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SEED-IDEA

A Revolution and a New Paradigm in Education

Knowledge is the sustenance of civilization and culture. Language is the instrument for mental comprehension and transmission of knowledge. Education is the means by which each generation passes on to the next in a concentrated, systematic manner the cumulative knowledge and wisdom acquired in the past. Of all the technologies developed by humanity, none is as powerful and sophisticated as the means we have fashioned to gather, organize, store, share and transmit knowledge. Education is the instrument of conscious human evolution.

We are on the cusp of a revolution potentially more powerful and important than any technological or political revolution in history. As the on-going revolution in information is generating and transmitting an unprecedented range and depth of data at dazzling speed, a parallel revolution in Knowledge is processing and analyzing that information to forge new fields of study, new perspectives and a greater understanding of the world we live in; a revolution in Education is about to transform the way human beings learn and transmit knowledge from one person and one generation to another. After centuries of slow, methodical development, education is evolving today more rapidly than ever before.

"We need an educational system that is far more flexible, adaptive and responsive to the changing needs of society and capable of developing more fully the seemingly unlimited range and depth of our individual and collective human potential."

Advances in communication technology are the immediate occasion and means of liberating education from the university classroom and the printed textbook into the boundless, timeless realm of cyberspace, but the Education Revolution involves far more than adaption of new technology, and the significance of what is happening extends far beyond online courses and e-books. For in the process, the barriers that have long isolated and insulated the university from the world around it are breaking down. The knowledge presently encapsulated in the organized curriculum of higher education represents only a tiny fraction of the cumulative knowledge of humanity. It does not fully reflect the vast knowledge of retired teachers, managers, and public officials that is so often lost when they retire, or the expertise acquired by entrepreneurs and businesses that spend hundreds of billions of dollars every year educating their own employees, or the knowledge acquired by the UN system and other international organizations over six decades of grappling with the challenges of global governance, or the knowledge and experience of thousands of NGOs working on issues related to peace, public policy, economy, ecology and social issues. All these will more easily find their way into the virtual classroom of tomorrow than they have into the physical classroom of the past.

Today education is rightly considered the single most important endowment for success in life. Those with higher education find better work opportunities, earn more, achieve greater security, and live longer, healthier, more satisfying lives. Yet, in spite of rising levels of education globally, unemployment is rising at the same time and it is reaching levels that threaten both human security and social stability in some countries. More education by itself is no longer sufficient. In a world that is changing so rapidly, we need an educational system that is far more flexible, adaptive and responsive to the changing needs of society and capable of developing more fully the seemingly unlimited range and depth of our individual and collective human potential, so essential at a time when we are severely overexploiting the earth's natural capital.

The revolution in education now makes it possible to bridge the gulf that presently divides the knowledge taught in universities from the practical knowledge and skills needed for accomplishment in life. Every student of economics learns the principles of micro-economics that would be operative under conditions of perfect competition, yet such conditions rarely, if ever, exist in the real world of the marketplace. Models and constructs are helpful for advancing our conceptual understanding, but mistaking models for the real world is a recipe for disaster. The awarding of Nobel Prizes in economics for the computerized trading models that have destabilized global financial markets is an instance. Controlled experiments in the laboratory are not adequate preparation for the complexity and spontaneity of life in the world outside. Biological models are insufficient to reflect the evolutionary potential of human consciousness.

In the mid-1990s, the city of Napa, California, asked a group of companies to help redesign high school education to better prepare students for career success. The officials were surprised that the most common criticism made by the companies had nothing to do with the content of the curriculum, but rather it related to the way the content was being taught. Students are taught in school to learn by themselves and they are evaluated solely on the basis of their individual performance in competition with their peers, yet, once they enter the world of work almost every task is a group endeavor requiring the capacity to cooperate with others and complement each other's capabilities. Napa established a new high school and adopted a new method of learning in which groups of students learn together and teach one another. The meteoric rise of Khan Academy and the MOOCs in North America is another visible expression of the new spirit of experimentation, entrepreneurship and innovation that is beginning to permeate the field of education at all levels.

Since the dawn of the Industrial Revolution, massification has infiltrated all aspects of modern life – from tract homes and brand name products to political movements and standardized modular education at all levels. The sheer immensity of the task of raising literacy and educational levels of hundreds of millions of people over the past century has necessitated and justified the mass production approach and that task is not complete. In order to raise the entire world to Western standards of higher education, the capacity of the world's colleges and universities would have to be tripled or quadrupled, an achievement that would

"Providing knowledge and skills is not all there is to education."

require enormous investment and decades to accomplish. Online education offers the possibility of an alternative or a complementary strategy that can not only extend the reach, but also immensely increase the range and variety of knowledge offered through the educational system. This is essential.

"Our future lies in evolving an educational system capable of nurturing and bringing out the full latent potentials of each individual."

In recent decades, the world has made immense progress in extending minimum rights and opportunities to all, but the challenge of human development does not end with meeting minimum needs. Providing knowledge and skills is not all there is to education. It can also impart the understanding and perspective to relate with others and integrate harmoniously with the world around, as well as the universal values which represent the essential wisdom for self-respect, social accomplishment and personal fulfillment. Humanity has a greater potential and a great destiny in store which can only be reached by releasing the creativity and initiative of every individual. Our future lies in evolving an educational system capable of nurturing and bringing out the full latent potentials of each individual. For as the development of the individual depends on the development of the society in which he lives, the fullest development of society depends on the fullest development of its individual members.

Not all changes are necessarily good and not all will welcome even those changes that bring obvious benefits. Much depends on our point of reference and perspective. Comparing online education with the best of the best traditional college education, it is likely to appear a poor and inadequate substitute. But that is hardly a fair standard for comparison. Even in the world's top universities, the difference between the handful of inspirational instructors and the rest is enormous and the distance between the best college and the national or global average is immense. And for hundreds of millions of youth, lack of access to affordable education represents an enormous gulf separating them from a better future. Some aspects of life may have been more civilized and luxurious for the aristocracies of the past, but those benefits accrued to only a tiny elite representing perhaps a tenth of one percent of the population, like the proverbial 10,000 families in aristocratic England. That is still largely true of quality education today. Imagine instead that the most knowledgeable and inspirational thousand or ten-thousand instructors in the world could be made available to students everywhere, at any time and in any language.

"Revolutions occur when society resists change and refuses to respond to the compelling call of the future."

Revolutions are messy affairs and often destroy as much as they create. But throughout history they have been the seeds of new freedom, fresh ideas and creative energies that liberate humanity from the limitations of the past and usher in unprecedented opportuni-

ties for people in general. Revolutions are what we make of them. Revolutions occur when society resists change and refuses to respond to the compelling call of the future. The good news today is that universities are among the leaders in revolutionizing the field of higher education. By this process they may lose some of the prestige and exclusive power that all traditional institutions acquire over time. But reaching out to collaborate actively with other reservoirs of knowledge and expertise in society, what they lose in exclusive status can be more than compensated by what they gain in richer content of knowledge and the capacity to meet social needs. Then a potentially disruptive revolution may be transformed into a rapid, constructive evolutionary movement the world so deeply needs to cope with the emerging challenges of the 21st century. A new paradigm in education may then become the basis for a new paradigm in human development and social evolution.

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Creative Consciousness

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Abstract

Consciousness is creative. That creativity expresses in myriad ways – as moments in time in which decades of progress can be achieved overnight, as organizational innovations of immense power for social accomplishment; as creative social values that further influence the evolution of organizations and society; as the creativity of individuality in the leader, genius, artist and inventor; as social creativity that converts raw human experience into civilization; as cultural creativity that transforms human relationships into sources of rich emotional capacity; and as value-based educational creativity that can awaken and nurture young minds to develop and discover their own inherent capacity for knowledge in freedom. Through such moments do society and humanity evolve. Education is society's most advanced institution for conscious social evolution. Values are the essence of society's knowledge for highest accomplishment. Education that imparts values is an evolutionary social organization that can hasten the emergence of that creative consciousness.

"Consciousness is self-aware energy."

Moments are creative. New ideas are conceived, great works inspired, new nations founded, momentous results achieved in creative moments. Sri Aurobindo described moments of creative consciousness as virginally creative moments. At such moments, one feels vividly alive and expansively cheerful, a sure index of success, as evidenced by the lively disposition of the heroine Elizabeth in Jane Austen's *Pride and Prejudice*. Everyone values the creative disposition, but enjoys it only when it is active. Educating the mind eliminates the uncertainties from one's life. Educating the Spirit lifts it out of the non-creative frame of mind into one of ever-living creative consciousness.

Consciousness is self-aware energy. When it falls into a routine it becomes very efficient. When it breaks new ground, it becomes creative. When a man acts creatively, the public takes note. When a public speaker delivers a creatively inspired speech, he can hold the audience spell-bound or send them into raptures. A moving music performance can raise the audience to great heights of inner appreciation. Even a cook who succeeds in bringing out the subtle rasa (essential taste) of food can inspire deep appreciation. A reader's creative understanding can evoke an inspiring vision that approaches the borders of genius.

1. Organizational Creativity

Organizations also experience creative moments. Organizations are forged by centuries

of social experience. They emerge from creative activities that organize social existence into creative systems. The act is the unit of life, even as thought is the unit of mental life. Act-activities-systems-organization form a progressive chain. When an organization becomes creative, it can transform the social life of a nation, as the Green Revolution rapidly transformed the national life of India by helping the nation attain self-sufficiency in food production. Based on a creative impulse of inspired individuality, it became a movement of national spiritual renaissance. One of its many consequences was to launch a revolution in rural banking that awakened India's rural population to the attractions of urbanization.

"To examine history in terms of the development and evolution of organizations will be a rewarding endeavor for sociologists, philosophers and even politicians."

Harlan Cleveland, a past President of the Academy, was creative with ideas related to organization. He conceived the idea of uncentralized organization. The Visa International credit card system captured his imagination as a dramatic example of the creative power of organization to spread worldwide in the field of consumer finance. The birth of the Internet is a more recent, broad and powerful instance of the same organizational principle which has permeated and transformed all aspects of global society. History has evolved from the history of kings into the history of peoples, nations, cultures, ideas, etc. To examine history in terms of the development and evolution of organizations will be a rewarding endeavor for sociologists, philosophers and even politicians. Cleveland understood the International Standards Organization (ISO) as another striking example of the role of uncentralized organization in the evolution of society. Ideas are a powerful basis for organization. Green Revolution was based on the idea of achieving food self-sufficiency, a seemingly impossible goal at that time, which India actually attained within five years. ISO is based on the idea that establishment of uniform technical standards will improve efficiency and quality of products and work and facilitate trade, which it has certainly done.

2. Values are Creative

Values are an even more powerful basis for organizations. Values are a form of subtle organization that guides understanding and decisions. Novels such as *Pride and Prejudice* and Trollope's *Dr. Thorne* bear witness to the enormous power of values for human accomplishment. The emerging values of individual freedom and social unity, which inspired Lincoln and galvanized America to abolish slavery and found a strong federal government after the Civil War, launched the USA on an evolutionary course that enabled it to emerge as the world's leading nation a century later. The emergence of values in society is a moment of creative organizational evolution. Society grows in many ways; commitment to high values is one. Moments in which society embraces a high value are creative moments.

"Society grows in many ways; commitment to high values is one."

3. Creativity and Social Evolution

Obstructive anachronisms in the society acquire formidable force of resistance to progress. Only the physical destruction of war is capable of destroying them. Post war periods are known for their infectious social creativity. WWI was hailed as the war to end all wars. But the social psychology of Europe at that time thrilled with the intensity that war offered as an outlet for its pugnacious energies. An Englishman commented that forty years of peace was intolerable to the national psyche. So, the first war half-consciously prepared for the second war. It was assumed that this horrendous war would mark the end of all wars. The end of the second war offered abundant opportunities to end wars forever, but the subconscious urge to prolong the spirit of war was too pronounced. Hence, it was followed by the intense tension of the Cold War for another 45 years.

True to this theory, the great post-war periods of the 20th century were expansive social creativity. World War II was followed by the founding of the UN, the Bretton Woods Institutions and the European Economic Community. The end of the Cold War was followed by the birth of the European Union and the WTO, and most especially the creation of the World Wide Web as the first truly global social organization. The full value of the Internet has not yet become apparent. It is a field of complex organizational growth in cyberspace, without which the advances of the last two decades would have taken centuries. Imagine the creative moment of such a field. The emerging revolution in online education is another creative evolutionary moment waiting to unfold.

Life is entirely creative. All her moments are creative moments. Each man has a different vision. For Steve Jobs, the founding of Apple Computers and launching of the iPod were such moments and their impact spread to reach the whole world. Trade is creative, creative of wealth. Money is the power created by trade. Coins, currency, checks, credit cards are its higher creative accomplishments. It was for trade that the English came to India. But they soon discovered an opportunity to found an empire. At a time of political confrontation in the early 1970s, the monetary benefits of trade motivated Nixon to make a trip to China, with momentous consequences which remain largely invisible, for it effectively eliminated the possibility of war between USA and China.

"Thirty years ago, a report submitted to the Club of Rome spoke about the essential role played by the service economy, the unorganized sector, and the non-monetarized sector. The author's thought has not yet received the recognition it deserves. It is a work of a genius."

Montessori, Summerhill and Glenn Doman mark creative moments in early childhood education. They all made education creative. For the child who is memorizing, a moment of original understanding is creative. Similarly, it is a creative moment for the teacher also when he shifts from addressing the memory of the students to addressing their creative minds.

Certain periods in history have been known as creative periods, such as the reign of Queen Elizabeth I in England. People living during such remarkable times will be creative in one way or another. Shakespeare is the most outstanding of many examples. Fashion marks a transient form of creativity at a shallow, superficial level. In many families and institutions there will be a highly creative person whose aura spreads through the whole family and institution. When that person leaves, the creative atmosphere also departs with him. The place loses its luster. When Mahatma Gandhi was assassinated, Nehru went on the radio declaring that the light had been lost over India.

A creative leader or a creative ideal can now give to the world such an inspiring atmosphere. This is a period in which the entire world population can inwardly expand towards higher values of light and felicity. Even the negative indications are indicative of the opportunity. Half-way through Obama's first presidential term, there was a marked change of attitude towards nuclear weapons. After 20 years, the Palestinians revived their efforts for economic planning. The Institute for Cultural Diplomacy was founded in Germany and seeks a solution for the issues that affect the countries of the Levant. The Arab Spring is a negative movement, but a positive symptom of the Spirit of the times.

"When we aspire for what is already there, it can be described as ambition. When we aspire for what is as yet unrealized, it is creative aspiration."

Fields like music and Market are wholly creative, each in its own way. Music has a creative effect when sound turns melodious. The market is creative of profits when it functions creatively. Traffic systems are quite ordinary and routine. But when we compare traffic systems in organized and unorganized countries, the creative role traffic regulation plays in promoting the welfare of a nation becomes apparent. Studying levels of corruption, implementation of human rights, implementation of law and levels of education reveal the complementary impact of each one on the others. Social Development is a creative field of study which is still in its formative stages.

4. Individual Creativity

A foundation named after Croatian physicist Nicola Tesla is trying to identify young people with the potential for genius. The traditional belief is that geniuses are born and not made. Creative consciousness when cultivated can form the bedrock on which genius flowers. Thirty years ago, a report submitted to the Club of Rome spoke about the essential role played by the service economy, the unorganized sector, and the non-monetarized sector. The author's thought has not yet received the recognition it deserves. It is a work of a genius.

"Evolution is not confined to biological species; it occurs in societies as well."

Creativity expresses through enormous energy. To organize that energy into consciousness is further greater work. Energy comes from aspiration. Aspiration for what? When we aspire for what is already there, it can be described as ambition. When we aspire for what is as yet unrealized, it is creative aspiration. Evolution is not confined to biological species; it occurs in societies as well. Evolution is organizing itself under the surface in every sector of society. The shift from memorization to understanding in education is a significant evolution in that field. It can go one step further from conscious understanding to subconscious or subtle understanding, intensifying the evolutionary process. It is not unknown in the world.

"The creativity of society accumulated as the achievements of a succession of creative moments over millennia is civilization. The distilled essence of civilization is culture."

In business and politics astute leaders possess a subtle form of understanding capable of sensing the pulse of the market or the people. Such leaders become very popular. Steve Jobs says he acquired intuitive perception during six months of his stay in India and relied on it for crucial successes in his life, such as invention of the Macintosh computer, Pixar's Toy Story, the iPod, iPhone, iPad and the highly successful Apple Stores. Lincoln possessed the uncanny intuitive sense to know just how much the public would support and tolerate and how far he could push the Northern states to abolish slavery without precipitating an open revolt. Food rationing introduced during the Second World War continued in South India until 1952 out of belief that removing it would lead to hoarding and sky-rocketing prices. The then Chief Minister of Madras Presidency, C. Rajagopalachari, intuitively perceived that rationing could be abolished without any ill-effects. People feared that prices would soar immediately. He was proved right when instead of rising, prices declined slightly. When people wondered how he managed to do it, he said that he did it relying on intuition. If the world's knowledge of intuition is brought into the field of education, it would revolutionize the field and transform teaching into a creative process.

