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STAKES IN MATHEMATICS EDUCATION FOR THE SOCIETIES OF TODAY AND TOMORROW

Les enjeux de l'éducation mathématique pour les sociétés d'aujourd'hui et de demain

par Ubiratan D'AMBROSIO

On examine dans cette contribution l'émergence des mathématiques comme une discipline dans les systèmes scolaires à partir du XIX^{e} siècle. La préoccupation des éducateurs de nombreux pays visant à offrir un enseignement mathématique actualisé dominait les réflexions sur les objectifs, les contenus et les méthodes de cet enseignement.

Ce mouvement s'étendit à tous les pays et devint ouvertement international. C'est dans ce cadre que la revue *L'Enseignement Mathématique* fut créée à Genève en 1899 et que la *Commission internationale de l'enseignement mathématique* fut établie par le Congrès international des mathématiciens à Rome en 1908. Des sociétés nationales surgirent dans plusieurs pays.

Après la Seconde Guerre mondiale, les processus de décolonisation et la nécessité d'instruire les jeunes pour d'autres genres de travail en les préparant à une société de consommateurs où ils soient conscients de l'état du monde, tant du point de vue de l'environnement que de la société, de l'économie et de la géopolitique, requièrent une nouvelle réflexion sur une éducation mathématique regroupant de nouvelles matières résultant d'une pensée interdisciplinaire et même transdisciplinaire, suite à l'effondrement de barrières culturelles et à l'établissement de nouvelles techniques de communication et d'information. Les objectifs, les contenus et les méthodes de l'instruction mathématique subissent des transformations profondes, dont cette contribution tente de tenir compte pour un enseignement mathématique renouvelé.

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THE SCENARIO IN THE TRANSITION FROM THE 19TH TO THE 20TH CENTURY

The transition from the 19th to the 20th century was marked by the effects of the three major revolutions of the Modern World: the *Industrial Revolution*, responsible for new models of production and labor relations; the *American Revolution*, establishing a new model of governance and political leadership; and the *French Revolution*, focusing on new social relations, advancing the modern concept of citizenship and generating new demands for bureaucracy and administration.

In geopolitics, the 19th century established the great empires which emerged from the colonial order. At the same time, new intellectual and material instruments, developed on the basis of Newtonian science, were the bases for the establishment of the new sciences of sociology and economics. There was also the noticeable emergence of new directions in Christianity, to a great extent proposing new perceptions of man and society. History was seen as a determinant of the state of the world.

The sciences, particularly mathematics, were consolidating the directions proposed since the 17th and 18th centuries. Rigor, precision, correctness were seen as major goals to be attained, both for the advancement of knowledge and as attributes of a valuable personality. Technology was an evidence of the righteousness of these pursuits. The Eiffel Tower, the Solvay Institute, the Nobel Prizes, are symbols of the achievements of modern technology.

The world order was apparently tranquil. The results of the Raj revolt and of the Zulu War, the successes of the Creoles (Americans born of European descent) in establishing independent mirror-nations in the Americas, were all indicators of this tranquility.

This World order implied the recognition of some universals. Mathematics was firmly established as a symbol of universal knowledge. And mathematicians from the entire world decided to assemble. An International Congress of Mathematicians was held in Zurich in 1897. Its membership reveals the dominating concept of universality: 197 members from 15 European countries plus 7 members from the USA. Another symbol of universality would be Esperanto, a universal language. Its structure, grammar, and vocabulary also reveal the prevailing concept of universality. Some mathematicians adhered to Esperanto.

The second International Congress of Mathematicians was convened in Paris, in 1900. The 232 participants came from 26 countries. Non-Europeans [1]) came from Algiers (1), Argentina (1), Brazil (1), Canada (1), Mexico (1), Peru (2), USA (8). The congress was marked by the conference of David Hilbert delivered in the section on *History and Pedagogy*, entitled simply 'Mathematical Problems', in which he formulated 23 problems which would mark the development of mathematics and, of course, Mathematics Education, throughout the 20th century.

