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"TECHNOLOGICAL CHANGE AND THE PEDAGOGICAL PROBLEM"
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Robert McClintock putting up one image.

I am sort of a warm-up band for the real work that this session has which is to draw out your views about what will help you accomplish the goals of Gateway and the betterment of engineering education and the betterment of education at large and I simply want to raise some issues, some thoughts, some questions about why this isn't easy to do. And I am an educational historian and I was going to try to speak about things like engineering which I know very little about. I will set my remarks in a historical context and this rather blurry image up here which in a sense, is the topic, the theme of what I want to get across. It is taken from the archives of the Eiffel Engineering Company. It is an image that was done prior to the building of the Tower by quite a bit. As they began to think about what kind of things they wanted to submit to the competition to construct something for the World's Fair in 1889.

It is an image that simply shows the tall structures of Paris, piled on top of each other in 1880. Put next to the Tower that they were beginning to design. And it makes a point that I think is important to keep in mind and that is that in major fields such as architecture or education, transportation, what have you, from time to time, historically, sets of development comes together which fundamentally alter the constraints of that field. The Eiffel Company was recognizing that iron girdles, elevators driven by electric motors, made possible a structure that, up until that time, was really outside the imagination of the architect and the engineer. Up until that time, these other buildings which are the taller things, the structures, starting with the Cathedral at Notre Dame, which is probably a 7 or 8 story structure by our normal count and various columns and the Arc of Triumphe and other things like them. By in large, buildings couldn't go over 5 or 6 stories high because human beings wouldn't like to run up and down stairs multiple times per day, more than 5 or 6 stories at a time.

Developments come which change constraints and the basic starting point that I think that we, as educators, in the last part of the 20th century and the first part of the 21st century, need to think about is the question of whether the digital technologies of information and communication technologies are for education, somewhat like plate glass, forced ventilation, elevators, steel and reinforced

concrete, were for architecture at the end of the 19th century, making possible an entirely different landscape of urban construction.

I think we need to hypothesize that we are in such a transition and what I want to talk about today are some of the factors that make that transition a very, very difficult one and that we, as educators, day in and day out, come up against as we try to do things significantly differently.

How many of you have thought about teaching your courses in a radically different way and concluded, 'Gee, that would be great. But you know I can't really do it'. I have certainly found that in most of my courses. I see a few heads nodding.

How many of you have tried, structured or restructured, a syllabus, said to yourself 'I am going to organize how I work with my students differently this term, this quarter' and then gotten a little ways into the course and found that you had to cut or slide back into the old things you almost always done?

We need to meditate, we need to think about, why such changes are difficult and unlike, in some ways, building new structures that haven't been imagined before, we are trying to introduce radical changes in educational institutions that are very well formed. Our universities, our schools, our system of education is a technology and structure that has evolved and developed over the last 500 years in close interaction with the way printed intellectual resources function in the cultural life of the West and increasingly the world.

I am going to speak primarily from the perspective of schools but it moves right on into the college. The school as we know it was really invented in the 150 years following the introduction of the printing press in Western Europe. There were schools connected with cathedrals and other institutions prior to then, but they were very, very specialized in marginal institutions. Most education was conducted by apprenticeships in one form or another of people going to work as indentured laborers, or members of the household sent off to a noble community or what have you. The school was a relatively limited specialized institution. It was one which had very little internal structure. It was a place where people would come to, somewhat desperately, to learn to read and write to begin with which, prior to print, was a very hard thing to do because you had to write your own grammar book, not really knowing how to write, in order to get a hold of one to work with.

The introduction of print really opened up a whole new pedagogical industry, that is a textbook and a whole new way of teaching and learning associated with the textbook and in many ways, the 500 years of educational history from roughly 1500 to the present is an educational history of institutionalizing and spreading a print based set of educational arrangements and they are difficult to innovate within because they are arrangements that have come to have many internal self-reinforcing factors within them and I want to speak about five of those factors.

- The way time and space has come to be organized for educational purposes.
- The way human energy has come to be motivated for educational purposes.
- The way human knowledge has come to be organized for those educational purposes.
- The way a horde of professional participants has been recruited, prepared and trained.
- And lastly, the internal, institutional and civic arrangements for mobilizing resources and managing human efforts within these educational institutions.

