing and management as well as by science.

Technology involves trade-offs, and thus consideration of the values and the risks that underly considerations of social, political and economic costs. Man/woman the creator is always involved with valuing. The audience, the student, can get personally involved with value relationships and the choices they provide should something be made big and slow or small and fast, cheap and imperfect or expensive and perfect? Should it be made?

Technology involves systems understanding of which is transferable to all fields of learning. I can apply what I learn about feedback in electric circuits to psychology and to history. I gain confidence in the proposes of my own learning by observing the transferability of structures and systems and their associated behavior.

Technology involves innovation. One of the paradoxes I find in our current educational deliberations is that innovation for technology transfer is seen as the security blanket of the nation's future-and yet it does not appear in educational objectives. If our learning in all subjects involved the technology of those subjects, consideration of innovation would be intimately involved.

Technology involves the brain and the senses, the affective and the cognitive. Media producers share with educators, I feel sure, the knowledge that learning is maximized by involving the senses with the mind. The "hands on" approach of museums and the best of science educators builds on this understanding.

Understanding principles, such as the conservation of energy, or concepts, such as equilibrium that have been developed over years of observation and analysis is difficult and takes time. It cannot be learned in a single lesson. As the cognitive and behavioral scientists now can help us understand, learners construct understanding. It cannot be given to them. Those of you skilled in multimedia approaches or just in good teaching, know this well. Understanding is constructed from prior knowledge assimilated in different ways at different times. It happens over time. It involves relationships; unrelated bits of information get lost or forgotten. People bring to the classroom, or newspaper or TV screen intuitive senses of how the physical world works. If the teacher, the viewer, does not build on this prior learning the viewer will block out the new learning --- will reject it.

Out of our failure to clarify learning objectives for Science, and to separate them out from learning objectives for Technology, we have imposed on teachers and parents objectives for understanding of principles and concepts that are, briefly, "too much too soon". To quote Arnold Arons, from his rich lifetime of teaching experience "We force a large fraction of students into blind memorization by imposing on them, particularly at high school and early University levels, materials requiring abstract reasoning capacities they have not yet attained".

Thus I support the suggestion, that I first heard from Morris Shamos, that technological literacy and (to quote our Commission report) "useful understanding" is achievable with specific short and long-term objectives for all students and adults in our society. Scientific literacy should be a progressive lifelong goal made available to all without restriction (except for the professional) by limiting short-term objectives.

We should de-snobtify science, makes it attitudes and way of looking at the universe available to everyone and elevate Technology to the elite position it deserves in all subjects: the facilitator and innovator that helps create Art and Science, Music & Mathematics.

During our forthcoming discussions about Science and the Media: Image information and Education, I hope we will keep in mind key distinctions between science and technology. We should clarify goals of scientific literacy that are intellectual, honest, accessible and that we should not continue to neglect technology:

- as content for study --- how and why things work.
- as a vehicle for integrated learning: e.g. Arts and sciences, Economics and Technology, Music and Mathematics
- as a commodity of value --- things made by human beings for human beings, in the engineering laboratory and on the assembly line, have human value.
- as a tool for learning and teaching --- computers, telecommunications, videotext, videodisk and interactive combinations of all of these have potential to expand teaching and learning resources that is at the earliest stages of exploration.

Above all, in exploring Science and Technology, let us identify the nature of the understanding we are seeking. One goal for this public understanding is, for me, that citizens not feel as strangers and afraid in our human-made world.