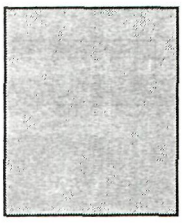
Modern scientific and technological progress, no doubt, is a boon to the mankind, yet it yields evil effects too. Here the author has analysed several issues of its bad effects on the environment and opined with conviction that these must be solved by overpowering the man-made climatic change through appropriate moral and ethical education of the new generation of the 21st centurey by properly trained teachers.



New Moral Responsibilities in Science Education for All

George Marx+

IN EARLIER MILLENNIA AND CENTURIES, THE social and technological progress was slow and unnoticeable within a few generations. Scholars were supposed to read and recapitulate classical authors, old and wise. Imperial dynasties ruled over *eternal* empires by the grace of God. The ultimate goal of rulers and believers was immortality. Time seemed to stand still. In that era, man created timeless models in order to understand the world he lived in. The model of human was the *statue*. Timeless arts like sculpture and architecture expressed the human desire for eternity. Timeless science like geometry and the statics of rigid bodies was developed. Motion was an outlaw, change was considered to be harmful and time was an ugly concept to be eliminated from the world order. Skills were transferred by imitation of parents. For the young, the *father* was the ultimate authority. The laws of morality were carved in marble.

But Galileo insisted *Eppur si muove!* So, 500 years ago the progress became noticeable. Columbus discovered a New World. According

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to the Baroque test, *motion* is beautiful. Arts in time, like music and theatre, expressed the soul of the New Age. Progress became fashionable : Toyenbee emphasised the call of new frontiers (the Wild West), or, Karl Marx was to write about the class struggle and revolutions. Even reformations happened in the Church. Newtonian dynamics and Darwinian evolution replaced timeless science. The *steam engine* served as the new model for human, transforming fuel to motion. To make engines, coal and steel became more important than gold and marble. Instead of static *force* of Archimedes, *energy* became the central concept. And wars erupted not for gold but for oil.

The industrial revolution put society into motion — people moved from farms to factories, from villages to cities. Imitation and respect of fathers was not sufficient any longer. Society invented the *school* where updated knowledge was taught. Thus in the eyes of the incoming new generations, the *teacher*, instead of the *father*, became the new authority. The time between the invention of steam engine (Watt, 1765) and locomotive (Stephenson, 1825), the discovery of electromagnetic induction (Faraday, 1831) and the use of alternating current for energy supply (Zipernowsky, 1885) and the telegraph (Morse, 1821) and the public telephone central (Puskas, 1879) took two generations, allowing enough time for the schools to introduce the new scientific and technological ideas to the classrooms, and thus to the thinking of the new generation.

School education had been made compulsory. School timetable, however, had been saturated in the 19th Century. Mechanics, geometrical optics, electrical current were taught in physics; combinations of chemical elements (oxidation and reduction) were taught in chemistry; taxonomy of unchangeable biological species was taught in biology. Science teachers did not speak of ethics and beauty. Humanistic and naturalistic morality was left to teachers of the arts, literature and history. This sharing of the duties had dubious result, as Arthur Koestler stated, *in recent history, more people were killed for ideological (nationalistic, racial, religious) reasons than for material gains.*

Then, hundred years ago, something unexpected happened — the 20th Century arrived and it turned out to be very different from earlier centuries. Modern science and its offspring— high technology — accelerated the rate of progress from centuries to decades. Electrons and radio waves became more important tools of progress than gold or steel were. In stead of brute *force* (muscle) or stored *energy* (petrol), the collection and development of *information* gave value to industrial products. (The negative aspect, *entropy*, ie, disorder, also gained attention, describing spontaneously increasing noise, disorder and pollution.) According to John von Neumann, the *computer* has become the appropriate model for humans because it can be reprogrammed when required.

The *neutron* was discovered (Chadwick, 1932) and the neutron chain reaction was patented within two years (Szilard, 1934); the nuclear pile started working (Chicago, 1942, Obninsk, 1946) and soon atomic bombs exploded (Hiroshima and Nagasaki, 1945).

Quantum mechanics (1925) was applied to explain the structure of solids (Wigner, 1942) and

very soon the transistor was invented (Bardeen, a student of Wigner, 1947); then portable transistor radios brought world news to our homes and inflamed nationalistic revolutions even among illiterate Bedouins, living far away from the newspapers.

Electronic computers (von Newmann, late 1940s) were followed by *e-mail* (Kemeny, early 1960s). Now entertainment, politics, art and finance are run by TV and E-mail — all at speeds approaching that of light.