Let simply start with time and space. We are surrounded almost always by classrooms and this is a good case and point. Here is a classroom designed for new technology but it looks a great deal like a classroom designed in 1500 for print based recitation. It has structure in it. The idea that one or maybe two or three people are going to be the center of attention. The source of information. And that essentially, the 25 or 30 people in the audience are all going to be doing the same thing in response to that instruction. Now, if you look at our educational places. They are really places designed for fairly groups of 25 to 30, sometimes much larger numbers, to do the same thing at the same time. Whether it is a lecture hall, a classroom like this, or even something smaller. That makes sense with printed textbooks because the principle of a textbook is to break the subject up into lessons, to assign the lessons, to have each person read that lesson together and to create recitation opportunities. That in one way or another, help us gauge who has gotten the lesson and who hasn't.

The technology that we are introducing. Let's think about those networks. Digital information and communication technology. What are their characteristics, features. They increasingly go everywhere. They increasingly have this incredible complexity of intertwined information, ideas, some of it of immense quality, others the dregs of our culture. But all of it there. All over the place. In such a way that

increasingly we might say that the design principle of this Eiffel Tower of emerging pedagogical is that the resources of our culture are available to any person, at any place, at any time, in any major, for any purpose. And this is really very radically different then the situation that has pertained in the past 500 years of what people are dependent on books. I have often tried to imagine what it would look like if children had to study a truly integrated curriculum. Instead of little backpacks on their backs with 3 or 4 books scaled to the capacity of an 11 year old, they would be going off to school with a wheelbarrow and something like the Encyclopedia Britannica piled into that wheelbarrow in which, in a sense, any part of the integrated cultural resources of our time could be available. This question of the integrated curriculum and the problem of creating print resources that can genuinely sustain it, is, in a sense, shifting very quickly with the World Wide Web and the Internet and CD-ROM and DVD and the complexity of fluid information that is emerging in historical sense at an incredible pace around us, is being changed radically. I am involved in many advanced networking projects in schools for putting T1 lines and in some cases ATM lines into New York City schools and inner-city schools and hundred megabyte Internet into the classroom and small group work stations in those classrooms. Those kids do have the complexity of cultural resources that are our culture has available to it now at their fingertip and this is a deep and profound change in the constraints that educators in those schools are working under and these changes are just washing over the educational system as a whole at a historically very, very rapid rate. And this raises deep questions about the organization of knowledge for educational purposes. Why do we divide things up in all the different subjects that we divide things up into? We might, following our great philosophers, say it is something in the nature of knowledge or something in the nature of physical and cultural reality. We might also say its something in the nature of a manageable book. You can only put so much into a chemistry text or an American History text. So, if you are going to work at that level of detail, you will have to find multiple subjects to break things up into. Or you, as an embodied human being, cannot work with it. We have to be, I think, alert to emerging fundamental restructurings of our understanding of what people can and should know as they pursue various lines of activity.

In organizing time and space, pedagogically, and we just only touched very briefly on the implications of that, of organizing knowledge pedagogically, and we have very briefly touched the surface of questions that might be raised about that. Think about motivation. How we get people to do things as students? The idea of

competition as a fundamental motivater of the student was really an innovation introduced by the Jesuits in the 16th century as they realized that students were more and more doing the same thing and if they are doing the same thing, then one way of getting people to do things with a little added vigor, is to pit one against other. Create a contest. That may or may not be fundamentally in accord with human needs, human characteristics. It is with something that works in that system and has tread or is the fundamental principle of student evaluation of the sorting activities of our educational institution. But in many ways, cooperation, collaboration, things that in a powerfully competitively driven system, use to be cheating, may in fact be very, very good principles of motivation. But things that we can't really institutionalize that easily. I know I keep trying to have collaborative work groups in my course and I come around to, 'Oh God, how am I going to grade this course?.' I know that in each group, there are people carrying the group and others who are along for the ride but I no longer really have a way of identifying that and I am not sure exactly, within the dynamics of a group, how to judge all of those things. These are fundamental questions that we, as educators, have to somehow come to grips with.