In the second paragraph of his paper, Hilbert says:

> History teaches the continuity of the development of science. We know that every age has its own problems, which the following age either solves or casts aside as profitless and replaces by new ones. […] the close of a great epoch not only invites us to look back into the past but also directs our thoughts to the unknown future. [Browder 1976, 1]

Almost one hundred years later, Stephen Smale would also refer to the interest of dealing with mathematical problems:

> … mathematics is more like art than other sciences. But there is one special difference, I find, which is that mathematics tends to be correct. Mistakes in mathematics are rarely significant for very long. But also mathematics tends to be more irrelevant. There is so much of mathematics that tends to go off in directions which are appreciated only by a very few, irrelevant even to the rest of mathematics. So I think there is a bigger danger in mathematics than there is in other sciences of tendencies to go off into irrelevancies, i.e., into things that are correct but not important. [Casacuberta & Castellet 1992, 88–89]

Not only correctness, interest, relevance, appreciation, have always been present in reflections about mathematics and mathematics education, but the utility of mathematics has also been emphasized. In the meeting of the British

[1]) In the next congress, held in Heidelberg in 1904, there was a larger number of participants (336), but only 18 came from outside Europe: 15 from the United States, 1 from Argentina, and 2 from Japan. In that same year, Japan would surprise the world by defeating the powerful Russian navy.

Association, called to discuss the reform proposed by John Perry, his concept of usefulness is, in itself, a program [Perry 1901, 4–5]. Its eight points focus on mental pleasure, on logical styles of thinking, on preparing for further studies and professions. Although Perry's focus was received with criticism and hostility [2]) by many mathematicians, his concept of usefulness has since then been recurrent in discussions about "why teach mathematics". Perry is but an example of the movement towards a renewed mathematics education on the eve of the 20th century. Even at the risk of being accused of banalizing the discussions about Education, I claim that the discussions about curriculum focus on *why*, *what* and *how* to teach, or *objectives*, *contents* and *methods* [D'Ambrosio 1983]. Much emphasis has been given to contents and methods. Objectives have essentially been taken for granted.

Mathematics education reform

In the second part of the 19th century, the social order was showing signs of fragility. The call for emancipation by the popular classes and by women had obvious reflections in education [3]). The success of the United States in building up a new nationality showed the potential of schools for social change. The claim for social change was strong. The developments of a new production system, as a result of the Industrial Revolution, called for a new kind of worker. The home, so important when artisanal production was prevailing, did not respond to the needs of the future worker.

The relation education–society was profoundly affected by two factors: the need for a new kind of worker; the great progress of psychology, with the recognition of specific behavior and special needs of children. These two factors, the development of productive social capabilities and the modern "discovery of the child" are, according to Manacorda [1989], characteristic of the new school emerging in the second half of the 19th century. The new educational thinking called for updated mathematical contents, as well as for new methods of teaching, reflecting findings in learning. An active school was proposed: hands-on projects, learning by doing. Motivation should have priority.

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[2]) 'hostility' is the tone of the reaction of F. A. Forsyth, as recognized by himself [Perry 1901, 39].

[3]) Quite interesting are the remarks of Mrs. W. N. Shaw on supporting mathematics teaching for girls: "… those powers in which the feminine mind is said to be peculiarly deficient — the powers of accurate observation and logical reasoning…" [Perry 1901, 50].

Mathematics Education was central for the new needs of labor. This is seen in Perry's and in several other proposals, where we recognize an appeal to psychology. In 1905 the Young couple wrote :

> We have heard it asserted that it would be harmful to a young child to be 'plagued with Geometry'. Geometry, as we have in view, is no plague. It requires no school-room, no blackboard, no special apparatus. It does not even require a trained teacher, nor does it demand the child's attention for long periods at a time. It is essentially a subject for home, and for an early age. [Young & Young 1905, vi]

And, resorting to paper folding, there follows good traditional Euclidean geometry. A few years later, Klein wrote :

> The child cannot possibly understand if numbers are explained axiomatically as abstract things devoid of content, with which one can operate according to formal rules. […] While this goes without saying, one should — *mutatis mutandis* — take it to the heart, that in all instruction, even in the university, mathematics should be associated with everything that is seriously interesting to the pupil at that particular stage of his development and that can in any way be brought into relation with mathematics. [Klein 1908, 4]

A conservative posture, encouraged by the recent theoretical advances of classical mathematics and its applications, pointed to a formal and structured organization of curricula. Objectives, aimed at keeping the established social and world order, were taken for granted. Contents were almost entirely agreed upon, methods would differ widely. Particularly interesting is Klein's argument in favor of calculating machines [Klein 1908, 17–22].