Science has immensely benefitted the world through the discovery of phenomena such as electricity and magnetism, etc. Equally momentous consequences will issue from the discovery of creative consciousness, rather the process that can result in creative consciousness. Even a momentary spark of creativity is highly productive. Sustained creative expression will benefit mankind in unimaginable ways.

5. Social Creativity

Society is creative and is characterized by periodic moments of momentous creativity. The creativity of society accumulated as the achievements of a succession of creative moments over millennia is civilization. That civilization is the essence of history which is itself the essence of social existence. The distilled essence of civilization is culture. Family is the creative social organization that nurtures the biological child to form the psychological citizen. The mother's loyalty enriched by the father's sense of responsibility form the flowerbed on which culture flourishes. The head of a family accepting responsibility for the whole

of the family can be called consciousness responsibility. The constitutional responsibility of a cabinet minister for all the actions of those in his department is the national symbol of it. The unwritten constitution places responsibility for whatever happens in the country in the hands of the Prime Minister.

The process of converting raw energy into creative energy for growth, development and evolution is common to all aspects of life. Our bodies convert the food that is consumed into physical energy for growth and transforms it into energy for healthy living and well-being at the physical level. Society converts raw social energy into organized productive energy and transforms it into cultural values such as honor and hospitality. The most advanced enlightened expression of this process is the conversion into cultural essence of life through education. What families, especially affluent aristocratic families, give to their children through private, personal education by tutors can now be made available to all the children of the world with the same flavor of human solicitude and affectionate responsibility. The World University Consortium can provide it to all who seek it. It can devise new courses that can bring to its process of learning by a process of teaching the higher value of learning for the child's consciousness.

6. Cultural Creativity

The mother is the main source of affection for the child. The wife who enters a man's life later on is a higher version of the same social emotion, whose highest expression is the sacred emotion of Love. Its birth is commonly vitiated by the social institution of marriage in which property is given central importance. If mercenary motives are not present and the child is raised with full affection, the human relationship formed around the child's psychological blossoming becomes the human efflorescence in old age. So great is its power that, according to ancient Tamil literature, it can prevent the graying on man's hair even in advanced age. This is its merest outer expression. Its inner cultural richness expresses as tolerance for the lapses of the younger generation. It is tolerance born out of the soul's inner freedom. That freedom can express as a playful cheerfulness which we find in the heroine of *Pride and Prejudice,* whose creative energies raise her whole family to a higher level of social life. Shakespeare's creativity is rich with subtle truths of life rising to the highest poetic expression, but mostly reflecting darker intensities of life. "Age does not wither" and "Whoever loved that loved not at first sight" are positive expressions of that creativity.

7. Creative Education

Great literature enriches ordinary daily life in many ways possible, but it mainly enriches the subconscious through its subtle faculty. The mind of the child is brilliantly receptive to the accumulated wisdom of the collective. However, formal education often buries this emerging wisdom. Fortunately modern technology can be commissioned to counter these ill-effects, as the iPod has done for music, capturing the world's imagination. When backed by proper technology, such courses can cater to the spirit of aspiring young humanity and awaken their imaginative faculties to develop inwardly and eventually blossom in full creative freedom.

Online courses for college students can be designed more easily than for lower level students. The lower one descends, the more intricate it becomes for various reasons. First, great care is needed not to spoil the innocence of young minds with organized social superstition. Children's minds are fresh and therefore can be easily contaminated. Moreover, no course can match the speed of a child's receptivity. Adult minds cannot appreciate the purity of a child's innocence of truth in goodness. Like a relay runner, the teacher must readily hand over the baton to the child to run further on its own.

"Values are the organized capacities of the cultural forces of society imparted to the next generation as an individual possession."

Society evolves by education. Sri Aurobindo called yoga an organized influence designed to take life to its maximum height by the shortest route. 'All life is yoga' is his mantra. Education is the next best. Values are the organized capacities of the cultural forces of society imparted to the next generation as an individual possession. Education that imparts values is an evolutionary social organization seeking to be born. The World University Consortium can be the vehicle for that accomplishment.

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Tomorrow's Universities and the Seven Pillars of the Knowledge Revolution*

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Abstract

The emerging Knowledge Revolution goes beyond the changing technologies and the challenges and opportunities they create to include the structure of knowledge and how it is transmitted inter-generationally and across countries. There are seven major features of that profound transformation, which I call "The Seven Pillars of the New Knowledge Revolution". These are: (i) Parsing, Life & Organization; (ii) Image & Text; (iii) Humans & Machines; (iv) Complexity & Chaos; (v) Computation & Research; (vi) Convergence & Transformation; and (vii) Pluridisciplinarity & Policy. This diagnosis has profound implications on how one should think about the design and management of our institutions of learning, starting not only with universities, but also the school system, as well as our research institutions (whether in universities or in public and private labs), and the supporting institutions of knowledge (like museums, libraries and archives). Radical proposals are advanced for the content, method, participants and organizational setting of education, as well as the role of the University as mediator of transitions, its relationship with society and economy, as well as its physical presence, governance structure and the values it should promote. Core functions and curricula for the future, along with the possibility of a global university consortium, are discussed.

1. Introduction

We all agree that we are moving rapidly towards the knowledge based society and the technology based economy, with the well-known and well-documented aspects of globalization overlaid on this transformation. Here, I am speaking of the structure and presentation of knowledge and how we humans will most likely be interacting with knowledge, whether we are academics or researchers or simply the descendants of those who used to go to public libraries and ask the librarian for assistance with a good book to read or a reference source for the paper they are preparing for college. This knowledge revolution shall have profound implications for the institutions of education from kindergarten through post-doctoral levels, research, whether public or private, and the cultural institutions that support our knowledge structure such as libraries, archives and museums.

* A slightly different version of this material was presented at the meeting of the International Association of Universities (IAU) in Puerto Rico on 28 November 2012.

It is this that I refer to as the "New Knowledge Revolution", a subject I have treated elsewhere at length and in more technical detail.[1] This knowledge revolution can be diagnosed by seven key characteristics, which I would like to call "pillars", and which I shall briefly describe here. These are:

- Parsing, Life & Organization
- Image & Text
- Humans & Machines
- Complexity & Chaos
- Computation & Research
- Convergence & Transformation
- Pluridisciplinarity & Policy

Before proceeding to discuss the manner in which I think this revolution will specifically impact the universities of tomorrow, and making some recommendations as to how that inevitable transformation could be handled to smooth out the change and embrace the future, a brief word about each of these seven pillars is pertinent here.

2. The Seven Pillars of the New Knowledge Revolution

2.1. Parsing, Life & Organization

Since the beginning of time, whether we were writing on scrolls or on codexes, whether the codexes were printed or in the form of manuscripts, the accumulation of knowledge has been based on parsed structures, with units put next to each other like bricks in a wall of an emerging structure.

It was the juxtaposition of these individual parsed works that created the accumulation of knowledge… the rising edifice built piece by piece, brick by brick or stone by stone…

In addition, each piece was "dead". By that I mean that once published it stayed as it was until a second edition would appear. If we both had copies of the same book, we could both open to, say, page 157 and find exactly the same thing in our respective copies. It did not change whether we did it immediately after the book appeared or decades later.

The Internet changed all that…

The web page became the unit of parsing. Instead of the classical sequence of presentation, we now think in terms of a home page and then hypertext links into other related documents. We can expect more fluidity into the merging of image, both still and video, and the transitions from one reference link into another.

Search engines complement the World Wide Web as the online material – unlike the traditionally published material – becomes alive. Today if I look up a web page, and you look it up at the same location a few hours later, it will probably have changed, since the material is constantly being updated.

Furthermore, as we move beyond the current structures of the web towards the semantic web, where we can search for relationships and concepts and not just objects, the structure of organization and presentation of knowledge will become one large interconnected vibrant living tissue of concepts, ideas and facts that is growing exponentially and which will require new modes of thinking to interact with it. It will automatically spawn these new modes of thinking and scholarship will no longer be parsed like bricks in a wall; it will be more like a smooth fluid flowing river.

If we were to try to take into account the emergence of the social linkages phenomena that the internet and the web have now made possible, we can now visualize what some specialists have called the "Meta-Web", which is attributed to high knowledge connectivity and high social connectivity. Does the Meta-Web prefigure the connectivity of intelligence?

2.2. Image & Text

Throughout history, the primary means for the transmission of information has been text. Images were difficult to produce and to reproduce. This has changed. With the digital revolution, everybody can record images and video, and computer generated graphics are becoming affordable for everybody.

The human brain can process visual information with incredible rapidity. Enormous detail can be captured and processed in a fraction of a second. So some new features of the current knowledge revolution appear imminent. One is the far larger reliance on image – in addition to text – in the communication of information and knowledge and the changing forms of the storage and retrieval devices that this will require as we move from text dependent book and journal to digital still and video image presentations as well as three dimensional virtual reality and holographic presentations. Interactivity will also become a feature of this new image-based virtual-reality world. Again what does that mean in terms of the presentation, the search and retrieval functions and the interaction between the researcher and the material in the future?

And what does this mean for the effective description in meta-data, the storage, searchability and retrievability of this enormous and growing world of still and moving images, both fixed and interactive? We will no longer be looking up images through keywords entered into text databases such as meta-data catalogues: Computers will do this for us.

2.3. Humans & Machines

With the exception of pure mathematics and some aspects of philosophy, it will no longer be possible for any human to search for, find and retrieve, and then manipulate knowledge in any field, much less add to it and communicate their own contribution, without the intermediation of machines. Even in literary criticism and the social sciences, the stock of material to search through can no longer be done manually.

This is not good or bad. It just is.

Now, after a special chess playing program called Big Blue of IBM defeated world champion Garry Kasparov in Chess in 1997, can we indeed ask, as some visionaries are doing,

whether "consciousness" and "intelligence" are emanating qualities from very complex systems? According to some, we are going to witness that happening with machines when they will pass certain thresholds of complexity and power, such as when the level of the processing power reaches certain sizes, and software advances within a decade or so after that to certain levels, all of which are likely to happen within the first half of the 21st century.

But whatever the merits of that particular debate and its ramifications, it is clear that changes are already noticeable in the domain of libraries and the internet. One example of that is the new World Digital Library: The system allows one to link video, image text and commentary and maps into one seamless whole and to search by many different approaches (time, geography, theme, cluster, or even by a single word) and browse the material as well as find what one wants from the digitized material on offer from all the countries of the world.

2.4. Complexity And Chaos

The world we live in is remarkably complex. The socio-economic transactions of a globalizing world are exceedingly intricate as, with the click of a mouse and the flight of an electron, billions of dollars move around the planet at the speed of light. The web of interconnected transactions is enormous, and the ripple effects of any single set of actions and its interaction with other effects are difficult to predict.

Our cities have become not only much larger but also much more complex, and ecosystems are not only delicate, they are intrinsically very intricate. So are biological systems.

The reality is complex and chaotic, meaning that complex systems have non-linear feedback loops that result in systems and subsystems that are extremely difficult to predict. Many of our models, based on the simple mathematics and analogies drawn from physics, are proving inadequate.

2.5. Computation & Research

Till now, Computing has been largely seen as the extension of a large calculating machine that can do dumb calculations at incredible speeds. Computer scientists and engineers were implementers who made the life of the creative people and the researchers less tedious. Wonderful tools, no doubt, but just tools all the same. Today, the concepts and the techniques of computing will become a central part of the new research paradigm. Computational Science concepts, tools and theorems will weave into the very fabric of science and scientific practice.

Consider data management. Data when organized becomes information. Information when explained becomes knowledge. That, in turn, when coupled with reflection, insight, and experience may lead to wisdom, but that is another story.

But beyond the scale and magnitude of the collections of data, we are looking for connections between collections of data. These pose particular problems that involve qualitatively different issues. Computer science is where the most work on such classes of problems has been done.

2.6. Convergence & Transformation

Domains are gradually converging. In simplest terms, once upon a time we had chemistry and biology as distinct and separate enterprises, now we have biochemistry. Such moments of convergence, generating new sciences and insights, turn out to be some of the most fecund moments in the evolution of our knowledge and the development of our technologies. Today we are witnessing the convergence of three hitherto separate fields with the birth of BINT: Bio / Info / Nano Technology.

At the same time, we need to develop what the NSF calls "Transformative Research". That is, research capable of changing the paradigm in some fields and domains, such as synthetic biology and femtochemistry. Such research is extremely valuable. We thus witnessed the discovery of the structure and mechanism of DNA engendered fields like genomics, proteomics and metabolomics.

A question before us is whether such developments will remain serendipitous or our research paradigm will systematically force the development of such converging domains and transformative insights. I believe we are poised to do the latter.

2.7. Pluridisciplinarity & Policy

There is real value in crossing disciplines. Both in academic organization and in tackling real-life problems, we note that the old "silos" of disciplines when functioning alone are counterproductive. Much of the most interesting work is being done in between the disciplines, where they intersect or where there are gaps.

We increasingly recognize that our real life problems, such as poverty, gender or the environment, are all multi-dimensional and complex and require a special way of organizing all the various disciplinary inputs. Just as we say that diversity is enriching, so is the sharing of knowledge across disciplines.

The nature of the challenge, its scale and complexity, require that many people have interactional expertise to improve their efficiency working across multiple disciplines as well as within the new interdisciplinary area.

3. Reinventing Education

The structure of the institutions of education and learning, those that channel the preparation of future generations of humans and the trans-generational passing-on of knowledge, will change. They will not only continue to evolve, they will morph into something unrecognizable to those who think of yesterday's schools as a model, or those who yearn for their collegiate university experience. The public and private laboratories and research institutes, those institutions that help in the production, assimilation and codification of current knowledge and the creation of

"[In the future] Continuous learning will be more than a slogan; it will be an economic necessity."

new knowledge, will also change. However, here, I will just say a few words on the more obvious likely impacts of the seven pillars of the new knowledge revolution on schools and universities, barely touching on research facilities.

"Schools in fact teach children the discipline to endure and master boring and repetitive tasks."

I think that we need to think even more boldly and dream of reinventing education completely.

The old model of rigid linear advance through 12 years of schooling, followed by four years of university after which one receives a degree that certifies entry into the labor force to practice some profession for forty years and then retire, will become totally obsolete. Continuous learning will be more than a slogan; it will be an economic necessity. The market will demand new skills, and an increasingly competitive world will force enterprises to continuously upgrade the skills of their labor force.

Furthermore, the existing model of education, under the heading socialization, also tries to enforce certain qualities deemed important by future employers. Schools in fact teach children the discipline to endure and master boring and repetitive tasks. Their natural tendency to communicate with their peers, to run and play is curbed, by being told to "sit still and be quiet". If they do not take easily to that regimen, they are now treated for Attention Deficit Disorder and even given drugs to assist them to comply. They have to stay hours listening to an authority figure, in a setting that is rarely a beautiful architectural space, on a chair and desk that are rarely comfortable furniture. The student learns to be docile and to respect authority and to manage to do repetitive and boring tasks effectively. The implicit model is to train workers for boring repetitive tasks in factories or offices, something the industrial economy of the 20th century clearly demanded, despite its dehumanizing aspects so effectively portrayed by Charles Chaplin in "Modern Times". However, the globalized modern economy is rapidly changing, and robots are more likely to take over the more repetitive aspects of jobs in the future. We already see this clearly on the assembly lines of the automotive industry, which is being followed by industry after industry. Likewise, in offices tasks like data entry and checking are also increasingly being taken over by computers. The future will be for a lot more collaboration between humans and machines, and thus we must question all aspects of the educational enterprise that we have inherited from the last century. No matter how successful they have been, the policies of the past are rarely the best to confront the challenges of the future.

Education is likely to change profoundly in the coming decades, in terms of content, participants, methods, and organizational setting. Let us consider each of these in turn.

3.1. On Content

Curricula and syllabi need to be revised to emphasize basic skills, problem solving and learning to learn. Teachers must be much better trained to become enablers who will encourage children to realize the joy of discovery, and be able to utilize teaching methods that allow each individual to change at their own pace.

The educational system of the future will witness an explosion in content, which is beyond our capacity to imagine today. People will emerge from their basic education, – including university level education – having learned to learn, and having acquired a basic infrastructure of fundamental skills, including interpersonal skills and the ability to function in a society. These fundamental skills will be complemented by a vast array of offerings in every conceivable combination of units and modules covering everything from artistic expression to advanced genomics, from music appreciation to mathematics. The flexibility of these combinations will allow people to learn continuously throughout their lives.

"We have barely scratched the surface of the potential that exists in self-learning."

New fields of learning will come about. The most important discoveries will be at the intersection of the existing disciplines. Totally new fields have come about, such as genomics and proteomics. And beyond the natural sciences we are discovering how important trans-disciplinary work is. We need the wisdom of the humanities in addition to the knowledge of the natural sciences. We need the insights of the social sciences to bear upon the technical options of engineering.

3.2. On the Participants

Participants in our educational enterprise will still involve parents at home and teachers at school. But students will play a bigger role in their own development. And virtual communities on the Internet will create a new form of peer group affecting the mental and emotional growth of the children and young adolescents of the future. I say this, fully cognizant of both its upside and downside. Perhaps we should be more open to what our children will have to tell us… Take the words of Robert Frost, the American Poet Laureate:

"Now I am old my teachers are the young.
What can't be molded must be cracked and sprung.
I strain at lessons fit to start a suture.
I go to school to youth to learn the future."

