Contemporary Higher Education:
Perspectives of an institute of technology

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The title of my talk this afternoon, which refers to the perspective of an institute of technology upon contemporary higher education, would have been scarcely comprehensible at the beginning of the nineteenth century. With few exceptions there were no such institutes in the United States. West Point Military Academy, founded in 1802, had a program in technology. That, together with the Gardiner Lyceum in Maine founded in 1823, and Rensselaer Institute, 1824, were all there were. The Erie Canal in New York State, completed in 1825, is sometimes referred to as the first American engineering university, and the Baltimore and Ohio Railroad as the first school of railroad engineering in the United States.[1]

American educators were biased against technical education. *The American Journal of Sciences and Arts* published a report in 1829 from the faculty of Yale which argued for the values of a classical humanist curriculum over a technical scientific one. Only the ancient learning, it claimed, could provide the discipline for the properly trained and cultivated mind.[2] This notable document influenced much of American education against technology throughout most of the nineteenth century. In that respect it mirrored Britain. Not until the early 1900s did Oxford and Cambridge establish chairs of engineering science. In the 1940s all students going up to Cambridge were required to have a reading knowledge of Latin. Only with regret was the requirement dropped, due to the Second World War, that all entering students should also have a reading knowledge of ancient Greek.

But currents were moving in the other direction. The City and Guilds of London Institute was founded in 1880 for the advancement of technical education. This was followed by the Technical Instruction Act of 1889. France was way ahead. With the encouragement of Louis XV the Ecole des Ponts et Chausses was founded in Paris in 1747, "the first engineering school ever."[3] Fifty years later the Ecole Polytechnique of Paris was founded by Napoleon. The French admired and respected engineering. Engineers rose to the top ranks of French society. In Britain they were referred to as navvies, less educated men who worked with their hands.

Until the passing of the Morrill Land Grant Act in 1862 authorizing the sale of federal lands to endow state colleges and universities, technical education in America was largely a matter of personal initiative. An outstanding example of that was Professor Benjamin Silliman, a scientific pioneer who devoted his life to making science popular and inspiring young men to follow scientific careers. One of Silliman's students was Amos Eaton who became the first professor and the driving force behind the newly established Rensselaer Institute, named after its founder.

Stephen Van Rensselaer was born into a wealthy and prominent Dutch family. A Harvard graduate, influential in New York State politics, he lived a privileged life, but he wanted to do something for young people less fortunate than he so he founded a technical institute.

"My principal object," he wrote, "in founding a technical institute is to qualify teachers for instructing the sons and daughters of farmers and mechanics… in the application of experimental chemistry, philosophy and natural history to agriculture, domestic economy, the arts and manufacturers…"[4]

Eaton, as I said, the first professor of RPI, was as enthusiastic and committed to scientific education as Silliman and Van Rensselaer. He required his students to give lectures, perform experiments, and study the scientific principles involved in manufacturing by visiting factories.

It was this professor whom a group of men in Rochester, NY, Nathaniel Rochester among them, invited to teach what they called the Chemical Class. They wanted to find out more about scientific and technological developments in Europe and other parts of America. In terms of scientific and technological interest and the initiative of its members the class was evocative of the Lunar Society of Birmingham, England, one hundred years before. Men such as Richard Arkwright, James Watt, Erasmus Darwin, Josiah Wedgewood, Joseph Priestly met once a month when the moon was full (hence the name) to discuss new scientific and technological developments. The British universities and the Royal Society looked down on such activities. Yet it was the Lunar Society, among several other informal societies at the time in England, that kept the interest going.[5]

The Chemical Class was a success; it made $200 from tuition fees which the members used for books and scientific models. From that they developed their own continuing organization, named the Athenaeum, which was granted a New York State Charter in 1830. This piece of history is of personal interest to me as it was the first step towards what later became the Rochester Institute of Technology where I taught for many years. The Athenaeum continued through much of the nineteenth century rather like educational TV, offering lectures on all kinds of topics: politics, history, the arts, science, geography, literature. It also had a library. For several years the Athenaeum was the most important cultural and educational center in Rochester.

This was a period of massive immigration to the United States. Between 1820 and 1930 thirty-eight million immigrants entered the country. They came from Germany, Ireland, Britain, Canada, Italy, Russia, Scandinavia among other countries, resulting in a huge increase in the size of cities. In 1860 about one person in four lived in a city or town. By 1880 the percentage was one of three; by 1900, one in two.