L'Enseignement Mathématique was founded in 1899 for contact, exchange of information and comparison of educational systems. I will not comment on the first series of the journal. This has been done in a very thoughtful and complete way by others. I will just add a few remarks, which may be taken as curiosities or may suggest reflections of a different nature :

1) all the so-called 'general' papers are written in French, except one in Esperanto, by M. Fréchet (1913), and a tiny few [4]) in English, by C. Runge (1912), D. E. Smith (1912), A. N. Whitehead (1913), and G. A. Miller (1915) ;
2) there are only two papers by Felix Klein, one in 1906 and another, joint with A. Gutzmer, in 1908, both about reforms in Germany ;

[4]) Of course English, German, Italian, and even Esperanto, do occur in other texts, in particular in reports of discussions.

3) very few articles came from South America, though there is one by Nicolas Besio Moreno [5]), from Argentina (1920);
4) in H. Fehr's report [1953] on the *Commission internationale de l'enseignement mathématique*, the USSR is not mentioned a single time, but there is a reference to a paper on mathematics education in Russie (*sic*), by D. Sintsof [6]). According to Manacorda [1989], many educational reforms in the Soviet Union, affecting particularly the objectives of education, and mathematics education in particular, were taking place.

In the International Congress of Mathematicians, held in Rome in 1908, an International Commission on the Teaching of Mathematics was created by initiative of David Eugene Smith, from the USA, with the main objective of comparing methods and plans of studies of different countries. A retrospective of this commission was given by the outgoing chairman, H. Fehr, in 1952 [Fehr 1953]. In the same year, 1952, the General assembly of the International Mathematical Union (IMU), convened in Rome, established the International Commission on Mathematical Instruction (ICMI), as a commission of the IMU.

Aftereffects of World War II

The Second World War represents a landmark in recent world history. It paved the way for a new world and social order. The emergence of a new technology, called *technoscience*, strongly grounded in new areas of mathematics, asked for profound reforms of mathematics education. This was generally called Modern Mathematics Movement. New priorities for economic reconstruction and defense prompted the adoption of new ideas in Mathematics Education, anchored on advances in the theory of cognition. The research conducted by Jean Piaget was a strong support in the Western world, a role played by A. R. Luria and Lev Vygotsky in the Soviet Union.

A major consequence of World War II was the establishment of the United Nations, in 1945. The charter was signed by 51 states. Soon it was enlarged by former colonies that achieved or were granted independence. The ideal of education for all was explicit in the Universal Declaration of Human Rights, issued by the United Nations in 1948. International cooperation was channeled through UNESCO, the Organization of American States, and similar organizations, as well as bilateral cooperation, establishing a new professional

[5]) a renowned engineer who was well informed on educational matters.

[6]) *L'Enseign. Math. 32* (1933), 81–87.

international figure: the expert, or consultant, or *coopérant*. The rhetoric of development implied the priority of mathematics over other disciplines in the curriculum. The Modern Mathematics Movement was seen as a valid option also for the nations belonging to the group called "Third World" [7]). I will not engage in pro and con arguments about the Modern Mathematics Movement. Instead, I will address social and cultural issues, which were largely disregarded in the movement.

The Cold War, immediately following the end of World War II, was marked by reconstruction of the economies, together with enormous spending in defense, which also provided funds for scientific research. Mathematics particularly benefited from generous military funding. At the same time, peace movements were active and the appeal of a new social and political order was intense. In the Third World, this appeal provided a fertile ground for civil wars and dictatorships, and a superb arena for the Cold War.

The postwar period was also marked by intense demographic change. Granting independence was, in most cases, accompanied by very loose immigration procedures by most colonial metropoli. Emigration became a goal. The more developed nations were subjected to a large number of legal and illegal immigrants. This was added to the demand for civil rights, which was particularly strong in the USA. Social exclusion, intimately associated with cultural differences, emerged as a new focus of attention. Multicultural education, particularly language education, became a new issue. Indeed, children, and even adults, may acquire, in schooling, different kinds of cultural identity, thus perceiving different orders of understanding themselves and the world. The social implications of language education, recognized as a major factor responsible for exclusion, drew the attention of educators [Freire 1970; Bernstein 1971].

The reflections focusing on language led scholars to examine the nature of languages and the cognitive implications of different languages. It was accepted that language was a cultural manifestation. Different cultures have different languages. The social implications of not respecting language differences were easily recognized. *But few would dare similar thinking about mathematics.*

In the International Congress of Mathematicians held in Oslo in 1936, it was decided that the next congress would take place in the USA in 1940. As a consequence of the war, the congress was convened only in 1950, in Cambridge, Massachusetts. The International Mathematical Union (IMU) was

[7]) A general view of the movement, particularly focused on Brazil, can be seen in [B. S. D'Ambrosio 1987].

founded [8]) in 1951 and its first General Assembly took place in Rome in 1952. In this meeting, it was approved that an International Commission on Mathematical Instruction (ICMI), a reorganization of the pre-war International Commission on the Teaching of Mathematics, be formalized as a commission of IMU.