3.3. On Methods

Methods of teaching in the last fifty years have been almost totally confined to formal instruction in classrooms. Lectures, tutorials and supervised work have been the staples of education from time immemorial. We have barely started to explore guided learning through such instruments as distance learning, the Open University and modular adult education classes. I say that noting that the open university has been around for more than four decades, and that Massive Open Online Courses (MOOCs) are now a reality through the experience of the Khan Academy (which has more than 3.9 million registered students), and the presence of UDACITY, COURSERA, edX and other offerings. We are just beginning to see the benefits of flipped classroom instruction where the lectures are on video and the students can learn at their convenient time (which also allows students to replay certain parts as many times as they want) and the contact hours will be spent with the teacher working with the students, at

problem solving and clarifications (the functions that were traditionally left to homework to be done by the student on their own time).

We have barely scratched the surface of the potential that exists in self-learning. New "games" or game-like approaches that allow youngsters to gradually master skills by solving ever harder problems will use the same self-encouragement mechanisms and inherent reward mechanisms that current and conventional games do in making the player move from level to level by shooting ever faster and killing more adversaries. The software advances and the private sector's interest to develop such new educational software along with the possibilities of having tablet computers available in India under $40 open up enormous possibilities that will allow us to do much more in guided learning, and to help a thoroughgoing revolution in self-learning.

Although I believe that formal instruction will continue to be important, it will increasingly be supplemented by flipped classroom instruction, MOOCs, games and both guided learning and self-learning will be enhanced through myriad offerings. It will not only benefit the youth in their school and college years. Driven by curiosity and self-interest, the lifelong learners of the future will alternate between broadening themselves or pursuing hobbies on the one hand, and acquiring marketable skills on the other. The offerings for both will be there.

3.4. On the Organizational Setting

Schools and universities will not be replaced by individuals working on computer terminals or on their mobile phones or other technologies, from home or from elsewhere. This is because they serve three functions: a skill and knowledge imparting function; a certification function; and a socialization function. The first and second will change along the lines I have just described. But the socialization function will remain.

Children need to be with other children of their age, and so do youth who are just reaching their maturity. They need to learn to interact and socialize with peers. Only schools and universities provide the requisite setting for such socialization, an essential factor for emotional development and the formation of effective citizens.

4. The University - Yesterday and Tomorrow

Universities are an essential institution in any society for many reasons.

4.1. The Mediator of Transition

They are the locus of the transition of adolescents into adults, and the incubator of effective citizens. It is the custodian of the great generational transition. The World Bank has identified five essential transitions that occur between the ages of 12 and 24 in most societies[2] and they make these years particularly important. Since the University helps mediate all these transitions, it is essential that it adapts the fashion in which it plays that role in the lives of our youth. These five transitions are:

Continuing to Learn: Whether to drop out of further structured instruction and university participation or not is the single most important decision in a teenager's life. Its repercussions and the future path of their career will be inevitably affected by it.

Starting to Work: The transition from a dependent student to an independent participant in the labor force occurs in these years, and traditionally with a pre-college or college education. The manner in which the university and by extension other institutions in the higher education system address that transition and facilitate it will have major impact on the economy and on society, not to mention the lives of the young people themselves.

Developing a Healthful Lifestyle: Key decisions on smoking, experimenting with drugs, attitudes towards sex and other choices that confront youth can make all the difference in terms of their adoption of a healthy lifestyle or not.

Beginning a Family: Family formation starts at the older end of the aforementioned age group. Thus, the attitudes that they gain at university and about the higher education system can make all the difference between a society with solid family units and one with broken homes. Household formation is about more than demographic change.

Exercising citizenship: The political awareness of the new generation is usually formed at the university where they join political parties, start to vote and get exposed to a wide spectrum of ideas and debates. Their future attitudes as responsible participating citizens or detached apathetic individuals will make a major difference in the effective democratic evolution of society.[3] The attitudes they develop towards politics and society will also make the difference between the rise of extremism and the success of pluralistic politics.

The World Bank was concerned with government policies that would increase investments directly and cultivate an environment for young people and their families to invest in themselves – what they called "decisions concerning the five phases with the biggest long-term impact on how human capital is kept safe, developed, and deployed". The World Bank then suggests that such policies should have three broad thrusts: expanding opportunities, enhancing capabilities, and providing second chances. Each pathway (opportunities, capabilities, and second chances) is applied to each of the five transitions, generating suggestions for reform.[4]

4.2. The University and the Economy

Two of the traditional functions of the University have a major impact on the economy: Research and certification.

One is, the search for truth in the context of research, and that increasingly involves partnerships with for-profit private sector entities in addition to the government financing of public goods research, with all the advantages and pitfalls that such an expanded partnership offers. The US Academies recently produced a report recommending ten specific actions that should be taken to maintain the pre-eminence of American research universities in the years to come.[5]

The other is the certification function. A university degree was assumed to certify that a graduate has acquired certain skills that an employer will want. Today, the lasting validity of that certification function is being challenged by the revolution in the knowledge society in ways that make it clear that the old model of 12 years of schooling, followed by four years of university and a degree that allows someone to practice a profession for 40 years and then retire is no longer valid. So what changes will be necessary?

First, the silos of disciplinarity in the traditional structure of instruction will have to change. Convergence and transformation are making it clear that although we all need a foundation in one discipline to build on, we also need to learn to interact with others in other disciplines. Universities must adapt to that horizontal broadening.

Second, constant updating of knowledge and skills will be necessary, and a vast program of adult education will become an integral part of the University of the Future. It will allow for flexible career transitions and the modular upgrading of skills in different disciplines. Thus, continuous education will become a necessity if labor productivity is to continue to increase.

4.3. Values

Another traditional and essential function is the university's unique role as the custodian of the past and the inventor of the new, not just in terms of the socialization function and the societally approved behavior of citizenship, but in terms of values and culture. Cultural identity and the meaning and role of our heritage are part of it. History, archeology, cultural studies are all part of learning about our past and maintaining our heritage. But universities are very much the places where the young learn to challenge the existing and the inherited, to seek novel answers and to invent the new. Thus, they become the locus of challenging the status quo, and sow the seeds of innovation, whose products and constructs will become the heritage of the future. This double process of preservation and renewal, of authentication and opening up to the foreign and the new, is one of the unique functions of the university, which will remain and will be expanded in the future.

The University also supports the formation and transmission of the values of science. These values include commitment to truth, to honoring each contributor, to promoting imagination and questioning, to challenging the existing paradigms, to valuing imagination, to remaining open to the contrarian view and to arbitrating disputes by evidence and rational thinking. These are profound societal values, not just necessary behaviors to do effective scientific research. These values are forged by teacher example and student practice.

But perhaps the most important value that a university can promote in its relationship to society is the value of freedom of expression. For that is the fundamental freedom necessary for the practice of other rights. By its practice other socio-political features will evolve. Accountability and pluralism require the contrarian view to be heard and the minority position to be respected. That is what freedom of expression is all about, and universities have been, and will remain, the defenders of these values against the tyranny of the majority and the tide of the conventional taste and opinion.

4.4. The University as a Physical Presence

Despite the enormous impact of the ICT revolution on many aspects of the learning experience, I do not believe that the university as a physical location will simply disappear. I believe that the university is not only going to remain the central part of a changing higher education system, but it is also going to remain a physical presence in our communities and our cities, and that the campus will remain a locus of interaction, not just within the university community, but also between the university and society.

Evidence for that abounds. MIT put all its courses online, but that did not result in the disappearance of applicants to obtain the MIT learning experience physically. MIT remains a major center of research and learning not just in the USA but in the world. The Bibliotheca Alexandrina and the University of Pittsburgh present the SuperCourse, with over 170,000 PowerPoint lectures, but that does not replace the need for a proper institutional set-up for learning and socialization. The role of the University as a physical presence should not be underestimated.

4.5. University Governance

The juridical status of the university is not the decisive issue in ensuring its excellence. Examples are many: e.g. UC Berkeley and Harvard show how a public and a private establishment can both be outstanding institutions. But in all cases a certain set of features mark their governance, including the degree of autonomy they enjoy in their decisions, the clarity of their sense of mission, and the standards they aspire to achieve.

Today, along with the general ideological drift in many parts of the world, there is a conception of idolizing the private sector, which suggests to some that higher education needs to develop a “business model” to curtail the increase in costs and promote efficiency. Some even go as far as suggesting copying the manufacturing Business Model with: Future employers as customers; Students' skills as products; Teachers as workers; and the Administration as managers. Nothing could be more destructive of the educational enterprise than thinking along those lines.

While the educational enterprise can certainly benefit from a radical overhaul in how it undertakes its duties, it is in the context of greater sharing with the students, greater involvement with parents and society, greater common exploration of the boundaries of the new, greater involvement of the social actors in this central societal enterprise that we must seek the business model for the 21st century. A decision-making structure in the university should include all the social actors as partners in this enterprise: Students, Faculty, Administration, Community, Parents, Government, Financiers, and Industry.

This would not only ensure a greater transparency, responsibility and accountability, it would also help resolve the old town-gown debate, as well as structure the involvement of the social actors in such a way that the essential autonomy of the institution is protected by embedding it in the context of this broadened partnership.

So, let me now try to summarize and bring together these various threads into ten recommendations that I would make for the University of Tomorrow.

5. Ten Aspects of Higher Education in the 21st Century

5.1. Part of a Renewed Education System: Reinventing Education

The ICT revolution and the transformation of knowledge manifested in the seven pillars are changing the concept and practice of education at this very moment, whether the authorities recognize it or not. Instruction is increasingly supplemented by guided learning and self-learning. The internet is opening undreamed of vistas of possibilities. Online education is a reality, and is growing fast.

On-line education can also leverage the "flipped classroom" technique used by a few innovative educators. The idea is to record the lectures separately, allow the students to see them on their own time, and maintain the classroom "face time" for the teachers and the students to work together on problem solving and other tasks. This "flips" the conventional approach where the classroom face time is used for lectures and the students do the exercises and problem solving on their own.

These and other innovations are still in the experimental stage, in the sense that we do not know if they will bring improvements in learning and retention or acquisition of problem solving skills and imagination by the students better than other more conventional teaching techniques. In the 1960s in the US there seemed to be a concept that different meant innovation which was by definition better than the existing conception. Experience has shown that not all innovations are improvements and not all old-fashioned techniques need to be discarded. This will be equally true of the new and dramatic change that the ICT revolution is bringing to education.

5.2. A Changed Higher Education Landscape

The ICT revolution is already offering many more options than anyone would have thought possible. Khan Academy (http://www.khanacademy.org/) offers all sorts of courses in all subjects with online tutorials and other toolkits and support systems for both teachers and learners. The University of the People (http://www.uopeople.org) is a tuition-free on-line university intended to democratize higher education. The Library of Alexandria, in collaboration with the University of Pittsburgh, offers the Science Supercourse (http://ssc.bibalex.org/), a collection of over 170,000 PowerPoint lectures that can be used as is, or from which individual slides can be taken to compose your own lecture, and there are many other examples, with more being created every day. Another initiative by The Jack Parker Corp. and Big Think, called "The Floating University", aims to offer online Ivy League courses a la carte for a relatively cheap cost… and there are many other examples.

Indeed the challenges to the classical model multiply every day. When Stanford University professor Sebastian Thrun first offered a free online version of his "Introduction to Artificial Intelligence" class, 160,000 students from around the world signed up. Impressed by that and inspired by the Khan Academy, he created a startup, called Udacity, to pursue that model.[6]

He is not alone. Others have moved into the area of Massive On-Line Open Courses (MOOCs). Two other Stanford professors have started a new startup called Coursera that is being used by a number of major research universities, with the purpose of offering MOOCs.

It is not clear whether all these will impact on the for-profit online universities and training programs and/or will impact the enrolments at the universities at which these professors learned and are or were teaching until recently. It is clear however, that the overall landscape of higher education is changing dramatically, even if the university, albeit a much transformed university, will remain a central player in the system in all societies.

Thus, we can say that the landscape for higher education institutions is rapidly changing and is going to change even more dramatically. Pluralism of approaches and institutions is the new norm. The old effort to fit universities into models and to straitjacket the models with equivalences is likely to be further eroded by these new creations with every passing day. I say that fully realizing that various universities will want to consider equivalences for learning done elsewhere or not under their purview if they are to acknowledge these in some sort of credit to some sort of degree or certification. But too many of these will exist for each to be recognized, and many of these options will survive whatever the old-line existing universities think of them.

Yet, none of these will actually replace the university as a physical institution, where things important to society are undertaken. They will be seen as complements to the transformed university, which will have many manifestations.

5.3. The University and Society

The University will be the locus of change in society. It is where the young learn to be adults, and where dependents become independent and active citizens. But it will be more. With continuing education becoming a must, I expect that the University of Tomorrow will have a large presence of ongoing adult learning programs. This will mean that the traditional concept of the community of scholars will be supplemented by returning adults. This will help intergenerational communications as much as lateral communications. That and a major expansion of community outreach will be part of the University of Tomorrow, diminishing if not abolishing the old town-gown dichotomy.

5.4. The University and the Economy

We all know the dual role of the university: from preparing young people for the rapidly changing job market to driving research and innovation in a society. Both of these functions shall remain. But with the much greater blurring of the boundaries that I expect in the years ahead, it will be necessary for the University of Tomorrow not to lose sight of its fundamental functions and get attracted to the profit-making mode which is the rightful preserve of the private sector. Having cautioned against the wrong choice of business model, I also caution universities against turning away from their broader socio-cultural mission towards the profitable and the excessive service of economic interests.

5.5. The Core Functions of the University

Many of the traditional functions of the university, such as the search for truth through research and dissemination and discussion, the defense of values, the mediation of transitions in young people's lives and the certification of having achieved a certain level of marketable skills, will remain. But the last, the certification function, will change dramatically in its content and in its manner of application as continuing education, and upgrading of these skills will become mandatory de-facto if not de-jure. Thus, the university will not be just a stage in everyone's life, but a lasting presence in our community, our society.

As we learn to learn, and use a wide array of self-learning and guided learning in addition to more traditional instruction, and as traditional instruction itself changes, we must be aware of the possible risks associated with such a transformation. Our pursuit of personal choices could lead to dilettantism, and the pursuit of Pluridisciplinarity may produce a generation of generalists who lack the proper disciplinary foundations to keep driving the boundaries of knowledge and the machinery of the Science, technology and innovation (STI) triangle, so necessary for socio-economic well-being.

This balancing act will be the biggest challenge before the universities of tomorrow. Those who succeed will be able to retain or achieve that aura of excellence that is difficult to define precisely, but that which great institutions of learning have always had.

5.6. Curricula for Tomorrow

There will be multiple offerings online, not just at large but involving participants on campus as well. Such MOOCs and more specialized versions of them will also allow for "flipped classroom" instruction.

The content of the regular curriculum will probably be a three-tiered structure, with emphasis on streamlined but bedrock core programs, and with lots of variation. The three tiers would cover:

- The foundation (a broad liberal arts and scientific exposure);
- The specialization in a discipline; and
- The transdisciplinary exposure.

The teaching curriculum will teach above all "learning to learn" and an approach to knowledge and research, as specific content is likely to evolve rapidly. A firm and broad foundation in these attitudinal skills, learning skills, inter-personal skills, and socialized behavior, as well as good grounding in one discipline and a broad exposure to the values of the university, will lead to graduation and the job market, followed by continuing life-long education, through formal instruction either online or in person, or a combination of both.

5.7. University Governance in the 21st century

The University needs to involve as partners in its decision making the broad gamut of social actors with whom it must interact, and who are affected by and can affect, the institution's decisions.

Opening up the University to a broader set of partners will not demean it or diminish its commitment to excellence and the core values it stands for. Stephen Jay Gould observed:

> *"It is important that we, as working scientists, combat these myths of our profession as something superior and apart. ... science can only be harmed in the long run by its self-proclaimed separation as a priesthood guarding the sacred rite called* ***the*** *scientific method.(emphasis in original) Science is accessible to all thinking people because it applies universal tools of intellect to its distinctive material."*[7]

5.8. What Business Model for the Future?

The attempt to copy the manufacturing business model into the university should be avoided. The business model it should adopt, however, is one where it can have a clear set of functions, and broad consensus by the social actors through its open governance structure, and seek to involve those whose decisions on funding will make the execution of these functions possible. That means the involvement of what are traditionally seen as external parties, must become part of the University's business partners: The private sector, government and the civil society. The nature of the partnership is to have clear expectations and transparency in the use of the funds that each party has allocated to the university.

The fine-tuning of this business model will raise the question of the right balance between research and teaching, the role of the university as advisor to the government and the undertaking of programs simply because they are popular with the civil society. It will also raise questions about changing the profiles of the faculty. But that is where the governance structure comes in as a corrective to ensure that the university does not drift towards a profit-making business model at the expense of its educational and cultural mission.