Rochester shared in this. In 1829, the year the Athenaeum was founded, its population was less than 10,000; by 1885, fifty six years later, more than 100,000. In the fifteen years from 1875 to 1890 over 52,000 people moved to the city. Across the country there was constant building of houses, shops, businesses and manufacturing companies to supply what was needed to keep the economy going. Obviously, also, there was a great expansion of education, but of a largely practical kind. MIT begin in 1859, Virginia Tech in 1872, Georgia Tech in 1885, Carnegie Mellon in 1900, Cal Tech in 1901, the Rochester Mechanics Institute in 1885. The students who attended these institutes were not looking for knowledge for its own sake. They wanted an education that would teach them how to do things, build houses, construct machinery, design railroads, and, of course, provide them with a salary. Their interests were practical.

In 1885 the Bausch and Lomb Optical Company of Rochester, New York, was the largest of its kind in the world. Neither John Bausch nor Henry Lomb had attended university or received technical training. They opened a shop that sold reading glasses, microscopes and other optical goods, but decided they could make more money if they manufactured what they sold. How they did that I find mysterious. Manufacturing requires technical knowledge and business acumen. Where did they learn? The Bausch and Lomb Company was very successful. However, success created a problem: where to find employees. Mr. Bausch wanted to hire a lens grinder. There were none in the city. The decision was therefore made by him and other business leaders in Rochester to create their own mechanics institute. The year was 1885.

The response was more than they expected. Four hundred students turned up for the first class. As their teacher later wryly observed, “We had to arrange a course of study adapted to the circumstances.” It revealed how many young people were anxious to do what they could to improve their lives.[6] Samuel Smiles who was alive at the time (he lived until 1904 almost twenty years later) would have been pleased. It justified the title of his book *Self Help*.

There are, of course, immensely more educational opportunities now than then. For example, Georgia Tech is a renowned technological institute but it is far from being the only one in Georgia. Currently about forty vocational, technical and trade schools and colleges can be found in the state of Georgia. That's one state out of fifty. There is therefore a huge interest across the country in technical scientific professional education.

This returns me to the title of my paper, the perspective of an institute of technology on higher education, and to a question implied by the title: To what extent is the perspective of an institute of technology different from that of other kinds of educational institution?

In some respect there is little if any difference. Every teacher, whether working in elementary or graduate school, faces the challenge and the opportunity of enabling students to learn. Whether in a liberal arts college introducing students to English poetry or in a technical institute introducing students to bio-informatics, the knowledge, the lucidity, the patience and the good humor of the teacher will be tested as much as ever he or she will test the students. Perhaps perspective is not quite the right term, yet if we use it carefully it can be helpful. It includes attitudes the teacher brings to the task of teaching and a point of view about what the results should be. When teaching poetry one directs attention to figurative language, ambiguity, indirection, how to interpret a poet's meaning when it is not clearly stated. The objective should be the understanding of particular poets, and particular forms of poetry, along with the literary and imaginative discipline required to form judgments about poetry.

Learning bio-informatics requires, as one professor put it, familiarity with the language of biology and the language of computers as well as how they interact. Students must call on a great deal of specific data. Ambiguities may be unavoidable, but generally speaking are not embraced as in the study of poetry. Two students can draw quite different meanings from a poem, and neither would be wrong. A similar result from a scientific experiment might lead to further experimentation. It is less likely that the differences would be allowed to stand as valuable in themselves except perhaps to show that that particular experiment won't work and that there is a need to devise another.

In important respects, then, there is no difference and in important respects there is a difference between the perspectives on higher education of an institute of technology, and the perspectives of other schools. In recent years I have had numerous discussions with science and engineering faculty. None argued that the humanities are not important, that studying music or eastern religion was a waste of time given that there are so many important practical matters to teach and learn. But these professors have a job to do, teaching their subjects, and students have a job of preparing themselves for their profession. They have to deal with issues peculiar to what they are trying to do. One is understanding complex material, another, learning how to relate to a pragmatic profit driven environment where most of the students would eventually spend their lives. Yet another is accepting that knowledge the students had worked so hard to acquire could quickly be outdated. These factors are of importance to those who pursue scientific and technological studies. They also govern the perspectives which an institute of technology has of higher education.

I don't find a neat and orderly way to present this other than consider a number of factors, in no special order, which are of particular importance to an institute of technology. They may help to answer my question about perspectives.