After World War II, mathematics was firmly established as universal knowledge. The political atmosphere just after World War II conduced, with respect to mathematics, to what has been called the '*American Declaration of Universality*', which proposed that mathematicians should convene independently of national allegiance [Lehto 1998, 74]. The universality implied objectives and goals for mathematics education defined irrespective of social and cultural parameters. In 1952 it was decided that ICMI should perform a study on the role of mathematics and mathematicians in the contemporary world. Duro Kurepa conducted the study, which was reported to the International Congress of Mathematicians in Amsterdam, 1954. The report gives special attention to several new directions of mathematical activity. Particularly interesting is the recognition of the importance of calculators:

> Les mathématiques se sont rapprochées de la physique et de la psychologie et on est en train d'examiner le mécanisme du «penser», du «calculer» et d'autres fonctions psychiques et intellectuelles. [9]) [Kurepa 1955, 100–101]

Recognizing the profound changes in the world, Kurepa gives a very comprehensive view of mathematics; he sees its role, because of the imminence of the presence of robots, as essential for the mutual understanding between individuals and collectivities in order to have a global apprehension of the world. The role of mathematics in *Weltanschauung* is clearly stated as a moral duty of the mathematician.

The questionnaire continued to produce interesting responses and reactions. The most intriguing, opening new perspectives for mathematics education, came from the renowned Japanese mathematician Yasuo Akizuki, a member of the Executive Committee of ICMI. In line with Kurepa, Akizuki proposed an emphasis on the reflective side of mathematics, looking into the world as a whole. He made a strong point for introducing the history of science and mathematics in all levels of teaching. The most interesting point in his argument is the recognition that mathematics is a *cultural product*. He recognizes that Western mathematics is present in Asia, and says:

[8]) For a full story of the I.M.U., see [Lehto 1998].

[9]) Mathematics gets closer to physics and to psychology and we are in the course of looking into the mechanisms of 'thinking', of 'calculating' and other psychic and intellectual functions.

> Oriental philosophies and religions are of a very different kind from those of the West. I can therefore imagine that there might also exist different modes of thinking even in mathematics. Thus I think we should not limit ourselves to applying directly the methods which are currently considered in Europe and America to be the best, but should study mathematical instruction in Asia properly. Such a study might prove to be of interest and value for the West as well as for the East. [Akizuki 1959, 289]

Although anthropologists and psychologists had been showing interest in different kinds of mathematics, better saying, different ways of mathematizing in different cultures, Akizuki's proposal did not attract the attention of the mathematical community until Claudia Zaslavsky published *Africa Counts*, in 1973 [Zaslavsky 1973].

NEW DIRECTIONS OF MATHEMATICS EDUCATION REFORMS

The Royaumont Seminar, in 1959, convened by initiative of the European Economic Cooperation Administration, which later became the Organization for Economic Co-operation and Development (OECD), established the major guidelines for the movement known as *Modern Mathematics*. Policies for universal implementation of the recommendations called for regional cooperation.

Marshall Stone, as the President of ICMI (1959–1962), marshaled cooperation in Mathematics Education in the Americas. The USA had been active in cooperation for development in the region, of vital importance in Cold War strategy, mainly through the Organization of the American States [10]). In 1961 the First Inter-American Conference on Mathematics Education was held in Bogotá, Colombia, largely financed by the NSF. Prestigious mathematicians from the USA and from Europe attended the conference, as well as representatives from almost every country of the Americas. As a result, the Inter-American Committee on Mathematics Education was founded, with Marshall Stone as its first President. In 1966 a Second Inter-American Conference on Mathematics Education was held and since then, in different countries of the Americas, conferences were convened every four years [Barrantes & Ruíz 1998]. The last one, the 10th IACME, took place in Maldonado, Uruguay, in November 1999.

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[10]) Indeed, national research councils had been created in almost every country in the Americas, modeled on the National Science Foundation.