5.9. Values and Modernization

The University requires free enquiry for the practice of research and the pursuit of knowledge. That requires the adoption of certain values that I have referred to elsewhere as the "Values of Science".[8] We all know that effective pursuit of science requires the protection of independence. Without independence of inquiry, there can be no true scientific research. The safeguards which independence requires are obvious: free inquiry, free thought, free speech, tolerance, and the willingness to arbitrate disputes on the basis of evidence. These are societal values worth defending, not just to promote the pursuit of science, but to have a better and more humane society. A society that is capable of adapting to change and embracing the new. A tolerant society.[9]

Tolerance based on the adoption of the values of science is different from the tolerance begotten by indifference to the behavior of others, dismissing them without engaging them. Tolerance among scientists must be based on respect. Respect as a personal value implies, in any society, the public acknowledgment of justice and due honor. ... "If these values did not exist the society of scientists would have had to invent them to make the practice of science possible. In societies where these values did not exist, science has had to create them."[10]

All of these values are the core values of the university. They are values honed by teacher example and student practice. But broader still are the functions that allow us to teach our

children that words such as truth, goodness, beauty, equality, liberty and justice are not empty words, but ideas that civilized humans live by.[11] The university is the place where citizenship is first exercised, and it is where youth – and the returning older former students joining the adult education programs – can be exposed to the notions of civil discourse, dialogue and orderly debate of complex ideas in the framework of pluralism and mutual respect. That is a core function of the University of Tomorrow, especially in these times of rapid change and globalization.

5.10. Building in Change

Whatever we do, and however much we reflect and plan, reality will overtake us with more change than we can anticipate. Thus, it will be essential to build in change into whatever plans we strive for. The mechanisms of constant and ongoing monitoring and evaluation of university performance and the changing socio-economic context in which they operate should be a feedback model to the decision making machinery in the governance model of the university. The ability to introduce change rapidly will be important. This will happen anyway in a pluralistic higher education sector as some of the institutions disappear and other new and innovative institutions appear.

6. A Global University?

While the internet has opened many avenues, and social media has become a part of everyone's life, it remains true that recent research finds that people who rely on Facebook for their socialization are less happy than those who actually have real world social interaction.[12]

It behooves us therefore to also raise the question about whether a global consortium of universities could offer at least some students a global university program that would allow real experiential learning about real people and real social contexts. Here are some thoughts, defined in mid-2013, suggesting what such a program could look like.

6.1. A Global Consortium and a Global Program

The nature of the global society towards which we are moving at frightening speed opens up new avenues for us to reflect on the possibilities that were barely feasible in the past. Already in Europe an acceptance of common standards and a systematic agreement between countries allow young people in the Erasmus Mundi program to take different semesters in different establishments in different countries as they work towards their degrees. This allows these young people to mix with youth of their age in different countries as they study with teachers of different nationalities and get exposed to the societies and cultures of various European countries. This undoubtedly broadens their perspectives, widens their network of acquaintances and expands their horizons, regardless of the content of the courses they are formally studying.

We have long advocated as part of the Euro-Med schemes an expansion of this Erasmus program to encourage youths from both sides of the Mediterranean to have the benefit of this multiple exposure to different cultures and different peoples. Today, thinking boldly, there is no reason why the idea of such a program should not be adapted at a global scale. It could

be built upon a foundation of MOOCs where membership in a class is no longer confined to those who are physically located near the professor and his or her base of teaching; it could be refined in the sense of having a consortium of participating universities that will agree to have such a program among their offerings, and make that option available to their students who participate in that program at the university, and a number of these students could then be the ones that physically go in different locations at different universities, and continue their studies in an expanded international framework. It takes the American "semester abroad" concept and the European Erasmus program to a new scale and would open avenues for the brightest among the students of the developing countries to explore new avenues and become the first students who are truly trained and socialized as citizens of the world.

7. Conclusions

Have we even begun to plumb the depth of the challenge and its implications? Can we even claim to have properly sketched out the full range of implications that the seven pillars of the new knowledge revolution will force upon us? Do we know what the technologies of the future will do to our ability to summon the spirit of the past and conjure inspiring images to help us create a new future? Who can tell?

> *"In this modern age, we are "Questers" who understand that knowledge and cultural expression are a journey and not a destination, and who recognize that there is more importance in the fecundity of the questions than in the finality of the answers."*

I hope that the recommendations that I have sketched out will help lay the foundations for a proper response to a rapidly changing world, not by trying to define that world accurately and prescribe actions precisely, but by proposing approaches that will involve the key actors and allow for maximum flexibility as we allow the institutions to evolve and the processes to adapt and the boundaries to move as we respond to that ever changing landscape, as we increasingly move into a world whose wonders we can only dimly perceive. It would be hubris to imagine that we – who could never have imagined the impact of the internet 20 years ago, or the reach of Facebook and Twitter ten years ago – would be able to lay down a precise path to the future for the next 20 years or so. We can only raise questions and express hopes…

No, there are no complete or even fully satisfying answers to many questions implicit in the discussions above. But in this modern age, we are "Questers", to use the expression of Boorstin,[13] who understand that knowledge and cultural expression are a journey and not a destination, and who recognize that there is more importance in the fecundity of the questions than in the finality of the answers.

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Online Education:
A Revolution in the Making

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Abstract

Internet and Communication Technologies are transforming education, taking it out of the traditional classroom and making it open, affordable and dynamic. Universities, publishers, corporates and individual lecturers are creating online courses. A course consists of video lectures, electronic study notes, online tests and assignments. Anyone who wishes to learn may enroll in these courses, take the lessons, complete the tests and assignments, and receive a certificate upon successful completion of the course. These Massive Open Online Courses (MOOCs) are making world class higher education available to all those who wish to learn, regardless of age, location or educational background. Education faces a number of challenges worldwide. Over 366 million youth are unenrolled in colleges. College education is growing more expensive. Many institutions face shortage of qualified faculty members, funding and infrastructure. Education over the internet can address many of these issues. Online classes are scaleable – a class of 50 can be expanded to teach 50,000. Teaching and learning over the internet can be done at a fraction of the cost of traditional classroom teaching. Flexibility, mobility, use of multimedia technologies, constant syllabus revision, collaboration and interactive discussions give online education an advantage. This is still an evolving field. New partnerships, innovations and technological advances are revolutionizing teaching and learning, and clearly, online education is an integral part of the future of education.

1. Introduction

A much quoted and requoted quip about education is that it has not changed much since the middle ages. If a physician from the 12th century were to enter an operation theatre in a hospital today, he would faint. Whereas a teacher from the same period could enter a classroom and feel quite at home. But this joke is becoming more and more obsolete every day. The past two years have seen such a phenomenal transformation in the nature of education that even a teacher from an earlier decade would feel the change.

Technology that has penetrated every aspect of our life has altered teaching and learning. Internet and Communication Technology(ICT) has rewritten the rules. The university is no longer the sole repository of scholarship. The class is not enclosed within the walls of the classroom anymore. Knowledge is not contained in a textbook. Imparting it is not the domain of the teacher. The degree is not the sole proof of learning. Education, as we have known it,

is on the cusp of a profound change. Gutenberg's printing press made books easier to print, and what had been handwritten, rare, precious and so tied to library shelves was freed of the chains. The computer and internet gave us the 'soft copy' that freed information from all physical media. ICT is virtually opening up education to the whole world.

"Education is an insurance against poverty."

2. Value of Education

Education is directly or indirectly connected to every global challenge we face. Statistics from every continent show that the higher the level of education, the lower the rate of unemployment. Even in countries where unemployment levels are high, the unemployment rate of those with a degree is less than unemployment rate of those without a college education. Higher educational attainment also correlates with higher earnings. Perhaps with the exception of Bill Gates, Steve Jobs, Mark Zuckerberg and a few others, college education is essential for a rewarding career.

That makes education an insurance against poverty. Illiteracy, unemployment and poverty form the hotbed of extremism, and education that tackles each of these issues is a safeguard against violence at all levels, domestic to international. Better educated people are better equipped to overcome the frictions of globalization and cultural differences. Historically, education and democracy have been inextricably linked. No country with very low levels of education has been democratic over the long term, and almost every country with a high level of education has remained a stable democracy.

Life expectancy is found to be strongly associated with education. Data shows that among 15 OECD countries, a man with tertiary education lives 8 years longer than one without a degree or diploma. According to a 2012 UNESCO report, each extra year of a girl's schooling reduces her fertility rate by 10%. At the same time, the probability of infant mortality reduces by 5% to 10%.The children of more educated people are better immunized and twice as likely to survive beyond age 5. Education also turns out to be the first vaccine against disease.

Those with higher levels of education are more likely to report stronger civic engagement. They take action to address ecological and social issues. Education plays a key role in our attempt to evolve a new global paradigm to meet today's challenges.

3. Gaps in Education Today

People arrive packed with food, sleeping bags and torches, ready to spend the night outside. They are not campers holidaying in the woods. Nor are they eager customers impatient to buy the latest model of the iPad or iPhone at an Apple store in New York or Beijing. They are parents of three year olds queuing up in front of the school gates in many Indian cities, to secure an application form for kindergarten. Application forms are limited in number, and obtaining a form is the first of many steps in obtaining school admission for their wards. So, the night before the forms are distributed, parents queue up on the road outside the school, to ensure that they get the form in the morning. If this is strange, college admission

can be worse. The acceptance rate in some Indian colleges is less than 2%, and the admission process is a pressure cooker like situation.

"If all those of college going age in India need to be enrolled in tertiary education, then the country will need 132,000 more colleges, and 4.1 million lecturers will have to be recruited to teach these new students."

The Indian national college enrollment rate is under 20%. If all those of college going age in the country need to be enrolled in tertiary education, then India will need to send 95 million new students to college. That means 132,000 more colleges will need to be built, and 4.1 million lecturers will have to be recruited to teach these new students. If in 65 years of independence, the nation has reached a position where it has 35,000 colleges and .8 million lecturers, what will be the time, cost, resources and effort required to multiply the educative capacity of the country 4 times in the next few years!

The Indian college education scenario is indicative of the same level of functioning in many other countries as well. The world over, more than 366 million youngsters are left out of tertiary education. If all of them are to be admitted to college, how can they be accommodated, or can they ever be accommodated? Such a large gap between demand and supply as it exists in India does not exist everywhere, but every country has its own set of issues.

"In the past three decades, average family income has risen by 16%, while fees at public universities have gone up by 250%."

According to *American Dream 2.0,* the Gates Foundation report, just over half the students who enroll in an institution of higher learning in the US graduate within 6 years. One of the primary reasons students drop out is finance. In the past three decades, average family income has risen by 16%, while fees at public universities have gone up by 250%. Some of the enrolled students are forced to drop out of college and take up a job because debts are piling up. The student loan debt of over $1.1 trillion in the US is composed of 38 million borrowers. The higher the fees, the greater the borrowing, and higher the default rate, dropout rate and the unemployment rate.

Where finance is not a problem, quality of education can be. Much as it may defy the imagination, there are schools and colleges that teach the technology of magnetic tapes and punched card readers to their students of computer science. Syllabus updation takes place once in a few years, while advancement in technology is announced every few weeks, if not days. There are classrooms without roofs, without walls, without even teachers. More than half the college faculty positions in India are currently vacant. Low college enrollment rates result in fewer eligible teachers and lack of good teachers affects college education in return.

Many other factors trouble education today. It is one of the first victims of conflict and violence. In societies where women are repressed, half the population is consequently left out of education. Those with special needs and challenges often face insurmountable obstacles

on their path to school and college. In the US, 57% of youth with visual impairments attend post secondary schools compared to 68% of the general population. In many developing countries, not even 10% of such youngsters receive any kind of education. With low levels of education, poverty follows.

4. The Online Revolution

The challenges facing education are numerous and varied. There have been attempts, some successful, made to address them in the past. But what makes this period momentous is that technology makes it possible to break into another space and time, taking education to a whole new plane.

When we order a book online from Amazon or one of the many similar online stores, we hardly wonder at the act. But when Jeff Bezos started Amazon.com 18 years ago, Barnes and Noble, the Borders Group and other large bookstore chains dominated the market, and the idea of a website competing with the giants was a new, even irrational one. But the startup not only overtook everyone else in the domestic market, but soon began selling to the whole world. The user friendliness of the site, the wide range of products, discounts, user reviews, wish lists, targeted advertising and the convenience of shopping from home made the whole idea a perfect success, and setting up an online store seems the most obvious thing to have done then.

The idea of online education is similar. Just as Amazon took the experience of shopping out of the brick and mortar store and made it available on the internet, enhanced the process and continues to do so in a hundred ways, it is possible to do the same with education. Both traditional universities and a range of startups are experimenting with new models that challenge centuries of convention. In another 18 years from now, online education will seem to be the most obvious thing to have done at this time. Today when one mentions major booksellers, the name of Amazon comes first to mind. In education, it is Harvard, Cambridge, MIT and the like. What will it be 18 years from now?

What is online education? The terms virtual education, e-learning, web-based training, computer-aided instruction and digital education are all references to the use of electronic media and ICT in education. In other words, it is what we have been doing since the 1960s. In 1960, the University of Illinois linked computer terminals in a classroom to allow students to access informational resources on a particular course while listening to recorded lectures. Today, when we read an online book or newspaper, a newsletter or even a mail message, we are engaged in online education. Participating in a discussion, reading a blog, visiting a website, watching a video, referring to an online dictionary or encyclopedia, even social networking are learning experiences, and come under the same definition.

If online education has been around for over half a century, why is everyone suddenly talking about it so much now? Since 2004, enrollment in online learning has recorded a growth of 2% per year. Almost 25% of all students in post-secondary education in the US were taking online courses in 2008. In 2009, it had risen to 44%. This figure is projected to rise to 81% by 2014. From being a marginal, experimental idea, online education is gaining

mainstream acceptance. From renowned universities to educational startups, from publishing houses to software companies, everyone has realized the potential of online education to democratize and revolutionize global education.

5. MOOCs

MOOCs, or Massive Open Online Courses, have become phenomenally popular. A MOOC refers to a web-based class that can support a large number of students. Anyone from anywhere in the world who wishes to learn can enroll in a course. Each course typically consists of short video lessons, with a lecturer or subject expert teaching the subject with the help of models, images, animation and video. Each lesson is followed by multiple choice tests that the students take online and assignments that they complete and submit. Multiple choice tests are automatically corrected, essays are peer reviewed or graded by teaching assistants. Students can email or chat with lecturers, participate in forum discussions, raise questions, form study circles and in some cases, even meet co-students offline. After all the video lectures have been watched and tests successfully taken, the student is awarded an electronic certificate of completion by the MOOC provider. These providers can be colleges, private educational companies, even individuals.

With advances in multimedia and technology, new and innovative methods of teaching and learning have evolved. Video conferencing software makes it possible to recreate a classroom in virtual reality. Social networking sites can be used for real time research. Cloud computing technology assists in online collaboration. Learning Management Systems allow anyone with little technical knowledge to create a course and present their expertise online. 3D gaming teaches as much as it entertains, and can improve the impact of education tremendously. Crowd sourcing harnesses the knowledge already discovered. E-book readers, notebook computers, tablets, phablets and the like that will be developed between the time of writing this article and its publication make dissemination of knowledge easier, more effective and affordable.

In a trendsetting move, MIT put all of its educational materials online in 2002, allowing free access to all. In ten years, many colleges have followed suit. According to the Babson Survey Research Group report, in 2012, 2.6% of the colleges in the US provided MOOCs, and an additional 9.4% were in the planning stages of creating MOOCs. Some colleges collaborate to provide their courses under a single platform. One example of a collaboration of many institutions is edX. It began as a combined initiative of Harvard University and MIT, and as of August 2013, University of California at Berkeley and 25 other international institutions were involved. Coursera and Udacity are two of the largest private MOOC providers. They are founded and managed by educational entrepreneurs and provide a platform for a college or lecturer to teach a free course online. Most MOOCs are not for credit, and do not award degrees that are officially recognized by universities. But some are experimenting with charging a fee, arranging a proctored examination at the end of the course, and providing a degree. Some colleges collaborate with private MOOC providers and allow their students to take some courses online. Online education is an evolving industry, and every day sees the birth of innovative ideas.

6. Advantages of Online Education

Best quality education can be made available to the whole world. Remember that one brilliant lecturer you had, whose classes were inspiring, who awakened in you an interest for the subject, whose lessons you still remember. Imagine if every student could learn from that lecturer. And if every subject could be taught by lecturers like that. The best lecturers in every field could be identified, and their courses made available on the internet. Faculty shortage will become a thing of the past. Every student regardless of country, background and academic proficiency could learn from the best talent in the world.

An online course need not be restricted to watching a recorded lecture. Animation, virtual reality, audio, video, virtual lab, video conferencing, chat, discussion forums and social networking sites make learning a richer experience. Imagine learning Shakespeare by watching his play enacted, geography through virtual visits to the places studied, history through documentaries and dramatic presentations of historical events, or science through films of actual experiments and conversation with famous scientists. It is no surprise that the Babson Survey Research Group report shows that 77% of academic leaders rate the learning outcomes in online education as the same or superior to those in face-to-face classes. Neil Armstrong called the first step he took on the moon as a giant leap for mankind. We are currently making that giant leap in education.