Perhaps we could begin with the book whose title is that of this conference, *Self Help*. It was immensely successful, but in a later edition Smiles admitted that the title of his book could be misleading. "It has led some," he wrote, "who have judged it merely by its title to suppose it consists of a eulogy of selfishness."[7] That's not at all what the author intended it to be. What I believe he did intend was that by helping ourselves we are or should be better able to help others.

I can't imagine any college or university of whatever kind which does not give that matter considerable attention. But each does it differently. The Eastman School of Music in Rochester works with children in the community to help them understand and appreciate music and encourages high school students in musical study and performance.

A technical institute provides help in its own way. RIT's Center for Bioscience Education and Training counsels and offers instruction for those who want to change their careers, and for those who have lost their job and seek training in a new career. Our Center for Integrated Management Studies deals not with individuals but with the companies that employ them. A company that has technical problems it cannot address on its own can apply to RIT. A team of faculty and specialists works with the company not only to solve the problem but also to determine how to prevent it from happening again. Such help is extremely practical, but when it succeeds the results are personal, so here the distinction between technical institutes and other kinds of institutions is not as clear cut. What is done in a helping way by all educational institutions is done for fellow humans.

Another issue not specific to only technical institutes but also medical schools, is the amount of factual data students are required to learn. Serious questions arise from that. A recent *Carnegie Foundation Report on Educating Engineers* published last year makes this observation.

"Engineers, as do physicians, nurses, lawyers, clergy and other professionals, work within ever increasing complexity and changing conditions." But that doesn't mean they simply have to learn more. Engineering schools are heavily influenced "by academic traditions that do not always support the profession's needs."[8] More than learning facts, the report cautions, analytical reasoning, practical skills, professional judgment are essential. One engineering faculty member told me that he is removing more and more factual material from the courses he teaches. Another declared that any student can find out anything in a moment with a computer. He doesn't have to learn it, just know where to find it. A colleague disagreed "students are becoming lazy. There's a base of knowledge they have to learn well enough to develop an intuitive understanding of how to relate it to the problems they encounter."

He is correct; certain information has to be learned. On the job there's often no time to look it up on the computer. But the other professors are also correct, as is the Carnegie Report. This is an ongoing educational issue.

A matter of specific concern to institutes of technology is how to attract women. Half, perhaps more than half, of all students in colleges and universities in America are women, but that is not generally the case in technical institutes. Only about fourteen percent of women were enrolled in engineering at RIT in 2002. Thought not a high percentage, it represents change for the better. Years ago I attended a graduation of engineering students. Among the 200 or so men was one woman. Everyone cheered. She was embarrassed. Now many more women are studying engineering. Some refuse to join the Society of Women Engineers. "I'm not a woman engineer, I'm an engineer." Yet stereotypes live on. "Boys invent things. Girls use the things that boys invent."[9] Sometimes girls can't use them. A mostly male group of engineers designed artificial heart valves sized to the male heart. Women, it is argued, "must be part of design teams who are reshaping the world if the reshaped world is to fit women as well as men."[10]

This is of importance to an institute of technology, especially in computing. "The Department of Commerce estimates that through 2012 the informational technology (IT) job growth will be almost double the number of graduates available."[11] Women represent a large potential resource of IT employees. They can be attracted. Carnegie Mellon raised the number of women in its computer programs from seven percent in 1995 to forty-two percent in 2000. [12] Ten years ago Georgia Institute of Technology introduced a requirement that every undergraduate on campus be taught computing. Of course, that included women. In the first few years the failure for women was over fifty percent, but with new teaching methods the failure rate has dropped. In the media computation course women are now succeeding at a better rate than men.[13] Attention is given, at RIT, to attracting women students when they are young. A group of forty high school junior girls was invited to our campus. Each girl wore a t-shirt. On the front was a question: "How many men does it take to build a rocket?" On the back was the answer, in big letters, "NONE!"

Minority enrollment is equally difficult. Some years ago a non-degree technical program was created, hoping to attract minority students, but many who took the entrance exam could not pass it. The local Urban League sued and charged discrimination. Later the charge was dropped. Technical subjects at almost any level are hard. Efforts now are being made to work with young people in their schools. The Vanguard program, in collaboration with the National Action Council for Minorities in Engineering, has been reasonably successful attracting black students into engineering programs. Less than six percent of the nation's two million engineers are African Americans, Native Americans or Hispanic Americans.[14] A major problem is that on a campus with primarily white students the few minority students feel uncomfortable." The same goes for minority faculty. Efforts are being made to create a community of minority students and faculty; when that happens on a campus others are willing to apply. But achieving that community is difficult for the minority faculty and students, and for the institution. Misunderstandings can be created unintentionally that are hard to overcome.