The series of International Congresses on Mathematical Education (ICME) gave the possibility of IMU focusing more on contents regarding Mathematics Education. In 1971 the IMU created the "Union Lectures", designed as an expository series of four to six lectures surveying current research themes. It was decided that the lectures would be published in *L'Enseignement Mathématique*. This was a prompt response to acts that may be interpreted as weakening the relations of *L'Enseignement Mathématique* with ICMI. Hans Freudenthal, while President of ICMI (1967–1970), sponsored the creation of *Educational Studies in Mathematics*, which obtained financial support from UNESCO. The following President of ICMI, James Lighthill (1971–1974), created an *ICMI Bulletin* in 1972, as a means of spreading information about ICMI activities. It was considered to play a complementary role to that of *L'Enseignement Mathématique*, which remains the official organ of ICMI. The *ICMI Bulletin*'s appeal to mathematics educators all over the world increased steadily, as it attained regularity of publication and a large worldwide coverage of events and issues. Indeed, looking retrospectively on the issues covered by the *ICMI Bulletin*, as seen in issue n° 47 (December 1999), we notice a very different character from *L'Enseignement Mathématique*. It is natural to question the necessity and the reason for this dual approach.

Scenarios for the transition from the 20th to the 21st century

Before World War II, the objectives of mathematics education, aimed at keeping the established social and world order, were taken for granted. Contents were almost entirely agreed upon and methods would not differ substantially. Anchored in advances in the cognitive sciences and the new possibilities of calculation and information retrieval, the Modern Mathematics movement brought new contents and new methods of mathematics education. However, the objectives of mathematics education were unclear. And they remain so. The rhetoric of personal and social advances is not clearly focused, and exclusion seems to be the most noticeable effect of mathematics education. The question "Why teach mathematics?" seems to be the crux [11]). But together with this question come other questions about the nature of mathematics and how to handle mathematics teaching. Mathematics in the making? Mathematics of everyday life? Mathematics grounded in cultural traditions? Mathematics as fun? Good old classical mathematics? Although not dichotomic, these strands do represent didactical options.

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[11]) I dealt with this question in ICME 3, Karlsruhe, 1976 [D'Ambrosio 1979].

To face these recurrent questions, I see as fundamental a new, broader understanding of the socio-cultural history of mathematics and of its education. This calls for attention to non-conventional sources, rather than to purely academic ones. The Program *Ethnomathematics* [D'Ambrosio 1992] provides the instruments to deal with these questions. The growing interest in ethnomathematics prompted the creation of an International Study Group in Ethnomathematics (ISGEm) in 1985. Since then, the publication, twice a year, of a *Newsletter* with international circulation, the realization of the First International Congress of Ethnomathematics, and the establishment of a web site[12]) have givem worldwide visibility to ethnomathematics. An electronic journal, *Mathematical Anthropology and Cultural Theory*[13]), has been recently created. As expected, criticism of ethnomathematics is mounting. Ethnomathematics was drawn into the Math Wars ! Recently *The Chronicle of Higher Education* started a very lively discussion on ethnomathematics. The discussions, which are going on, are an echo to the completely mistaken title of the article "*Good-bye, Pythagoras !*" [Greene 2000].

Good old Pythagoras will ever be present to enable us to fly and to communicate via the internet and many other important achievements of modern civilization. The "male and female triangles" of the Xingu culture will not do that. And, of course, there is no point in teaching a boy or girl in Chicago the way the Xingu culture classifies triangles, except if shown as a piece of folklore, which indeed harms the proposal of ethnomathematics. Critics of ethnomathematics and, regrettably, even some supporters of ethnomathematics, are missing the point. Ethnomathematics does not propose to replace academic mathematics by folkloric mathematics, or Mickey Mouse mathematics, as it used to be called in the sixties. I am afraid the ethnomathematics proposal risks being seen — and practiced ! — in the same distorted way as the Modern Mathematics movement. Soon a modern Tom Lehrer will sell thousands of CDs ridiculing ethnomathematics, as Buffalo Bill's *Wild West Show* did with Native American culture.

The key issue is much deeper. It asks for a discussion of the major objectives of education and of schooling in the future. And, of course, how does mathematics fit in this future. The difficulty resides in a simple question : what do we know about the future ? Clearly, the way we see the future — and the way we want the future — guide our actions in the present.

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[12]) http://www.rpi.edu/~eglash/isgem.htm

[13]) http://www.SBBay.org/MACT

THE FUTURE

I am not alone in dreaming of a future without hatred and bigotry, with peace among nations, peace in society, peace with the environment, individuals in peace with themselves. IMU is sponsoring *World Mathematical Year 2000*. The Assembly General of the United Nations has proclaimed 2001 to 2010 as the "*International Decade for a Culture of Peace and Non-violence for the Children of the World*". The Assembly called on relevant United Nations bodies, non-governmental organizations (NGOs), religious bodies and groups, educational institutions, artists and the media to support the Decade actively for the benefit of every child in the world. How do we respond to this call? How does the IMU resolution and the UN resolution relate? Shouldn't they be intrinsic to each other? After all, mathematics is the dorsal spine of modern civilization.