What we need to know, what it means to be a professional educator, has become, in many ways, been defined by the texts to which we teach. Has been defined in many ways by this fragmentation of this body of knowledge for various purposes. That define my specialized expertise. But is that the case that we will continue to have the same kind of intellectual needs as professionals in this fast changing environment that we are working in. What I am seeing increasingly in K-12 schools where, all too often, we have a grievously poorly educated core of teachers. They are suddenly finding themselves working where their students not only know more about the technology than they do, but by virtue of the technology, when its well networked and they have access to a scope of knowledge, a scope of analytical skills that the teachers have never before encountered except perhaps in one another, faculty member, in their higher education. I think we are going to have to radically reconceptulize what we understand the professional training of a well prepared teacher to be, it is in one sense going to have to be much more humble 'I do not know better than my students', in another sense, it may have to be far more at the leading edge of many intellectual developments than it has been in the past.

Lastly, a fifth area that I think is all in cline in all of this is in a sense the area of public expectations which are at work, both in our institutions and that our

institutions of education are embedded in themselves.   Much of the drive nationally in K-12 for higher standards and testing movement, accountability, is in a very ironic tension with drives towards innovation and introduction of new technologies.   New ways of organizing the classroom.   We have, in many ways, mobilize as societies, the resources to conduct and build up formal education to the very extensive levels that it has been built up now.   By arguing systematically that we need "x" increment of people who are masters of "y" increment of knowledge and we have really developed a kind of gigantic sorting and allocation mechanism in which we train mechanical engineers and civil engineers and we know that they know something different from each other.   And then, this'es and that'es and people who only go through high school really have to get their working knowledge on the job in many ways but should have enough knowledge to participate intelligently in the affairs of an increasingly complex society.

We have been pushing this idea that a successful society must allocate the knowledge that it needs to the talents that it has and make sure that all of those are integrated into the complex population and work environment.   In a certain sense, the natural, intellectual characteristics of these networks that we are building up means that everyone is going to have assess to everything all of the time and what is that going to do to this fundamentally gigantic sorting system.   Is its rationale going to fully continue?   Are we going to have the same balance between the need for specialized knowledge and skill versus the need for generalized capacity.

I would like to pose these thoughts, these five areas I think present a difficult environment to innovate and to produce change in because the same action that might alter motivation may not be feasible if you are given a space that was designed for the old ways and you may find yourself teaching an element of the curriculum that has been chopped off for reasons that are no longer entirely sensible in the intellectual environment that is emerging, and so on, and so forth..

Each of these things reinforces the other things and it is hard to find a single lever point to change the system.   I want to close with one last thought that may be a little bit more hopeful to be found in a complex set of reinforcing factors.   And that is a history of educational efforts is one of extreme continuity and resistance to change punctuated by periods of rather fundamental and radical change.   The most recent one being with the introduction of printed technology into Western cultures some 500 years ago.   When those basic periods of rapid change seem to take hold, I think that one can observe there is a basic pedagogical problem that a society has

to face gets redefined. The way I look back on pre-modern, pre-print education, the basic pedagogical problem was to develop the memory. To expand the individual's capacity for storage and retrieval, things that they encountered of significance in their lives. Because the media constraints were such that other than architectural structures, it was very hard to go back to a culturally significant location. You read a manuscript once in your life. Went away from it and you had to recall it and many of the architectural structures were mamonic structures. Gothic cathedrals is a complex set of imagery of statutes and stained glass windows that tells stories and images all over the place and rituals and lethagies take you through those. Rehearsing their significance of each of the images. What could you recall? How well could you recall it? Gave way to an idea that people were working with books and other stored media of information. And in that I think we come to understand the contents of those books as knowledge and the educational or pedagogical problem was really to develop an answer to 'what do you know?' and if we look at the educational history of the last 500 years, it is in a very deep sense an effort to generate working answers to that question for each person participating in the educational institution.

Here are my answers to the question 'what do I know?' I think we need to ask in the emerging environment whether this question 'what do your know?' might be giving way to some other question and I simply like to leave us with the thought perhaps its going to be increasingly not 'what do your know?' but 'what can you do?". That a lot of the pedagogical reforms and I think Gateway and in many ways, engineers, are professionally acculturated to coping with complex self-reinforcing factors and may be a few of the engineering will be very much at the forefront of fundamental institutional responses to these challenged. Many of the reforms going on in engineering are based on a recognition that the quality of engineering graduates is being judged more and more by the companies that they go into and by the society at large. They are not concerned as much to test and ask what does an engineer know, but to ask what the engineer can do. How ready are you to enter into a working group designing this and producing that and this kind of a shift, and it is a subtle complex difficult shift, is one that I suspect may fairly rapidly, again in the historical sense, ripple through our educational institution and we will find a much more of a pedagogical built on introducing people into organized patterns of activity and action in which they can develop a sense and feel for what is done in this area and how it is done and if they can do that, then they have criteria built into their engagement and action for exploiting this incredibly flexible information and knowledge environment around us by being

able to say 'I am doing this' and for this, this is the appropriate information that I need out of that system. I will stop there.