Another issue – costs. Surely every college and university has to deal with costs. Yet it could be argued they are especially difficult to control at an institute of technology. The director of a program in a college of science told me that going through his budget he found one lab was costing roughly $250,000 a year simply to maintain. Eliminate the lab? Yes, but it provided students with hands on experience they needed. The *Carnegie Foundation Report* I mentioned earlier described labs as a missed opportunity.[15] One school teaches beginning anatomy to nurse practitioners and pre-med students by computer simulation in a large classroom. Another school teaches it in small groups with cadavers. Which provides the student with a better learning experience and which is less expensive? "What do we do?" I was asked in an interview, "We buy equipment for $50,000 and two months later it's out of date."

Much of the equipment is not bought but donated, as for example a seven million dollar Heidelberg Press, and a manikin that breathes, bleeds and simulates illnesses, valued at $65,000. In many cases the donated equipment is second generation, not any longer up-to-date enough for actual production, but suitable for teaching.

Some departments have gone a step further by making the following proposal: If we had cutting edge equipment, the equipment that companies are currently using, new graduates would be that much better prepared to start work, which would be to the advantage of the companies they work for. One company agreed and provided a grant of $2 million dollars to be paid in annual installments of $200,000 a year to buy new equipment.

This illustrates the close relationship that an institute of technology must have with the business, industrial community. It's a matter of trust that an institute is really sensitive to their needs. In some respects the workplace is never far away from the classroom, a relationship of particular importance during this recession. The institute does its best to strengthen the companies it works with; the companies endeavor to provide equipment and donations to support the educational programs. Obviously this is part of the perspective on higher education is taken by an institute of technology.

The factors I have referred to; maintaining a balance between the huge amount of information students must absorb in a technical curriculum yet not requiring too much, (the balance can be hard to determine) developing ways to attract women to technical programs and to enroll minority students often unprepared for what is taught, dealing with the real challenge of costs, usually much greater than other kinds of colleges and universities, and focusing on the need to work closely with the business and manufacturing communities. As I stated, the classroom is not separate from the business community, nor from state and Federal governments. They provide necessary funding. Yet what a college or a university teaches, how it teaches, and all decisions about its educational practices and objectives must be determined independently. Generally speaking that is understood.

A further characteristic of a technical institute crucial, yet obvious, is that of innovation. This can mean developing new programs or keeping up to date with those an institute already has. A renowned School of Printing, for decades at the top of its profession began to lose students.

Why? It was not giving attention to new developments in digital printing. Some older faculty didn't like it; new equipment had not been purchased. Students didn't come. An opposite example, when the Food and Drug Administration approved the manufacture of humulin, a synthetic insulin (a break-through for recombinant DNA) our own biology department created a biotechnology program, the first in the nation, to respond to what would be the demand for biotechnology graduates. That was in 1983.[16] More recently RIT created a PhD program in sustainability, a relatively new discipline described simply as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

Other areas of research are in fuel cell technology and nanotechnology both so extensive that different colleges and universities work on them cooperatively, each specializing in a part.

Computer science and informational technology may be the fastest growing discipline of any. This is particularly true in the past three or four years with new inventions and modifications appearing all the time. Digital technology is a great part of this. A professor at a technology forum held at Georgia Institute of Technology last year told a *Chronicle of Higher Education* reporter, "I lead a college of about 130 faculty members, three departments, five research centers, all in the general information technology space in computer science, computational science, robotics. For good or bad we are in the position of having to simultaneously react to what is going on in the IT industry and anticipate it."[17]

At present there are many emerging technologies, each providing research opportunities for those technical institutes that want to pursue them. But which should be pursued? Several factors govern that, not the least of which is money. Others include what an institute is already doing, how a new program or a new direction will complement that, how it will provide opportunities for its present students and attract more.

A development currently being discussed at RIT is affiliation with Rochester General Hospital, the oldest in the city. Many affiliations exist between hospitals and universities. This would be the only affiliation between a hospital and an institute of technology in the United States. In certain ways it makes sense. Bio-medical engineering, would be one example. Artificial hearts have already been constructed. The next step, as a bioengineering professor explained to me, would be to grow a new heart. Existing technologies can be adapted to medical needs such as a walking stick, or cane, that will itself guide blind people away from and around an object in their path, glasses for those suffering from macular degeneration which enable them to look directly at the person to whom they are speaking instead of sideways. The techniques of industrial engineering can be applied to the operating room

An immediate benefit to the Institute would be greater opportunities for students to have real life experiences. Nurse practioner and physician assistant students could go on rounds with medical residents; medical illustration students could be present at surgeries.