All these changes happened within one human life-span! No wonder that respect of parents and teachers decreased. Young *pop-stars*, who sang about today, were the new idols. Runaway children left lonely elders behind. Protests against traditional social structure by street *graffiti*, vandalism, terrorism and senseless school murders are well known symptoms of the conflicts between the traditional education and the fast-changing technological reality in the Western youth. *Stop the world, we want to get off* is the slogan of today's youth.

The media, politicians and the grassroot public were shocked by the unexpected invasion of private life by ununderstood *aliens* like the nonlinear physics, quantum mechanics, molecular genetics, and nuclear technology. The new century that has come requires new ethics.

Patriotic morality has been affected by jet flight, sky TV, nuclear arms, ballistic missiles. New weapons have made patriotic, racial, religious fundamentalism untenable. Acid rain, produced by our coal power plants, kills pine forests in the neighbouring countries, and thus create new tensions amongst nations.

Global morality today raises hard questions for the nations of the world. The carbon dioxide released by the heavy industry, power plants, the transport system, the burning of fossil fuels, mainly in the First World, accumulates in the atmosphere and results in the global warming of the climate. Enhanced evaporation results in draught and forest fires in the tropics, increased global circulation of water, more extended snow cover in the North, and steeper temperature differences and monsoon seasons, even in the temperate zones and thus increase in hurricanes and floods worldwide. Does the owner of the high-powered car feel his responsibility, when African children die due to draught or floods kill innocent babies in faraway Bangladesh or on a tropical island?

Parental morality has included our duties to feed and educate our young children. But we use chlorofluorocarbons (CFCs) like freon in our air conditioners and freezers. When these molecules escape, they survive in the atmosphere for a century and diffuse to the stratosphere through decades creating holes in the ozone shield. Thus freon, released in 1960s by parents, resulted in harmful ultraviolet exposure of sunbathing teenagers in the 1980s and manifested itself in tripled abundance of skin cancer amongst the teenagers in the 1990s. The fate of the atmosphere does not interest politicians (looking for the next election) or businessmen (looking for the end of the financial year). It is relevant only for parents who have children, and for teachers who have students.

Sexual morality has been affected directly by contraceptive pills, then by the menace of AIDS epidemic rather than by any written commandments.

Human dignity is supposed to respect the privacy of the individual. Successful cloning of a sheep, the birth of Dolly, created huge attacks from *humanists* who are well educated in literature and history but not in molecular genetics. The first great scientific enterprise of the 21st century is the Human Genome Project. Let us think ahead: if every individual comes to know his or her own genetic blueprint, he or she can be prepared to avoid those specific diseases which could shorten his or her own life and this, obviously, is a good news. But if insurance companies were informed about the genetic prospects of their clients, they would raise the fee of life insurance. Will our sons and daughters select mates by checking their genome first? Will yet-to-be-born babies be aborted artificially if their genomes are disliked by their mothers? But who can tell what is good or bad? What is the genetic difference between abnormal dumb and abnormal genius?

School teachers are not prepared to discuss these new ethical issues because they are not prepared for them. Teachers of literature are trained to discuss novels written in the past century and not to educate for aesthetic and ethical aspects of the Internet. Teachers of history feel themselves more at home in the 18th and the 19th centuries than in the 20th century just gone and the just started 21st. Thus, science education has to accept the responsibility of offering moral education for all the citizens of the 21st century.

But, as we mentioned, school curricula had been saturated and fixed already in the late 19th century. So, what to teach? What are the choices?

- in *mathematics* : additions of fractions or computer language?
- in *physics* : sliding on an inclined plane or the ozone hole?
- in *chemistry* : manufacturing sulphuric acid or acid rain
- in *biology* : lion or the flue and AIDS virus?
- *in earth science* : national parks or climatic changes?

and so on.....

Our school heritage may prefer the first choices. However, our newspaper-reading and TV-viewing students may be more interested in the second ones. *Mathematics* offers only a timeless model of the world. *History* is in the past tense and good at explaining why things happened. *Geography* is in the present tense and good at describing where are the present borderlines and capitals of the countries. *Physics* is in the future tense, its goal being to anticipate events. This is what makes science relevant to the citizens living in our accelerating time. Dennis Gabor, the Hungarian-British Nobel laureate, wrote in his book *Inventing the Future*, : *Moses showed the Promised Land to his people but then led them around for forty years in the wilderness until a new generation worthy of it grew up. Now forty years is not an unreasonable estimate for educating a new generation which can live in leisure created by high technology, but we must find a better equivalent of wilderness. At present stage of information technology, the time ought to be shorter — merely the time to train teachers and for the teachers to train the first generation of workers. It is not the education of the youth which is slow, but the education of the political leaders.*

Due to hightech, in contrast to Moses, we have not got the 40 years to solve the problems of humankind.