Q:

A: Yes, I think it does so with the benefits of print era in the sense that the networks of stored information that are now rapidly going on line, are at the, in principle at least, at the fingertips of both mentor and apprentice so they are doing that, now engaging in action in a much, much, much richer environment of knowledge and I think that is something means that the educational strategies that we create cannot be simple returned to, and even if they are, a lot of them we now think of distance learning as how to explore classrooms from distance locations. Distance learning may be how do we interact with students in various working locations with us as, in a sense, gatekeepers and coaches, of how to work the information environment in that distance practically.   But basically, I think the drive to re-integrate the locust of education with the world of work and daily activity is all around us very subtlety and if we probe why people are interested in distance learning, we will learn that most people in our society who want an education cannot afford to come to one or another campus to get nothing but education.

Q: What kind of value does Columbia give to its faculty to put a lot of effort into technological education and less emphasis ....?

A   I was on a review conducted by our provost of one person who have put a great deal of effort into on-line work and had not published in traditional ways a great deal of material and I am sorry to report that the person did not get tenure. I would, however, say that the question you are asking was posed and thought about by all the people on the tenure committee at great lengths in this particular review and many of us who were inclined to say, not inclined to say, who do say that one must find ways if we are going to sustain the processes of change, we must find ways to assess and integrate such activity into the review. We, in the end, thought that while we were not happy with the way that fully had been done because we kind of know what a publication in a reference journal is, but we don't exactly know equivalent signs of quality are relative to on-line. At least it was being engaged and that we suspected that in this particular case, had the person only produced research, it probably would also have been a negative review anyway. I think that this is one of the many kinds of factors where the system as it exists,

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reinforces most crucially in the incentives it project to people. Many conservative resistance is the same. But at the same time, it is a real problem of inventing standards of judgment. My wife teaches at a very good New York City high school history and she started at one point trying to have students do on-line presentations instead of papers. She came home and she said 'I no longer know who's doing a good job. My criteria for judgment aren't there.' And so its not only in tenure and review and it is not a simply problem. Its one where we unfortunately have happened many times and one reason why I think historical change rarely comes in smooth curves, the new always presents itself in cultural social reality as an underdeveloped,, not fully worked out pattern of experience while the old is there in a very fully developed, rich, complex pattern of experience and how you make the judgment one versus the other is a problem. So I think tenure and review committees have to keep hammering out and asking these questions, looking for criteria, looking for ways to integrate it in a fair sound way. But it will continue to be an impediment for many younger people and I know in many schools I worked in and I think its fair to say on the Columbia campus, there is a disproportionate, some leadership role or innovated role by people in mid career, people who in many ways who you would not expect to be the innovators, or people who are little bit out of the mode of graduate students who want to do something different, the assistant professors, are often the whole institution, prepping them to re-capitulate the traditional role.

Q:

A: I am not sure. Are you asking whether I think people in educational foundations are ..... we're the most aggrevious sources of resistance.

Q:

A: I actually spent a year consulting to Jay Islen, the President of Cooper Union when he first became President of Cooper Union and really he was having a problem of getting the social studies and humanists who taught the freshman across an engineering school, an architectural school, and an art school, how to interact creatively with the people teaching in each of the three professional schools. I kind of became convinced that the source of innovation was not going to be the humanist and social sciences but insofar as those three professional schools or undergraduate professionally oriented schools, really focused on design as something that people do. That in many ways I wanted him to argue that design

is going to be THE great liberal art of the 21st century because we live in a built environment and it is the people who are making the design choices that gets embodied in that built environment that we live in. Who are in effect determining the fundamental feature of the quality of life that all of us experience and that if we start thinking about design that way, the full range of skills that are needed for excellence in design, along with all the human issues and cultural issues, that should feed into the qualitative implication of different design choices, kind of get drawn together and I do believe that is a line of potential innovation of great importance in sort of trying to say 'who can lead us where' and I would like to see a kind of simplicity sometimes within same engineering school. We just make things. I like to see people perhaps .... *END OF SIDE ONE, NOTHING ON SIDE TWO.*