Expansion is possible on a scale larger than ever conceived of before. Imagine doubling the size of a traditional college class. If a class of 50 were to be expanded to accommodate 100 students, it might be managed with some ingenuity. If another 100 were to be enrolled in the same class, it might be difficult. But if a 1000 students need to be taught, it would require setting up new classrooms or a college itself, hiring lecturers, providing the infrastructure and a lot of time and money. Whereas in the case of an online class, a class of 50 can accommodate 50,000, 5 million, or even 50 million. The digital classroom does not have the constraints that its physical version has. Scalability is critical in education systems of the future. Tertiary education participation rate in 2010 was 80% in OECD countries. It is 26% for China, 18% for India, 41% for Latin America and 7% for Sub-Saharan Africa. Like the proverbial Bata salesman who saw people barefoot in Africa and found in it a huge opportunity, the poor enrollment rates in countries in Asia and Africa can be seen as an indication of an exponential rise in the demand for education there.The enrollment rate has tripled in China between 2000 and 2010. In the same period, India and Latin America have seen doubling of rates. An education system that aims to provide education to all needs the potential to incorporate students in large numbers, read millions.

Flexible hours and self-paced learning suit those who are trying to juggle work, family and studies. After finance, the next greatest challenge to retaining students is class timing. All those who drop out of college because they need a job or cannot leave the house for family reasons can be retained if they are allowed to take classes when and where they can. Online education can be paced to adapt to the speed and capacity of each individual student, so above average learners can proceed quickly and others can take more time. Space and time become irrelevant. Students can take a class at home, at work, during travel, or just about

anywhere. The class is not limited by time either. Once a lecture is recorded, it is available forever. Students can watch it any number of times till they master the subject. We can have talented and inspiring lecturers teach us even after they are gone. Imagine having Einstein tutor you at home on a one-to-one basis. It is just one of the possibilities of online education.

Text and audio content can be made available in multiple languages. With the help of translation software, educational resources in one language can be made available to everyone in every language spoken on earth. This automatically expands the student base from North America and parts of Europe to include the whole world. Some countries and colleges have resources for those with physical challenges. If these could be made available to all such people in countries where such facilities are not even conceived of yet, or have never been attempted for want of resources, hope for a better life will replace despair.

Online education lends itself most naturally to collaboration between colleges, government organizations, companies and communities. This opens up infinite opportunities for students. It also lends itself to be customized and specialized to meet the varied interests and needs of students, far more than is possible in the bulk educational delivery system now prevalent for higher education. Syllabus revision can be done on an ongoing basis, without a lengthy procedure, administerial bureaucracy and the cost of reprinting thousands of books. This way, students stay updated with rapid social and technological advances. A wider range of subjects is available for students to choose from. This especially benefits students in rural areas and small towns where colleges offer limited program options. Students benefit from exposure to many cultures and viewpoints. Learning from a lecturer from another country, and discussing with peers spread all over the globe, students gain a global perspective that would otherwise have been beyond their reach, and which will qualify them to become global citizens.

In a world where the cost of education is rising rapidly beyond the reach of many students even in Western countries, online learning represents a way to deliver education at a fraction of the cost of traditional classroom education. Apart from tuition, costs of transportation and accommodation can also be saved.

7. Questions about Online Education

We may talk about online education saving everyone time, money and a lot of trouble, but there are also many who vehemently call for saving education from this online frenzy. When The New York Times declared 2012 the year of the MOOC, there were others who termed it the year of hyperbole. Selling books, headphones or used cars may very well be done online, but education is not a commodity to be sold. It is a process to be experienced. Nothing ever can replace the physical presence of a teacher. Teachers do not just teach their subject. In a hundred ways, they pass on their passion for learning, their values and principles to us. Their presence inside and outside the classroom, their handwritten notes on the answer sheets, their jokes and reprimands, their scholarship have all influenced us deeply. How can an image on a computer screen fill that place? Attending class with a group of friends, scribbling messages to one another, discussing, arguing, studying together – aren't all these as integral a part of college as acquiring a degree? The time spent at the college canteen, dorm, lab, campus

grounds, baseball matches, class outings are all learning experiences that teach us lessons that last a lifetime. Can all this be stimulated in virtual reality? Lifelong relationships often begin in school and college. How can the internet give all these? In a world where people are already getting addicted to gadgets and becoming more isolated, what will the youngsters of the next generation be like if they are left in front of the computer all day or night? What will the physiological, social, psychological consequences be? Doesn't the virtual world come with its share of problems – problems of security, hacking, identity theft? How can one make sure that the youngster sitting at the computer is watching a video lecture and not indulging in some recreational activity that does not serve any purpose? What if a forum discussion strays from the subject to personal affairs? Evaluating a multiple choice question can be automated, but how can a software program evaluate an essay on the subtle humor in the works of William Makepeace Thackeray? It is not easy to stay focused and self-motivated when one is given freedom. Why is the dropout rate in MOOCs so high? How can an employer be certain that the applicant actually took the online course and tests, and not a proxy? These are some of the questions being raised.

"When Gutenberg started printing Bibles, the capacity to read and write was taken as a sign of genius and many protested that the Word was meant to be read only by priests."

New developments are always received with some degree of skepticism or opposition. When Gutenberg started printing Bibles, the capacity to read and write was taken as a sign of genius and many protested that the Word was meant to be read only by priests.When electric street lights were introduced in Germany, some declared it as evil. God had meant the day to be bright and the night dark, man should not interfere with the divine will. When Apollo 11 was launched, there were some who criticized spending millions of dollars on a fool's errand. Until the dawn of the PC, working with computers was regarded as the sole province of engineers and scientists. The ATM, cell phone, satellite TV, social networking, e-commerce, internet banking, wearable computers – which one of these was welcomed without cynicism, only to be accepted as a matter of fact in due course?

8. Interactivity

An internet-based education need not exclude the traditional classroom. A blended or hybrid version can combine the best of both formats and elevate education to as yet unknown standards. When a lecturer uses a recorded lecture, there is more time for direct interaction with students. Any student can directly email the lecturer, have a live chat discussion, or participate in a video conference. Skype, Webex, Google Hangouts are some of the video conferencing platforms that enable the creation of global classrooms. More versatile and user-friendly group discussion software and feature-rich social networking sites allow students to relate to their classmates.

Online education need not isolate the student; it can enable him/her to connect in ways never done before to students across continents, cultures and age groups. Some forums allow

voice messages in addition to text. Live chat makes discussion as close to a classroom discussion as possible. Questions posted in forums in Coursera courses are answered, on an average, in 22 minutes. Students who are active in the forums, who answer questions, or even raise them are noted, and their participation is positively reflected in their grades. Posts can be voted for, and students whose posts receive the most votes are similarly appreciated on the completion of the course. Forums keep track of the most popular topics and questions raised, and the MOOC instructor personally responds to them, or takes them up during subsequent live conferences.

Following instructors or peers on Facebook, Twitter and other social networking sites makes learning fun, and more effective. A lecturer teaching science fiction asked his students to watch a film as a course requirement. Students could watch the movie anywhere they found convenient, but were required to 'live tweet' their viewings. This created a collective experience out of the disparate viewings. Then he used Storify, a tool to collect updates from social networks and created an interactive, dynamic and social story, and put his students' posts together. The tweets and the story form as much an education as his course that follows. Moreover, they make students connect with each other in dynamic ways. Using video conferencing facility, another lecturer taught a global classroom, followed by a live discussion between students in the US, Brazil, India and China. Inkling, a company that creates interactive digital textbooks, allows the reader to not only take notes, but also create study groups online, and lets one see others' notes and highlights in real time, creating running discussions on the go. Kno Inc., an education software company, lets you get even your professor's notes right in your e-reader.

Many educators are using Pinterest, the pinboard-style photo-sharing website, to aggregate images, create visual scrapbooks, publish students' work, and engage a group. The networking power of Facebook is already legendary. A study of Facebook usage among educators and students concluded that the participation of a mentor and mentee on a Facebook group page is seen to positively affect their relationship both online and offline. Students and mentors that interacted regularly, posting questions and receiving feedback through the page, were observed as having a stronger relationship than other mentor-mentee pairs.

Peer review which is part of some online courses can be an education in itself. Online forums make it possible for students to raise questions and to teach one another as well. Some MOOCs allow students to identify classmates from the same vicinity, and enable physical meetings, much as home schooling students have their study groups and joint activities on a regular basis. Coursera meet ups allow Courserans living in the same locality to meet, discuss the course or any other subject. At a meet up in Menlo Park in 2012, the organizers expected a turnout of 100 students, but more than 600 attendees arrived, raising the question whether meet ups are the new classrooms. Interaction, meetings and socializing are possible even in online education.

9. Education 3.0

Education as we used to know it, and which is now termed Education 1.0, was imparted by teachers in the classroom using textbooks and notes. Education 2.0 saw the cautious

acceptance of technology. Computers and the internet were used to supplement teaching and learning. Today what we are witnessing is Education 3.0. Education takes place everywhere, in the classroom, at home, on the road, in the workplace, anywhere. It comes from teachers, classmates, friends, strangers. Technology has permeated everything, and education has become lifelong.

New learning methods have always evolved. An advertisement for shorthand courses through weekly mailed lessons was seen in the Boston Gazette in 1728. The University of London first offered distance learning degrees in 1858. In the 1930s, schools and colleges in the US were using radio to teach students. UK's Open University established in 1969 initially relied on radio and television broadcasts for delivering its courses. In 1976, Coastline Community College in the US combined computer assisted instruction with telecourses to successfully establish online distance learning. The limitations of the classroom were overcome long before the internet. Distance and Open learning have provided education to students who either could not, or did not attend regular classes. According to the 2011 report of the US Department of Education, 20% of all students enrolled in college took at least one distance education class, and 4% enrolled in an entire program through distance education. In India, 24% of all students study through the correspondence method. IGNOU, an Indian open university, teaches 3.5 million students each year. Turkey's Anadolu University and Allama Iqbal Open University in Pakistan educate nearly 2 million students each. Since its launch,UK's Open University has taught almost 1.8 million people worldwide. Online education is one step in a long continuum.

Online education is to distance education what the E-book reader is to the book. It is not a glorified version of the older one. It brings much greater capabilities than ever imagined to improve the quality and effectiveness of this huge field. True, there is only so much that can be transmitted through wires, or wirelessly. Online education is the solution to a number of problems, and at the same time poses a different set of challenges.

10. Innovations Unlimited

Startups and established companies alike come up with products, services and ideas that seek to improve online education and meet the challenges it presents. The range of subjects offered by MOOCs and providers of online education leave the students spoilt for choice. There are search engines such as Moocse that search the MOOCs for the required course. Class Central, MOOC List and moocs.co are online course aggregators or directories that list all available courses. Some even allow students to rate the courses they have taken and lecturers they have had, to guide others. Learning Management Systems (LMS) such as Blackboard, Moodle and Desire2Learn allow the creation and management of online courses. Presentation, audio, video and graphics software allow a subject expert to create all the components that make up the course. One need not be a college lecturer or a PhD holder to create a course, companies like Udemy and Educreations allow anyone to host courses online and share knowledge with the world. Khan Academy, Codementor, Colingo, Magoosh and many others focus on one or a few subjects exclusively. TED Talks educate in an unconventional, inspiring way. Major players such as Apple, Samsung, Nokia and Sony create devices that

cater to the educational needs of students. Others like Datawind come up with low cost devices that aim to make digital education affordable to all. Publishing houses like Pearson and tech companies like Inkling and Kno create interactive, digital textbooks that allow the reader to organize notes and take tests on the internet, so that the plethora of information does not overwhelm the student. Organizing software such as Zotero allow one to categorize data, ebooks, websites, videos, notes, and synchronize all these online with other users. Kno Inc. provides a personal study dashboard that helps students track their learning engagement for each ebook they use. Wordle, a tool for generating customized "word clouds" from text, can be used to make text more visually appealing, and put to uses that are limited only by one's imagination. Biometric devices for identity verification aim to minimize fraud. Hardware, software and strategies that seek to prevent malpractice during the course and evaluation, and different revenue models that will make open courses sustainable are mooted. Google and edX are collaborating on a new online learning platform, MOOC.org, which they aim to make the YouTube for MOOCs. Udacity, along with other online education providers and tech companies in Silicon Valley, has launched The Open Education Alliance, which is an experiment in open education. Collaborations are the rule of the day, with tech giants and startups, government and voluntary organizations, universities and publishing houses coming together to educate. Tools are available for every conceivable aspect of learning − for event scheduling, translation, flashcard creation, mind mapping, document sharing, digital storytelling, screen casting, note taking, blogging etc.

11. Assessment & Certification

There are course providers that adopt the freemium model, where the basic course is provided for free, and students are charged to take a proctored exam, and receive credit for the course. Coursera launched Signature Track, which gives students the opportunity to earn Verified Certificates in recognition of their work and completion of a course, and within 9 months of the launch, 25,000 had signed up. These certificates are building a reputation as an accessible credential for adults to demonstrate their proficiency in a range of skills and disciplines. Signature Track links one's online coursework to one's real identity. It provides financial aid for students who are unable to pay for the certificate. Its participants are substantially more likely than the average Coursera student to complete a course. These Verified Certificates are beginning to be included in resumes, cover letters and LinkedIn profiles. Certification ties in with employment opportunities.

12. Employment

Many online educators provide training for students through tie-ups with companies. Some allow companies to recruit from among their students. The Cisco Learning Network is a social networking site that lets users seek knowledge, training, and support to enhance their careers through various certifications offered online. The portal also has a mentorship programme where peers anywhere in the world can mentor others that are preparing for certification exams via discussion forums, blogs, video interviews and wikis. Udacity allows students to share their resume with recruiters and provides employment assistance by matching students with prospective employers. Knight Center for Journalism in the Americas'

program on journalism offers students the chance to interact and learn directly from data journalism experts working for leading U.S. publications. The advantage of education providers partnering with companies is that students can be trained in a way that ensures they will be hired, almost guaranteeing employment. There are now enterprises like Accredible that translate all online learning into a five star rating to assist recruiters take a decision about the applicant. Online accreditation and certification are going to assume a lot of significance given the projected shortage of graduates worldwide. Manpower Group's 2013 Talent Shortage Survey finds that currently, 35% of employers worldwide report having difficulty filling jobs due to a lack of available talent. A 2013 study by the Lumina Foundation finds that by 2020, 65% of the workforce will require some form of post-secondary education. At the current trajectory, the US will be at 48.1%. A study by the McKinsey Global Institute says that by 2020, there will be about 38-40 million too few college and university graduates to satisfy the demands of the global labor market.

"The Academy has envisioned an idea half a century ahead of its time, and is perfectly poised to assume leadership by creating a World University Consortium."

13. World University Consortium

"The future of education is online."

Education is breaking out of monastic retreat and coming into much closer contact with the real world. Online education blurs the line between the university and society-at-large enabling other players to become major knowledge providers and enabling academia to experiment with new types of courses that do not fit within the confines of conventional academic disciplines. The completion rates of MOOCs may be low, but given that the strength of many MOOCs runs into tens of thousands of students, even a completion rate of 10 or 20% means a class larger than most college classrooms. The course "Functional Programming Principles in Scala," from Switzerland's École Polytechnique Fédérale de Lausanne attracted 50,000 students. 83,000 enrolled in "A History of the World since 1300" at Princeton University.University of Edinburgh's course "Introduction to Philosophy" drew almost 100,000 participants. With such numbers, even a miniscule completion rate translates into a very large class.

The founders of the World Academy of Art and Science were inspired in 1960 by the idea of establishing a "world university". The Academy has envisioned an idea half a century ahead of its time, and is perfectly poised to assume leadership in this initiative by creating a World University Consortium.

14. The Future is Online

The future of education is online. The claim is backed by all available data. The Babson Survey Research Group, supported by The Sloan Consortium, Pearson and the College Board, has been studying online education since 2002. Its January 2013 report, *Changing Course: Ten Years of Tracking Online Education in the United States*, is the tenth annual

report in this series. According to it, 71.7% of higher education institutions were offering some form of online learning in 2002. In 2012, it had risen to 86.5%. 34.5% of these offered complete online programs rather than individual courses. Now the number is 62.4%.

In 2003, 57% of academic leaders rated the learning outcomes in online education as the same or superior to those in traditional classroom learning. In 2012, the number had risen to 77%. However, faculty resistance to online teaching is considerable. 27.6% had accepted the value and legitimacy of online education in 2002, and that rate has inched up to 30.2% in a decade. Academic leaders and faculty members at institutions with online offerings have a more favorable opinion of the outcome of online courses than those at institutions with no online offerings.

69% of chief academic leaders say that online learning is critical to an institution's long term strategy. The number of American students taking at least one online course is 6.7 million. The proportion of all students taking at least one online course is 32%, up from 9.6% ten years earlier. Mark Twain is supposed to have humorously said that he never let his schooling interfere with his education. His words are literally coming true for many.

The cold numbers above all represent heartwarming human stories. A self-learner left a note in one of the popular MOOCs. He had been working as a shelf stacker for 6 years, applying for 4 jobs every week but with no avail. Programming had long fascinated him, but there had been no opportunity to learn. The advent of online courses had provided the opening, and the shelf stacker took a programming course, applied for a software job, and found one that paid more than twice his earlier salary. When he went to a dentist and filled out a form, under occupation, he put 'software engineer' instead of 'shelf stacker'. There can be no number affixed to the sense of satisfaction, pride and joy in that.