The chain from scientific laboratories to teacher training colleges, to becoming a school teacher, then for student learning something in the class-rooms to be able to realise it later in grownup society, it is a road far too long. The society which can accelerate this transformation, will win and will influence the world economy and the world history in the present century.

This is where the direct link between the scientist and the school teacher, a short-cut between scientific research and school education, comes in. "for the newborn baby, every joke is new". Teenagers are not interested in tradition, they are open towards the future. If they see that science is relevant for shaping the future, they pay attention immediately and are even willing to re-educate their own parents. Our Hungarian experiences indicate, if the physics teacher starts speaking about climatic change or radioactivity, even humanistically oriented students (to-be prime ministers, lawyers, businessmen) pay immediate attention to the physics lesson and they are ready to discuss it because it's about their own 21st century.

Let me mention only one specific example, ie, the nuclear literacy of the youth. The memory of Hiroshima and Nagasaki and the memory of Three Miles Island and Chernobyl are heavy burdens to be borne by the nuclear power industry. But the ethnic conflicts and irresponsible diplomatic behaviour killed more people than atomic bombs did in Hiroshima and Nagasaki. Gas accidents kill more than nuclear accidents do. Air pollution caused by coal industry (or smoking) kills a hundred times more each year that the fallout from Chernobyl might kill in decades. But for a TV reporter, it is difficult to understand that a graphite moderated, water cooled reactor shows positive feedback at thermal fluctuations while a water moderated, water cooled shows a negative feedback as it stops working when the water moderator boils away due to overheating. The difference is similar to the difference in the responses of a barrel of gasoline or a barrel of bear if we throw a flaming match into them. Our pupils, however, can understand it easily.

If we ask the antinuclear environmentalists, should we use the dirty coal power in stead of nuclear plant, they react : "Conserve energy, insulate your windows!" But it is a wide experience in northern and central Europe that after the oil crisis the increased insulation of dwellings raised the indoor radon level by a factor of 2 or 3. In a moderate climate, radon and its progenies produce the main radiation dose for the population! (In Hungary, the average radon dose per year is ten times higher than the radiation load from Chernobyl in 1996, in spite of the fact that Chernobyl is only 400 miles away from Budapest.)

I think that air pollution and global warming are ethical problems in the same way as nuclear armament is. We communicate these problems to teachers. Teachers have noticed that discussing issues of global responsibility towards

the future within physics, chemistry, geography and biology lessons always results in each student paying attention (even those to be poets, businessmen and politicians). Teachers are convinced that nuclear disarmament, energy options and carbon dioxide greenhouse warming are *scientific problems* which are made even more interesting due to their *social relevance* and the associated *ethical responsibility.*

In a highly successful teacher initiative by Esther Toth, 15000 Hungarian secondary school students have measured the radon activity concentrations in their own bedrooms over a year. When a visiting educator raised a question as to how they would react in the event of a nearby nuclear accident of Chernobyl, the students replied that they would measure the fallout!

The winter of 1998-99 was especially cold, frosty and rich in snow in Hungary. During that winter, the radon surplus dose exceeded that what the Hungarians received in 1986 from Chernobyl. This was what school children measured and understood.

At the centenary of birth of Leo Szilard — the Hungarian inventor of chain reaction and inhomogenous nuclear reactor — *a Leo Szilard Student competition* was initiated and quickly spread over Hungary, testing the students' understanding of nuclear issues, involving both theoretical and experimental tasks. Hundreds of secondary students participated year by year and the winners were gladly welcomed in Hungarian universities without further entrance exams. These boys and girls could answer such tricky (physical? technological? economical? social?) nuclear questions which would be too difficult even for some older professors. Recently, a statistically significant fraction of Hungarian secondary school leavers was asked how would they respond to the increasing demand for electricity. The options were use of coal power, oil and gas, nuclear power, hydropower, and through import restrictions in its use. A vast majority of the students chose nuclear option. This outcome was very much different from the *public* view as represented in newspapers, the electronic media and the parliament.

This supports my personal view that science classes may educate the global citizenry. At this turn of the millennium, we should be discussing the moral aspects of science education. Let me repeat my thesis : *in a democratic society, people must understand the future.* Decisions have to be made by the society. Citizens have to understand the issues so they can evaluate them with ethical responsibility and then force their decisions on the politicians.

We cannot give now final answers to all questions emerging at the turn of the century. It is the incoming generations who must understand and shape their own future. Our students and their children and grandchildren will be decisionmaking citizens of the 21st century. I am convinced that actual problems like man-made climatic change can be solved by education.