What I have attempted through these examples is to describe the distinctive way in which an institute of technology regards higher education. There is much more to it than in this brief survey. Yet one issue remains that cannot be neglected because it underlies them all. It is referred to near the conclusion of the Carnegie Foundation Report. When I read it I was caught by surprise.

> "Because engineering inevitably means intervening in the world, all engineering projects carry with them responsibility for the effects of those interventions. Students need

> powerful learning opportunities much like that of medical students on their first introduction to the clinical care of actual patients, in order to recognize that they will always need to know much more than they do, and that social and ethical connections are as important, if not more so, as electrical and mechanical ones."[18]

What serious minded adult would question that the perspective of a technical institute upon higher education must include more than the practical, scientific, technical subjects that it teaches? Yet making that happen requires going beyond affirming its importance. A great number of students who enter a technical institute know what they want to study and they stay with it until they graduate. They don't want to be distracted by extraneous subjects. Yet even so, many of the same students discover that those subjects, remote from their majors, open their understanding to aspects of life they had never before considered, and they find them to be meaningful and exciting. This requires, however, first rate flexible and imaginative teaching along with administrative support.

Many years ago C.P. Snow, novelist and scientist, wrote an essay on the "Two Cultures," the scientific, technical, mathematical, and the humanistic. He argued that there is a deep gulf between them. Snow did not identify with either side against the other. But his astute observation was an accurate description of much thinking in his time. The term he coined, "two cultures" caught on and has been widely influential. Fifty years later we live in a much more pervasively scientific and technological society, one in which, I would suggest there are not two cultures, but many interacting and overlapping cultures beyond what could have been imagined then.

An institute of technology has the responsibility to help its students experience the excitement of this new cultural environment and make it a part of their lives.

[1] Earl F. Cheit. *The Useful Arts and the Liberal Tradition*. (New York: McGraw Hill Book Company, 1975, p. 59. Quoted from James Kip Finch *Trends in Engineering Education.* (1948).

[2] Richard Hofstadter and Wilson Smith eds. *American Higher Education: A Documentary History*. (Chicago, University of Chicago Press. 1961.) 1:275.

[3] Gretar Tryggrason, Diran Apelian. "Re-Engineering Engineering Education for the Challenges of the 21st Century" *JOM* October 2006, 58.10 p. 15.

[4] Grant Venn. *Man, Education and Work*. (Washington, DC. American Council on Education, 1964) p. 42.

[5] J. Bronowski Bruce Mazlish. *The Western Intellectual Tradition* (New York, London, Harper Torchbooks 1962) pp. 323 ff.

[6] Dane R. Gordon. *Rochester Institute of Technology: Industrial Development and Educational Innovation in an American City*. Second Edition (Rochester, NY, RIT Press, 2007) p. 29.

[7] Samuel Smiles. *Self Help*. (Harmondsworth, Middlesex, England, Penguin Books Ltd. 1986) p. 17.

[8] Sheri D. Sheppard, Kelly Macatangay, Anne Colby, William M. Sullivan. "Educating Engineers, Designing for the Future of the Field" (Stanford, CA *The Carnegie Foundation for the Advancement of Teaching Summary* 2008) p. 4.

[9] Jane Margolis and Alan Fisher. *Unlocking the Clubhouse. Women in Computing*. (Cambridge, Mass, MIT Press 2002) pp. 2.12.

[10] Ibid. p. 3. Matthew Daneman. "IT Gender Gap under Study by Pair at RIT" Rochester *Democrat and Chronicle*. July 20, 2003, 3B5.

[11] *Embedding the Women's College Model Within a Co-Educational Technical Setting: Educating Women to be Leaders in Engineering and Technology*. p. 1 RIT Archives.

[12] *Unlocking the Clubhouse*. p. 137.

[13] Mark Guzdial. "Education: Teaching Computing to Everyone" *Communications of the AGM*. May 2009. Vol. 52. No. 5. Pp. 31-32.

[14] *Rochester Institute of Technology*. p. 515.

[15] *Carnegie Foundation Report*. p. 6.

[16] *Rochester Institute of Technology*. p. 380.

[17] "IT on Campuses: What the Future Holds" *Chronicle of Higher Education*. April 14, 2008. Vol. 54. Issue 30. Pp. B6-B9.

[18] *Carnegie Foundation Report*. p. 9.