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The Double Helix of Learning and Work*

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Editors' Note

The Double Helix of Learning and Work by Orio Giarini and Mircea Malitza is a report to the Club of Rome first published by UNESCO in 2003. It advances fundamental paradigm-changing ideas in the field of education. Drawing inspiration from the double helix structure of DNA, the authors seek to strengthen the relationship between education and employment in order to bring 'The Knowledge Society' within reach. This article contains the first chapter of the report. Successive chapters will be carried in subsequent issues of *Cadmus*.

Chapter 1
"I Learn, therefore I Change"

1.1. LIFELONG LEARNING: A BLOCKED PROJECT

A new concept of *lifelong education* emerged by the end of the second half of the Twentieth Century. Over that period, human societies had tended to place education among their top priorities. The idea that good schooling was the underlying prerequisite of modern life, welfare, and normal social integration had never seemed more obvious. The widespread interest in education was exploited by political parties, which busily produced doctrines, solutions, and reform plans. In the developed countries, education benefited from extensive support and generous facilities, while the developing countries inaugurated campaigns against illiteracy and for the establishment of structured education systems.

Nevertheless, dissatisfaction about the performance of educational institutions has persisted from one generation to the next. Since Philip H. Coombs published *The World Educational Crisis* (1968), the catchword has been: all countries face a severe crisis in their education systems, and all countries have solemnly launched comprehensive reforms. Few people understood that the very idea of intermittent reform was wrong and that a good school

needed to undergo continuous reform, adjusting itself to the needs of society and to the new promises of technology after having introduced proper mechanisms for change into its institutional setup.

"Education does not conclude with graduation or a doctoral paper, but it remains open-ended."

It is difficult to expect that, all by itself, one of the most conservative structures of civil society should be able to develop a vocation for perpetual change. For centuries, people have perceived education as a fixed system through which "innocent" young people are processed in order to be returned to society after a decade or two, well-equipped with knowledge and skills that are necessary for a productive life. No matter how many efforts are made to humanize this process by imparting to it affective, moral, or aesthetic dimensions, deep down it has never changed.

Education is viewed as a system with an input and an output, and its effectiveness is measured by means of statistics, costs, infrastructure, and personnel. At its core lies a centuries-old set of subjects or disciplines in a *curriculum* that has a flow similar to that of etymology, like a river that gradually deepens and branches out. Ever since the days of ancient Greece, mathematics has been mathematics, music has been music, astronomy has been astronomy, and medicine has been medicine. Until recently, despite the dynamic evolution of the content, *i.e.,* the syllabus, one thing has been clear: the river flows into the sea, and the school is a closed chapter for those who have left it.

Hence, the revolutionary importance of the newly emerging concept. Under several different names, such as *permanent education, continuous education, recurrent education,* it states the same thing. Education does not conclude with graduation or a doctoral paper, but it remains open-ended. The graduates of classical cycles return to take up new subjects. Since the 1990s, this idea has been embodied in the principle of lifelong education or lifelong learning. It points to what was suggested several decades ago, namely learning from "the cradle to the grave".

Let us assume that adult thirst for knowledge has not been discouraged by the closed doors of the official educational or school system, which is considered to be *formal* because it is regulated by laws, ordered by professional *fora,* and recognized by means of official documents, *i.e.,* diplomas. Adults, therefore, have had to resort to *non-formal* organizations that have come in a Variety of forms: so-called peoples' universities, evening courses, and university-level special courses on arts, sports, religion, and foreign languages that entitled graduates to recognition through certificates or other such documents, however, at a lower level than that conferred by "official" diplomas. Such certificates have only acknowledged the fact that a given person has taken a certain course, without providing an additionally recognized right.

At the same time, the explosive development of the mass media, despite their pre-eminently commercial character and focus on entertainment, has been offering new sources of information and knowledge regarding such topics as history, economics, social science, and culture. That kind of acquired knowledge is not entitled even to the less authoritative reco-

gnition provided by a certificate of non-formal education. Everything that an individual can pick up from his or her family or kin group, from readings, or from watching television falls under the no less important category of *informal education.*

Lifelong education is a new and powerful concept that illustrates the changing relationship between the state and its citizens. It is not limited to individuals in a certain age group who have to go to school. Rather the entire population claims the same right, in regard to education, that it has acquired in regard to health care: lifetime access.

The term, *lifelong,* applies to education as well as to learning. The word, *learning,* was introduced over the past few decades, rather than *education,* to emphasize the primacy of the learning process, whereby the individual is supposed to play the leading role, while the notion of an educational system carries the connotation of external intervention. In such a vision, the teacher does not administer knowledge, values, and skills, but returns to *maieutics* – the Socratic method – as a means to facilitate the acquisition of knowledge by those who are interested in doing so.

The ministries of education still retain their names, there being no "ministries of learning". The whole system that is being organized, financed, and maintained by the state is education-rather than learning-based, even though the latter should, in fact, be its basis of operation. Lifelong learning does exist, even if it is an individual responsibility. Each individual resorts to whatever methods may be available to maintain the continuous functioning of learning mechanisms.

The concept of lifelong learning, however, is no longer embraced by the societies of today, simply in the sense of informal and non-formal resources. It is permeating a new vision of education as a guiding and organizing principle. Its merit is to induce a unitary/unifying vision of all education or learning phases, from kindergarten to the doctorate, and on, for a sixty-year life span.

Lifelong learning has come into the limelight for the following simple reasons. The last few decades of the past century coincided with a spectacular explosion of human knowledge. (Here, knowledge is understood as any statement subject to universal verification and validation, a scientific theorem, or a technological recipe, blueprint, or know-how.) Science and technology provide the most accurate definition of knowledge. In a broader sense, knowledge is also acquaintance gained by experience and work, even if it is not theorized or formalized. A huge amount of practical knowledge has been transmitted from generation to generation and has been incorporated into skills to be applied.

Science and technology are the pillars of civilization, followed by universal practices such as trade and other economic activities. Cultures belong to a different sphere, that of beliefs, values, and particularities of language and history which account for their splendid variety.

It has been noted that a piece of knowledge is a perishable product. It is subject to a law similar to that applying to radioactive substance physics:the half-life principle. The school enclosure functions under a similar hypothesis: it equips persons with knowledge that is

supposed to be relevant for the rest of their lives. But the existing system appears to be shaky once school leavers discover that everything they have acquired or learned is no longer valid after a lapse of ten years. A specialist in technology would normally consider that the "shelf life of a degree in engineering is about three years". The halving time of some radioactive substances is hundreds of years, but in the case of knowledge, halving may take less than a decade. Either the inherent frailty of knowledge must be acknowledged, or a radical recycling procedure must be introduced. This last solution points to continuous or lifetime learning.

The second root of the concept is demographic. Life expectancy has increased in the developed countries beyond the age of 70. Young contingents are smaller. The whole of society is aging. The closed educational system was designed and developed for large cohorts of young people and for short active lives. As we write these lines, an 81-year-old Japanese minister is replacing a 71-year old one. The third age has started to look for ways of keeping busy, and it is demonstrating remarkable participatory impulses. Elderly people would like to keep abreast of the times, but the bastion of formal education stays closed.

The social dimension cannot be overlooked. Civil society, today, is vocal. There are numbers upon numbers of non-governmental organizations, movements for the protection of individual rights, for the emancipation of women, and for the inclusion of minorities. Not only do engineers find themselves disoriented when confronted with new technologies, but also those adults, who, when requested to give an opinion, discover that their schooling has not taught them how to communicate, to co-operate, to initiate a new project, or to found a business. Should the doors of the system to active life be thrown open, a greater concordance between theory and the actual throb of life and nature would be achieved as well as the promise of a more harmonious and less schizoid or stressful life. In fact, this last social argument supports and explains the wide attraction that lifelong education now enjoys.

> The high-tech information society is, by its very nature, a changing society that is continuously requiring the mastering of new information and new techniques usable in occupational pursuits. We have, since the early 1960s, been talking about "life-long", "permanent", or "continuing" education which means that no matter how much formal education a person has been able to acquire at the beginning of his or her life, relearning and new learning has to take place continuously throughout the rest of this person's life. Today, in some countries, the costs incurred by enterprises for the upgrading of the competencies of their personnel are of the same order of size as for the entire public system of education (Torsten Husén, "Education by the Year 2025", 1999-2000).

The key question is the following: why does this universally recognized, embraced, and proclaimed concept not work? The question is not about the effectiveness of the vast rhetorical exercise in its favour. What is being evoked is the fact that one rarely encounters a 40-, 50, or 60-year old person who returns to a university saying, "I want to go on", and who finds a welcoming open door. The system is not prepared for such an eventuality. Should this person be sent to the same college from which he or she graduated? But this person has different interests now which do not fit into the educational sphere of that college. Should the

university authorities recommend new textbooks, select bibliographies, extensive courses so that the person might keep in touch with contemporary knowledge? But he or she only needs clarifications, specific applications of that vast amount of knowledge in his or her field of interest, with a meaningful impact on his or her social roles. All this person can receive is a short summer course, designed with the best of intentions by some well-meaning professors, sometimes in collaboration with industry.

When asked about their involvement in lifelong education, universities will briefly mention such *ad hoc* courses that entitle one not to a diploma, but to a mere certificate. They do not offer an orderly learning system; they do not include the applicant into a coherent programme; and they show no interest in what he has formally learned. Why is that? Because higher education curricula stop short of any extension, they do not have open valences to future possible programmes. Programmes are invariably terminal.

This reality draws attention to an element without which the concept remains inapplicable: the curriculum has to be open at the end, while now it is fatally closed. It has to continue into the fourth stage (the other three being clearly defined: basic, secondary, and tertiary). That is, the stage of active life, when life's actor has full and mature possession of his or her capacity to learn alone (goal choice, course choice, choice of the best time frame), assisted by tutors, and enjoying the educational facilities of the school (libraries, laboratories, and other logistical paraphernalia).

As for official recognition, the concept of lifelong education has broken all records. The European Union countries introduced it into the Treaty of Amsterdam. The year, 1996, was declared the "European Year of Lifelong Education". The entire education and training programme of the Communication Commission (Towards a Europe of Knowledge) for 2000-2006 is centered on the subject of lifelong learning. Following the major series of reports that introduced the concept, the recent UNESCO Delors Report (1998) ranks it first among the principles that are most likely to guide the future of education.

Despite significant conceptual progress, the situation in the field remains confused and unsatisfactory. According to the EURYDICE Survey of March 2000 (European Commission, 2000) "as in the case of other desirable social goals, there is a difference between the ideal and the reality, theory and practice, and promises and results".

Is the current situation a result of the difficulty in formulating a precise definition of lifelong education, a fact that has been pointed out by many analysts? All major concepts that influence political activity – *i.e.,* democracy, liberty, welfare – are fuzzy. There is no clear boundary, no precise beginning and end. But this fuzziness does not impede either the broad use of such concepts or their incorporation into legislation and common law.

The present state of the implementation of the concept is that of a huge basket of experiences, in which all attempts, otherwise praiseworthy, to embrace all new forms of learning pertaining to each and every social category and age are thrown in.

It is to be noted, however, that the assembled experiences have been conceived either outside the classical system or in addition to it. If they stay outside, there will be plenty

of goodwill and understanding. Jonasson's (1988) report is quite clear. Four categories of learners (some young students, some aged students, graduates, and those seeking employment diversification in new fields) make up *heterogeneous* groups that require a different, more clear-cut system. The objections of the advocates of the existing educational system, with its traditional and acknowledged discipline, rigour, and academic ethos, arise when a single lifelong education system is brought into question. Pressing the matter to the root of that resistance, one finds an element that has been badly neglected so far: the pressing need for a single methodology, for one homogeneous system, based on a new perspective on knowledge, which still appears to be dominated by the archaic schema of disciplines and their curricula. How can continuous lifelong education be introduced when the traditional curricula are designed for a discontinuous and closed education?

"Interdisciplinarity has been another cardinal idea of the past few decades. It has been the same guiding light for scientific research as lifelong learning has been for education. As in the case of education, what has blocked its coming to fruition has come from the same source: the watertight separation of disciplines or fields of knowledge."

It is only by breaking that deadlock and overcoming the contemporary impasse and confusion that it will become possible to give free rein to one of the most interesting ideas of our time.

1.2. INTERDISCIPLINARITY: AN AILING IDEA

Interdisciplinarity has been another cardinal idea of the past few decades. It has been the same guiding light for scientific research as lifelong learning has been for education. As in the case of education, what has blocked its coming to fruition has come from the same source: the watertight separation of disciplines or fields of knowledge.

Disciplines in the education system more or less coincide with the divisions in the classical schema of sciences. A given science has been conventionally defined according to its object, methods, and theories (also including its language and concepts). Astronomy, mathematics, logic, and mechanics have been recognized as such since antiquity, and their spheres are sharply delineated by the above-mentioned definition. But the progress of knowledge has created new fields of science. Thus, the social and human sciences were slowly emancipated from the embrace of philosophy. The difficulty has lain not so much in defining the objects of the new fields, but, rather, in the elaboration of their particular methodologies, basic theories, and concepts that should be comparable in rigour to those of the older sciences.

The common front of all sciences has always been the complexity of reality. Advancement has depended directly on the progress of technology or on the symbolic apparatus that has led research into areas previously inaccessible to direct observation or non-abstract repre-

sentation. The atomic era, the cosmic era, and the era of genetics that mankind has entered almost concomitantly these days are the most visible headlines of the new fields of science. In all these fields, our imagination is incapable of producing representations. The atom, the cell, or outer space require not only technical tools of access but also abstract tools, *i.e.,* mathematical models playing the part of a mental technology. The complexity of these three levels of reality has reached unprecedented levels.

The sciences need to rely on one another in their endeavour to move forward. Piaget enumerates them according to the criterion of growing complexity and decreasing generality: mathematics, mechanics, physics, chemistry, biology, and physiological psychology. Each field is connected to a less complex field: mechanics is subordinated to mathematics; physics creates a new branch (*i.e.,* mathematical physics); physical chemistry becomes a branch of chemistry; biology becomes so indebted to chemistry that it accepts a biochemical merger; and physiological psychology introduces mathematical methods and biochemical mechanisms in its effort to account for human behaviour.

Taking a cue from the historical solidarity of research branches that went so far as to create mixed fields in the natural sciences, the second half of the Twentieth Century acknowledged the primordial need for *interdisciplinarity* with renewed intensity. The concept has evolved from isolated cases to gain the status of a general organizing principle of knowledge. The disciplines are tending to break away from the stage of stark separatist defense and to accept the imperative of interdisciplinarity.

The *multidisciplinary* approach, defined as a partnership of distinct disciplines, follows logically. The same holds true in the case of a *pluridisciplinary* team made up of specialists in mathematics, physics, chemistry, astronomy, and various technologies who plan and manage a cosmic flight. *Pluridisciplinarity* adds a new touch to *multidisciplinarity,* in attempting to describe the joint efforts of two or more related disciplines to solve a common problem. *Cross-disciplinarity* means pushing back the boundaries of a classical disciplinary turf and making a daring foray into the methods of another, as in the case of "mathematical music". There is also *transdisciplinarity* in the attempt to transcend the boundaries of a discipline by moving into an area of principles or of general methods. The term has also been used when exploring visions or outlooks accessible to the general public without requiring specialist training.

The most widely used and accurate term is *interdisciplinarity,* which contains both the simple joint action or exchange of methods among disciplines and their merger. It announces the prevalence of the problem to be solved over the disciplines that might claim it for their own spheres of concern. It sets out from the existence of "academic disciplines", which it does not demolish, but rather combines into a scientific production co-operative.

The division between natural and social sciences, which became the subject of a major debate in the Nineteenth Century, is based, not so much on the specificity of the object of study – living and inanimate nature or man and society, respectively, but rather on the different methods they use. Within the experiment incorporated by the social sciences, towards

the end of their speculative age, the observer was no longer exterior to the experiment but became part of it. Objectivity received a different meaning in the approaches of the social and the natural sciences. Unlike the latter, psychology started to make use of introspection. Despite the tensions between them (see the dispute between psychology and sociology), the social sciences and the humanities, nowadays, have caught the interdisciplinary fever in an effort to define their own identities.

History has an older record of spawning connected sciences: archaeology, epigraphy, documentaristics, numismatics, museography, ethnology, ethnography, and others – all distinct disciplines.

Economics made a pact with mathematics the moment it became, prevailingly, a science of the measurable. In its quest for improved methods, it began to make use of the mathematical models employed in physics (mechanics, gas theory, thermodynamics), thus encroaching upon their privileged field of application. No sooner had the game theory been elaborated for the distinctive purposes of mathematics than it spread widely both into the social sciences (*e.g.,* the theory of conflicts) and into the natural sciences (*e.g.,* ecology).

The major cross disciplinary impact that mathematical models have had deserves special mention. The era of quantification was heralded when all the sciences, striving for rigour, resorted to measuring and quantifiable procedures. As a science of structures (and not of quantity), mathematics is actually related to structuralism, a trend with many echoes in the social and human sciences. Levi-Strauss (1949) would soon use mathematical instruments in ethnography just as Piaget (1967) did for the study of the evolution of thinking. It was linguistics that eventually confirmed the mathematical model in the humanities, the first to create a new discipline: mathematical linguistics. Then natural and artificial languages and grammars inspired the search for idioms to express nature, society, and life. The language of genes was next to be explored, and algebraic grammars attempted to decipher the underlying principle of the phenomenon of life.

Several trends influenced all disciplines more or less successfully during periods of considerable enthusiasm. We may thus mention cybernetics (the science of common mechanisms in technology and society), systems theory, semiotics, the theory of catastrophes, the theory of chaos, and later, computer science. They may be viewed as the off-spring of mathematics, the cardinal science of symbols and of abstract objects.

We should now ask ourselves whether or not this interdisciplinary impulse, born of the research function of disciplines and of the purposes assumed by science, has been followed by a similar process insofar as the pedagogical side of disciplines as subjects to be taught in schools is concerned. The answer is negative. Pedagogical disciplines have retired into a form of isolation that appears to be far tighter than academic disciplines with their penchant for symbioses and synergies.

Moreover, when schools have attempted to “update” themselves, they have only received “purist” acquisitions.

Such was the case of the Bourbaki School* and its search for fundamental structures, which inspired the idea of introducing the set as a basic concept instead of the number. The result was a broadly unsuccessful pedagogical experience (see, Kline, 1973). The prevalence of academic purists caused probability calculus to lose the weak position it once held, not to mention the disappearance of trigonometry and determinants. Had the school been inspired by mathematical models, it would have introduced finite mathematics resulting in a larger number of easily assimilated applications.

We should have expected the Humboldtian model of university, which provided universities with a research function, to better synchronize the pace of research with that of formal education. Despite the advent of that seminal idea, the gap between science and school-taught disciplines deepened. Departments and faculties became more specialized; chairs were established for increasingly narrow disciplines. One of the pioneers of spatial navigation, Hermann Oberth – whose book (*The Rocket towards Interplanetary Spaces,* 1923) was described by his student, Wernher von Braun, as "the scientific fundament of special navigation development technology" – was a high school teacher in a small town in Transylvania when he wrote it. When asked how he could possibly have acquired the information required for such an insight, he simply replied: "I graduated from Cluj University, Faculty of Sciences, where I took courses in mathematics, physics, and chemistry". Here we have an interesting example of a complex, eminently interdisciplinary, object of research based on multidisciplinary university education *avant la lettre.*

Medicine has probably benefited most from the multidisciplinary approach and acquired an impressive advantage in the process. This success is due mainly to the fact that it is a confederation of sciences or disciplines (anatomy, physiology, hematology, etc.) and that it remains open to new disciplines (such as infra-microbiology). When a physician needs to examine a patient, all disciplines compete and converge in his or her analysis and diagnosis. Another range of disciplines concerns fact-finding and treatment (radiology, balneology, chemotherapy, etc.). Today, medicine is, of course, the expression of its own evolution, but it is also the result of massive and decisive contributions from the external apparatus of cell biology, chemistry, and high technology (lasers, magnetoscopy, computers, etc.).

A less often cited scientific revolution, in the same order of magnitude as that occurring in medicine, is the *revolution of materials.* A new class of materials, with new properties, is invading the artificial human environment from house and furniture to goods of mass consumption, automobiles, etc., gradually substituting for "traditional" materials. The paternity of such materials is so interdisciplinary that their source becomes uncertain: metallurgy, inorganic chemistry, physics, industrial procedures, and others all coalesce to produce them.

These two examples also point to the difficulties and dilemmas of interdisciplinarity. Let us assume that the object of study is an unknown disease or a new composite material. An interdisciplinary team is formed. Which is the most economical, that is, the cheapest and the

*"'Bourbaki' is the collective pseudonym for the authorship of thirty-six volumes of comprehensive texts, started in 1939, by an élite group of French mathematicians, designed to present mathematics in a contemporary and original way, and to illustrate its axiomatic structure" (see: <http://education.guardian.co.uk/Print/0,3858,4545977,00.html>)

most efficient way to assemble the team: with persons each representing a single discipline or with persons who, by virtue of their education, possess the necessary knowledge from all these disciplines? Is it the team that has to be interdisciplinary as a group, or should interdisciplinarity apply to its individual members? In the first case, more people are called upon; therefore, the costs rise. Time is required for them to become accustomed to one another, and so the costs rise even higher.

"Almost all problems are now interdisciplinary, and they claim an adequate preparation."

The cost issue has long been a part of decision-making in the management of research and education, sometimes emerging as a decisive argument. There were people who regarded costs as irrelevant when it came to the progress of knowledge or to the shaping of personality, but their number has tended to decrease considerably. The other component of that reasoning, *efficiency,* is even more persistent. In pursuit of a goal, teamwork is crucial. Efficiency is based on communication, which, in its turn, is based on common language. It is thus better for fellow members of a team to have related interdisciplinary training.

The optimal research solution eventually depends on how learning is organized. The more interdisciplinary the latter, the better the chance for the former. The pressure on research with respect to interdisciplinarity has been passed on to education that has been in no hurry to react. The disciplines are even more obstinate and rigid in education than they are in research.

The stubbornness of the disciplines in higher education is forcing graduates to start anew at other faculties in order to be able to cope with the demands of their jobs. A young man from Germany says he is a physician, but he is now studying computer science because he has come to realize that he needs the latter as much as he needs medical information. Engineers who study economics, philologists who study management, and computer scientists who undergo training in finance represent frequent cases of costly and unnecessary duplication. What can be more inefficient than achieving interdisciplinarity by enrolling in two faculties instead of in one? The answer given by formal education to this phenomenon is very unsatisfactory. In the best cases, graduates are directed to non-formal education, parallel to but outside the system.

He that will enquire out the best books in every science, and inform himself of the most material authors of the several sects of philosophy and religion, will not find it an infinite work to acquaint himself with the sentiments of mankind concerning the most weighty and comprehensive subjects. Let him exercise the freedom of his reason and understanding in such a latitude as this, and his mind will be strengthened, his capacity enlarged, his faculties improved; and the light, which the remote and scattered parts of truth will give to one another will so assist his judgment, that he will seldom be widely out, or miss giving proof of a clear head and a comprehensive knowledge. At least, this is the only way I know to give the understanding its due improvement to the full extent of his capacity, and to distinguish the two most different things I know in this world, a logical chicaner from a man of reason (John Locke, *Of the Conduct of Understanding,* 1706).

Seven conclusions can be drawn from the above considerations:

i. The two contemporary strong trends, interdisciplinarity and continuous education, are interconnected, and they both rely on constituted, quasi-rigid bodies of knowledge, *i.e.,* the disciplines.

ii. Disciplines have begun to lose their function, much as is happening to the State in politics. They are eroded, but not abolished. Their roles change. A new criterion for the evaluation of disciplines refers to the measurement of their open valences and their readiness to combine with other disciplines rather than to their endurance in splendid isolation. It is all about achieving interdisciplinary partnerships.

iii. The transition that is now taking place is one from the pre-eminence of the disciplines to that of the problems to be solved. Almost all problems are now interdisciplinary, and they claim an adequate preparation.

iv. In order to become lifelong, education has to provide for an ability to use information in future professions that are defined according to the type of tasks, subjects, and problems to be solved.

v. Research is likely to be more open, more flexible, and more receptive to interdisciplinarity than is the more conservative educational system.

vi. Because they are joined in a common knowledge-acquisition process, the schools of research and of education rely on knowledge classification in disciplines. Both of them are obstructed by the rigidity of institutionalized disciplines and by their respective spokespersons.

vii. The liberation of the two concepts from persistent schemas for the purposes of true development demands a flexible schema of knowledge classification to replace the stiff academic or educational disciplines by smaller, easily combined units. These should be the building blocks for interdisciplinary edifices that are able to accommodate all the directions indicated by the nature and demands of the problems to be solved.

1.3. WHAT PEOPLE FOR WHAT SOCIETY?

For centuries, education has been organized and learning has been oriented according to the prevailing models or theories about what an educated person should be.

Quite influential for a long period, Plato's schema favoured the generation of an élite capable of leading a hierarchic society, while other groups, also belonging to the societal structure, such as warriors and workers, were to be trained separately. Hence the special attention that was paid to abstract and philosophical learning, in ancient Greece, and the neglect of practical or manual work. The dichotomy between liberal and vocational studies persisted. The Thomist scholastic model should also be mentioned with reference to the pre-eminence of faith and theology over reason and philosophy.

The philosophy of the Enlightenment primarily praised science, reason, and experience. John Locke, in *Some Thoughts Concerning Education* (1693), named virtue, wisdom, bree-

ding, and learning as goals of education. The focus was on individual freedom, and the role of institutions was looked upon with suspicion.

The reaction to the Enlightenment created the naturalistic school. Rousseau emphasized emotion and intuition. Marx was preoccupied with healing the alienation brought about by class division and proposed the ideal of the *communal man,* free only within his socially acknowledged needs and responsibilities.

In education, the pragmatism of Peirce, James, and Dewey led to the design of a reflexive, critical man, whose sources of knowledge were activity and experience. The behaviourists substituted control for liberty and, based on the role of the reward and punishment schema, suggested performance achievement by means of exterior conditioning that left little room for personal initiative. Programmed education is linked to this school, but it should not be entirely discarded along with its reductionist premises.

Many postwar philosophical trends influenced education by introducing new concepts, as in the case of existentialism: choice and decision in an existential situation. Hence, the growing role of responsibility and authenticity, the ideal being "to be" instead of "to seem" or "to have". The number of versions proposed as educational ideals is quite large, and the lack of agreement points to their historical character, that is, to their random emergence and dependence on the dominant vision or philosophy at a certain historical moment. This reality is an incentive or at least a justification for our generation to try and to free itself from the pressures of tradition or of common law and to formulate its own guiding principles for education.

Two major debates took place in an effort to formulate educational goals and the means to achieve them:

i. Does education serve the needs of society or those of the individual?
ii. Does education focus on the knowledge object or on its subject?

The first dichotomy points to the pre-eminence of society over the individual or the other way round. If society comes first, then education is shaped according to its needs; but as these are perceived differently by classes and groups, the debate will continue at the social and political level. As a reaction to totalitarianism that imposed the goals of society, regardless of individual destinies, the focus shifted to the rights and aspirations of individuals. Still, whenever society feels an acute need, *e.g.,* for development, education will be oriented towards the macro-social objective. In the developed countries, the emergence of an unwanted phenomenon such as unemployment introduces that general concern into the educational discourse, somewhat diminishing the attention paid to individual choices. Moreover, a certain parallelism with the content of political discourse can also be established. The more conservative part of the political spectrum with a fondness for economic liberalism will support free initiative and will focus on the individual. Social democrats will put a premium on solving social problems, thus taking their cue from the perceived interest of society.

The second dichotomy arises from the notion of how education should function. The main concern could be about the object of education, *i.e.,* the substance of the knowledge to be taught. At the opposite pole, the critical point could be the assimilation and processing

of knowledge by individual subjects. In the former category, we have the hetero-structuring processes, the actions whereby the student becomes an exterior agent, while the object of knowledge to be transmitted is seen as preeminent. Such is the case of traditional schools in which the arrow goes from knowledge to the students, the same as in behaviourism and cybernetics. In the latter category, it is the action of the individual student that matters in the first place. The fact of using the notion of *learning* more than that of *education* stands for the priority that is currently given to the subject (the individual).

In this respect, the parallelism with political discourse is no longer perfect. Despite the preference given to the individual and to personal initiative, the conservatives favour stronger control and discipline. While the social democrats emphasize the primacy of society and the role of its educational institutions, they tend to justify more lenient, loose, or permissive control systems and to show more confidence in the individual. When it comes to conveying their values, the conservatives appear to be more skeptical about the preferences of individuals or their ability to make free (and good) choices.

There are other paradoxes as well. The existentialist trend vehemently upheld the necessity of a strong relationship between learning and life. If one takes a closer look, one cannot help noting that, with its focus on the present tense, that school of thought was quite deficient in its contemplation of the future. It never provided a long-term educational solution.

In the absence of strong and clear orientations that are capable of gaining broad consensus, it becomes possible and, indeed, necessary to seek solutions outside the prevailing political, philosophical, or ideological discourse. Most of the trends in education are not mistaken when they signal the importance of either the individual or the social factor, but start sinning when they dismiss or neglect the importance of other factors, such as institutionalized education.

Intuition suggests the idea that modern societal and economic development depend not so much on achieving perfect, deterministic, and sure objectives, but rather on developing creative activities, in a world where uncertainty, probability, and risk are a given condition, providing a circumstance of real opportunities and choice.

This would not be a step backwards towards irrationality. Quite the contrary, more intelligence, more rationality, more initiative are required to cope with situations of uncertainty, which after all are the daily experience of every living being. The simplistic vision of mechanized pre-programmed robots belongs much more to a deterministic world: the attempt to achieve abstract "certainty" and "perfect information" can only lead to a dogmatic, pseudo-religious system on the one hand, or, on the other, to the annihilation of all intelligence, to the destruction of all hope for development and creativity. Hence, the prevailing atmosphere of pessimism in the world. The marrying-up of contemporary scientific thinking with social sciences, and in particular with economics, in an increasingly complex world which is interactive even beyond the limits of planet Earth, is providing a rich source of moral and intellectual stimulus for reconstructing an Image of the Future. Learning to face uncertainties and to manage risk beneath these new horizons might in turn lead to a quantum leap in the human condition (Orio Giarini and Walter R. Stahel, *The Limits to Certainty: The Facing Risks in the New Service Economy,* 1993).

A realistic approach should start, in our view, from the old and simple idea according to which education has to prepare the individual for life in society. The system has to be designed with an aim to help the individual find and play a rewarding role, in both moral and material terms, while offering him or her maximum freedom of choice. Let us start by identifying the ideas that are likely to meet general consensus.

i. *Increased societal rate of change*: Change is occurring in society at a speed unknown to previous generations that could accept the prospect of a constant or linear trajectory in the course of their lives. According to the principle that "the rate of learning should be higher than the rate of change", the primary task of education is to train people so that they can master change and not suffer from it.

– Corollary: Flexible frames of mind.

ii. *Anticipation, no more adaptation:* The ability to adapt, once considered as the privilege of an intelligent person, has become an insufficient outcome in the case of education today. Adapting oneself to a given situation means staying behind the events at all times, because at the moment of adaptation, things have moved again. Adaptation has acquired a new meaning: it is running behind the events, always trying to catch up with them. Cultivating an anticipatory attitude in conditions of uncertainty and risk in young people means equipping them with the kind of knowledge that enables them never to be taken by surprise.

– Corollary: Introducing foresight courses and techniques: probability calculus - a new Weltanschauung since the age of algebra, living with incessant change and uncertainty.

iii. *Continual renewal of knowledge:* The perishable nature of information along with the rapid pace of change lays the foundation for continuous education.

– Corollary: Adequate teaching of knowledge, including the "map of ignorance" and open problems, science museums, real and virtual experiences.

iv. *Lifelong education:* Subject's approval of continuing learning, perpetual incorporation of learning into a learning process with open perspectives.

– Corollary: Continuous curricula as possible roads into maps of knowledge.

v. *Interdisciplinarity:* De-emphasizing disciplines in favour of problem solving.

– Corollary: Introducing global problems (i.e., food, water, population, health, education, environment, habitat, etc.) requiring highly interdisciplinary approaches in growing proportions.

vi. *Distinction between identity and role*: Identities are the product of cultures (involving beliefs, values, and tradition). They have to be encouraged through a type of education that trains people in a multiple-culture society. Roles are assigned by civilization.

Civilization requires specific roles to be performed by teams made up of people with different identities. The job is a particular instance of the role.

– Corollary: Education becomes flexible in relation to cultures building upon today's multiculturalism. The resulting variety is compensated by the improvement and transmission of universal knowledge values, the common treasure of a single civilization.

vii. *Mobility of the individual*: This is one of the features of the society of tomorrow, one that is already noticeable in the current major trends.

– Corollary: Education is meant to prepare people for a new kind of life, with more roles to play; this kind of life requires higher mobility, not only movement but also transfer from one role to another.

viii. Competitiveness, an increasingly salient feature of societies based on a market economy.

– Corollary: Education can decisively enhance the competitive edge (as it has already done so far: formal and non-formal contests, examinations, challenges, recognition of qualifications, especially by means of credits, etc.), while paying attention to equal opportunities and equitable rewards.

ix. *Free initiative*: A cardinal requirement in today's society; it calls for educating for creativity and the encouragement of innovation.

– Corollary: If the emphasis on innovative spirit and the exaltation of creativity have not led to nameable results, such a situation results from the fact that new methodologies have been placed outside school or learning. The capacity to create and to innovate presupposes general orientations in education, freedom and courage to take the initiative, and a highly associative and combinatorial system of knowledge.

x. *The network* is the horizontal structure of the society of the future leading to a reduction of vertical hierarchy.

– Corollary: Development of the ability to work in a team, to choose partners, and to maintain partnerships. The networks give a global (or at least a regional) dimension to human activities. The training of people is thus performed within a regional and global horizon.

xi. *Communication* is already at the center of attention. It solves the dilemma of the individual versus society and is consequently elevated to the rank of a philosophical concept (Habermas, 1973).

– Corollary: Introducing interactive communication in the current learning process in combination with the acquisition of techniques for conveying articulate and correct messages in several international languages.

xii. *Technologies* (ICT) facilitate learning activities by providing the basic tools and tangible support for the knowledge acquisition process.

– Corollary: The subject of learning is an individual using a computer and a modem, seen above all as intellectual tools. He or she should know how to handle those tools for communication, knowledge management, reasoning, and experimentation.

The debate on the goals of education and the principles to be recommended by the philosophy of education gradually lead one to the discovery of the possible features of the future society in which the individual strives to find a place for him- or herself and to interact with it. Whether one starts with the individual or with society is irrelevant. Nor is it relevant to speak either of the flow of knowledge from society towards the individual as an object of study or of the flow from the individual, as a knowing agent, towards society as a repository of knowledge.

An analysis of the present trends from a prospective angle tends to put at rest the disputes and dilemmas of education by introducing other vital problems into the discussion. If knowing a subject becomes inseparable from computer technology, what will counterbalance one's physical solitude and what kind of face-to-face inter-human activities will have to be maintained and encouraged? If communication presupposes the mastery of widely spoken languages, what becomes of the relationship between one's mother tongue and other languages, given the fact that generalized automatic translation is not yet in the cards? If mobility is a must, how can excessive versatility be avoided? If competition is the law, what are the personal virtues or traits of character that will have to be cultivated in order to keep human interaction within peaceful and non-violent limits?

At any rate, knowledge – a fundamental concept for lifelong education and a basic concept for interdisciplinary research – also remains *the* concept when the goals of education are considered. The definition of knowledge as the *knowledge industry* is thus confirmed. An examination of the area of goals leads to the conclusion that the low efficiency of education as related to its aims is due to the use of inadequate methods for presenting, processing, assimilating, and storing knowledge in individual or social memory.

1.4. LEARNING AND WORK IN THE KNOWLEDGE ERA

The description of the new economy at the stage of globalization as the "knowledge economy" imparts a new status to education and changes the structure of labour and employment.

Education, viewed as the industry of knowledge, is assigned a central place in society. It witnesses an acknowledgement of its numerous claims for resources and attention. The classical formula defining the economic factors (*i.e.,* capital, natural resources, and labour) is modified once information has been identified as another basic economic factor. Nevertheless, a neutral piece of information is just a supporting element for a piece of knowledge.

Nowadays, knowledge is the main resource that is added to the classical triad. Still, it can only add value to natural resources and capital through the agency of the people who make up the labour force. In the past, the degree of personal qualification altered the supplementary

demand for manpower, but it pointed to the proportion of "skills" rather than to the quantity of knowledge it saved from manual work. The advent of the knowledge economy indicates a superior phase, one that accounts for the portion of universal knowledge that people bring to the process of problem solving (production, services, organization).

What is this knowledge? It is a continuous process that produces precise statements in a univocal language that is universally valid, or justifiable by means of a reproducible process, regarding the various relations that develop in the real world. These pieces of knowledge are grouped into large branches, such as physics and its disciplines that multiply through increasing specialization into a family comprising several dozens of disciplines. The treatises assembling those pieces of specialized knowledge as well as hundreds of learned magazines register their incessant progress.

From a mathematical point a view, each branch is a graph called a tree. Metaphorically speaking, the classical schema of science classification is a collection of trees, a sort of "orchard".

The schema gets complicated the moment interdisciplinarity comes into play. Arches meet and the graph becomes a lattice. In the tree of physics, there are disciplines that link to other branches and further on to the trees of other disciplines.

Rather than being a catalogue of isolated "trees", science is represented in a huge single table. It should be noted that the advance is marked by a diminishing generality of the object and by increasing complexity.

For centuries, education has copied the disciplines of science, confining itself to the main branches and several subdivisions. No subject, except for the topics of doctoral dissertations, has pushed specialization to the outer limits. Today it is physically impossible for an individual to keep pace with the latest developments. Making out what is essential and what is not from the viewpoint of knowledge and skill transmission and assimilation is a Herculean task. The current approach amounts to selection and simplification, with an occasional, *ad hoc,* chance to gain deeper insights through optional courses in various areas of the immense knowledge map.

Let us briefly examine the persisting dilemmas of education, starting from that of *generality versus specialty*. A preference for generality appeared at the time when the educational goals were set for ensuring the development of the intellect (France and Germany), of character (England), or of the citizen (USA). It still has undeniable applications in the way primary education is designed, possibly also secondary education and other compulsory courses. But for higher education, the goal of training specialists prevails.

The answer that the school keeps giving to the question, "What is a specialist?" refers to the disciplines. One may be a specialist in mathematics, chemistry, biology, or in a subdivision of those disciplines; the narrower it is, the more meaningful the specialization. Still, in the field of actual work and practical activities, the answer to that question is different. The specialist is defined according to what he or she can do, the type of problems he or she

can solve, or the roles he or she can play. The disciplines are no longer defining elements: they are parts of each specialization. A large number of specializations strives to acquire the ability to develop practical approaches to real problems or tasks. The more graduates there are, the more difficult it becomes for them to find employment. Speciality defined by activity gains in importance. Specialty is treasured, but not disciplinary specialities; rather, hands-on activity and work are treasured.

The successive paradigms that embrace all knowledge are transgressing the boundaries between disciplines. They lead to alternative knowledge segmentation based on new criteria that challenge the established fields:

> according to the type of crisis that emerges; according to the type and degree of complexity of the process; according to the way temporality is involved and to the relationship with chronological time; according to the type of symmetry or asymmetry; according to the way some metaphorical processes are employed; according to the type of logic, particularly to the degree of employing non-classical logic; according to the nature of cognitive models; according to the nature of the systems involved (the modern theory of systems); according to the nature of language structures; according to the nature of semiotic processes (Marcus, 1999).

Related to this dilemma of education is that of *theory versus applications.* It is obvious that the disciplines will encourage the theoretical trend, since theory is their real vocation. To applied education, the vocational option is provided. The preference for theory in the established disciplines turns vocational education into a secondary choice. Moreover, having opted for vocational education (producing workers, technicians, accountants, schoolteachers, etc.), an individual has fewer chances to rejoin the theoretical direction that ensures access to higher-valued and better-paid jobs. The prejudice that favours theory over practice has run so deep that the vocational option is considered worthy only of "drop-outs". "If you don't learn, you'll become an apprentice!" The most important differentiation among students would occur at the end of compulsory education (around the age of 16).

A major error was made in the confrontation of approaches: apprenticeship was left out of the inventory of methods. There was no room left for private learning in a single, unique model (the master), once the teacher of a discipline had talked to an entire class within a school. The tutorial system in the British colleges was an exception to the rule. Another exception was the German system of vocational learning. Other systems did not even include apprenticeship in Vocational education. In the arts or sports schools, apprenticeship has also been maintained as the best solution for performance learning (*i.e.,* musical instruments, skating, skiing, swimming, etc.). The tutor or the master is obviously an expression of interdisciplinarity. A new schema of education needs to reintegrate the tutorial system.

The sociology of education opened an interesting subject when, embarking upon an analysis of the *mechanism of manipulation by means of schooling,* it attempted to elaborate a theory of cultural transmissions (see Bernstein, 1972). It started from the definition of the curriculum that "entails a principle... whereby of all the possible contents of time, some con-

tents are given a special status and enter into an open or closed relation with each other". It is to be noted that this definition actually represents a constellation emerging from a system of choices (of the designers of the system). The social nature of this exercise has to be emphasized.

There are two distinct types of curriculum: *collected and integrated.* Two aiding concepts (*classification and framework*) assist in the design of a typology of educational codes. "Any organization of educational knowledge which involves strong classification gives rise to... a collection code. Any organization of educational knowledge which involves a marked attempt to reduce the strength of classification is here called an integrated code". On the other hand, the *frame* "refers to the form of the context in which knowledge is transmitted and received" to "the specific pedagogical relationship of teacher and taught" and, what is important, "to the strength of the boundary between what may be transmitted and what may not be transmitted". Based on this schema, the author considers that "the European non-specialized, subject-based form of collection involves strong classification but exceptionally strong framing"; the English version "involves strong classification, but relatively weaker framing than the European type. It is specialized, with very strong insulation between "pure" and ''applied" knowledge; the course-based non-specialized USA form of the collection... has the weakest classification and framing of the collection code".

The implications of this analysis reveal that the way of designing the curriculum as well as the code and the frame are the mechanisms through which society gains control and reaches the desired goals. In case society aims at building an open structure (*i.e.,* one which accepts a variety of opinions and a diversity of categories, obtaining the solidarity of the citizens through integration processes around common projects), we shall have to consider designing the curriculum in such a way as to accommodate that democratic requirement. The new schema will be mirrored in the increasing degree of individual choice within the connection between the fields of knowledge and the ability to move from one to another, in other words embracing an integrated code with the least constraining frame.

> God alone is worthy of supreme consciousness, but man is made God's plaything, and that is the best part of him. Therefore, every man and woman should live accordingly, and play the noblest games and be of another mind from what they are at present.... For they deem war a serious thing, though in war there is neither play nor culture worthy the name..., which are the things we deem most serious. Hence all must live in peace as well as they possibly can. What, then, is the right way of living? Life must be lived as play, playing certain games, making sacrifices, singing and dancing, and then a man will be able to propitiate the gods, and defend himself against his enemies and win the contest (Plato, *Laws, vii,* 796).

The computer science revolution has brought an unexpected element into the discussion of *motivation,* which is essential to the learning process: *the play.* The passion with which children use the computer is by all means remarkable. The hours they spend punching the keyboard, the amount of concentration they put into it, unequaled by study or reading, have

been simply explained by the fact that a miraculous new game object had entered their lives. The ancient Romans, who used the same word to designate both school and play (*ludus*), inferred the main source of interest of the very young.

Through games, young people learn computer programming and virtues. The computer becomes their guide on the Internet, in their visits to museums, libraries, and sources of knowledge. It stimulates experiments: children drive cars and pilot aircraft in the virtual world at a time when simulation games become accredited learning methods for managers, financiers, investment strategists, etc.

The books by Johan Huizinga (1955) and Caillois (2001) revealed the deep meaning of games in human society, where fundamental activities (politics, economy, and culture) are reducible to ludic interpretations. Far from being an evasion of serious study ("Are you learning or playing?"), the game knocks at the door of the educational system, bringing an important amount of motivation and autonomous behaviour. It also fulfills another requirement of education, namely the development of curiosity and of the ability to ask questions and to formulate hypotheses: the mark of creativity. The child experiences invalidation or confirmation of an assumption in the same way as he or she wins or loses a game. Once introduced into the learning process, the ludic element breaks the century-old spell of the constraint (the long school years) and permanently shifts the focus onto the subject of learning.

The classical system based on the theoretical teaching of disciplines has been criticized for its neglect of *skill or aptitude* development. Here is the young subject of learning handling a machine: the computer. He or she simultaneously uses his or her hands and his or her head. From the very beginning, he or she depends on communication skills and develops them continuously: he or she types; he or she produces texts; he or she reads and answers messages and commands; he or she conceives various programmes or complies with their requirements; or he or she applies the rules for the operation and maintenance of a device that is at the same time a television screen and a telephone. All that is valued in a specific skill (*i.e.,* meticulousness, patience, continuity of effort, concentration, accepting a fixed workplace, undergoing a self-improvement process, and closely observing a sequence of commands) implicitly becomes part of the training of a young person who uses a computer. This instrument, which is nothing but a node in a network, also encourages teamwork.

Should we have to indicate the most important quality for the learning process, we would emphasize the *ability to concentrate.* It is well known that this ability is not well developed in early childhood (a maximum of twenty minutes at a time for children in kindergarten and primary school). Later on, the capacity to concentrate has to be maintained through various procedures known to educators (e.g., interrupting the discourse to engage in dialogue, standard time distribution, etc.). In contemporary society, noise, multiple simultaneous signals, and dozens of visual, written, or auditory sources that assault young individuals conspire against their ability to concentrate.

Educators have confirmed a deterioration in the ability of school children to concentrate when they are confronted with the onslaught of the multi-source information society. It is

therefore difficult to estimate the important part that the computer plays in the development of that valuable capacity. The passion with which the subject gets involved in a programme or a simulation game has caused concern about the "loneliness" awaiting him or her as a result of the curtailment of social contact and dialogue. The same suspicion was voiced in the case of distance learning as compared to the advantages of the classical "face-to-face" system. Of course, education is entitled to design compensatory methods to develop sociability and direct contact with other people.

Two decisive advantages come to mind with respect to the classical system. Knowledge is not merely streamlined through a passage of written text or an oral communication. All senses are open to capture information. First and foremost, the images are visual ones. *Multi-media,* is the type of presentation in which the text is accompanied by images (including movie sequences), graphs that modify and move, spatial representations, the voice of the presenter and, possibly, music. Can a speech and a few notes on the blackboard compete with a multi-media history lesson that includes visits to museums or the sites of past events, even with a feature movie evoking them?

Secondly, the computer has become *interactive.* Three decades ago, the early use of audiovisual teaching aids in schools caused considerable enthusiasm. It was soon proved that their main deficiency was that they encouraged passivity. The image on the screen or the voice coming from the headphones could not be questioned. The progress of artificial intelligence enables the computer to introduce reasoning and the possibility of dialogue. When the computer does not understand the question posed by the subject, it asks for additional information and produces an answer that has not existed in its inventory of possible answers. This answer could be compared to that of a competent teacher.

We shall now turn to anthropology in order to establish the advantages of a new education. Humans are weak creatures, with pulses of Renaissance force. They place themselves at the core of things to consolidate their precarious condition. Compared to the animal realm (particularly to a similar medium-sized animal), human physical abilities and instincts are puny: muscular strength, ability to run, sharp teeth, etc. It is through symbols and tools that humans make up for this deficiency. They use both to create universes that otherwise do not exist in nature.

The symbols and tools belong to two spheres in which humans nest: the *noosphere* and the *technosphere.* They are both products of human *imagination.* Knowledge is based on symbols. Humankind departs from reality to return to it armed with symbolic models. Culture is a product of symbols, and tools (that need symbols) are the basis of civilization. Both presuppose continuous effort, hard toil, and obstinate determination. According to Goethe, even if man fails, he who continues and strives shall be redeemed.

The anthropological insight prompts us to place *technology* on the same footing with symbolic activity. In doing so, we differ from the ancient Greeks who did not accept the nobility of tools. The second remark points to the development of imagination that owes more to fairy tales and science fiction than to formal school education. Finally, there is the *ethic of work* at the ludic level, introduced and developed within the learning process so that

it will then operate to the end of human life. From this point of view, leisure is nothing but a contemporary commercial myth.

> The conclusions of the Lisbon European Council confirm that the move towards life-long learning must accompany a successful transition to a knowledge-based economy and society. Europe's education and training systems are at the heart of the coming changes. They too, must adapt.... The Commission and the Member States have defined lifelong learning, within the European Employment Strategy, as all purposeful learning activity, undertaken on an ongoing basis with the aim of improving knowledge, skills, and competence.... Lifelong learning is no longer just one aspect of education and training; it must become the guiding principle for provision and participation across the full continuum of learning contexts. The coming decade must witness the implementation of this vision. All those living in Europe, without exception, should have equal opportunities to adjust [to] the demands of social and economic change and to participate actively in the shaping of Europe's future. (European Commission. *A Memorandum on Lifelong Learning,* Staff Working Paper, Brussels, 30 October, 2000).

The conclusions of the approach outlined in this chapter are the following:

i. Education, in the era of knowledge, returns to its real vocation as a *knowledge institution.* The *Knowledge Economy* has the merit of discussing education, research, and work in the same framework. The organization of education and its effectiveness rely on the way knowledge is transmitted and assimilated. The revolution does not start from the substance that comes by itself, but from the methods.

ii. Knowledge is archaically classified in large disciplinary blocks that education assumes as teaching subjects. The first step is to reclassify knowledge into units or building blocks, modules that may be handled easily and combined within an integrated system having permeable internal boundaries. To put it in sociological terms, an integrated code and weak curricular frames are needed.

iii. The free combination of modules facilitates the coupling of natural sciences not only with the technical sciences but also with the social sciences, the humanities, and the arts, thus achieving a balance among the factors that make up individual personality.

iv. The combination of modules into a personal itinerary presupposes the autonomy of the subject, and meeting its demands means "learning to learn".

v. The dilemma, "theory versus activity", disappears the moment learning modules are able to combine with activity modules, and lifelong learning is paralleled by lifelong working.

vi. Gradual specialization for the final target of activity is achieved with the general contribution of all disciplines.

vii. Constraints are lessened through the introduction of the ludic element, essential to both learning and work.

viii. Skill acquisition is not an isolated chapter; it is integrated into the process of knowing comprising both the "what" and the "how".

ix. Imagination and concentration are some of the important faculties for this system to break fresh ground.

x. Education will be role-oriented, this concept comprising professions, work, social and political functions, and any aspiration towards creative activity.

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