To give priority to peace may be a dream, maybe utopia, which justifies my efforts as an educator and my joy as a grandfather, who hopes to survive to become a great-grandfather! The future generations must live in a better world than the one which our and the previous generations before us have constructed. What can we offer to the future generations? Not our model. But a *critical* view of this model and of the knowledge system in which it was built. Mathematics is recognized as central to this knowledge system. Hence, mathematics, and its history, are subjected to this critical view [14]).

It is important to understand some characteristics of the so-called echo-boom generation (those born between 1977 and 1997). The boom generation, responsible for much of the expansion of the educational systems in the sixties and for the important events of 1968, is now reaching retirement age. The effects of this retirement play an important role in public finances, hence on politics. Much of my data refers to the USA but can easily be extrapolated to the developed world, where educational decisions set the standard. The echo-boom generation is the largest ever, about 80 million young people, spanning from 3 to 23 years old, with an enormous purchasing power. Cinema and television — currently the object of political disputes over who controls them — are of lesser importance for the echo-boomers. Instead, they access the Internet and they feel control over it. Effectively, they have control, as hackers demonstrate. They benefit from the technology gap between generations, which include parents, teachers, politicians, executives and decision makers in general.

[14]) This was a motivation for my proposal of editing a section for the *Zentralblatt für Didaktik der Mathematik* on "Mathematics, peace and ethics". It appeared in *Zbl. Didaktik Math. 30* (June 1998), Heft 3.

The economy, work and personal relations will be the most affected. They will be in control in a couple of decades. Most probably they will not be co-opted by the system, as it happened with the 'rebels' of the sixties. The echo-boomers are creating a new culture [15]).

How will mathematics fit in this new culture? We need to understand how, in other epochs, mathematics was affected by changing scenarios. This justifies my insistence on history of mathematics, not as understanding the development of a corpus of knowledge, but as a response to societal changes. Does society influence [16]) the development of mathematics?

Throughout history, in every culture, we recognize the efforts to develop instruments: i) to communicate; ii) to cope with reality; iii) to understand and to explain reality, providing the tools of critical thinking; iv) to define strategies for action. These goals can be identified in every ethnomathematics [17]). Greek mathematics focused mainly on iii) and iv). The propædeutical character of mathematical education, which has been intrinsic to curriculum development in the 20th century, emphasized ii).

In face of the new facilities of computation and information retrieval, there is no place for the propædeutical character of mathematical education. Numbers, figures, signs are *communicative instruments*, enriching the capability of discourse and conversation, of description. Critical familiarity with them, embedded in diversified cultural environments, is part of dealing with communicative instruments. Cultural environments mean calculators and computers if they are around, beads and threads if they are around, paper, pencil, chalk and blackboard if they are around. To create a school environment detached from the socio-cultural environment is justified only if projecting into the future, like the use of fiction as a pedagogical tool. Discontinuities between school and out-of-school environments must be accompanied by a critical reflection, not as a teaching device. Teaching goes on more and more in out-of-school environments. Both mathematics and ethnomathematics provide instruments to socialize the quantitative and qualitative ways of dealing with the surrounding reality.

It is a responsibility of schools to prepare students to generate new realities, prospective or imaginary, that is, to be creative; to be able to explain and understand reality with the capability of moving into the future equipped with

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15) See an interesting article in the journal *The Futurist 34 (5)* (Sept.–Oct. 2000).

16) Quite provocative is the paper by Loren R. Graham 'Do Mathematical Equations Display Social Attributes?' [Graham 2000].

17) See [Urton 1997].

strategies of action. This requires abstraction, conceptualization, in essence the domain of *analytic instruments*. Both mathematics and ethnomathematics provide such instruments, as history shows us.

Technology is part of our world, and will be even more so in the future. From birth through death, we improve the capabilities of our body, the distribution of biological or sky time, our reachable and productive space, as well as our capability of communicating with living and dead individuals and cultures, through technology. When, why and how artifacts and instruments can be used, combined, improved and invented, that is, critical familiarity with *material instruments* that are part of modern civilization, already or potentially accessible, is an important objective of education. Both mathematics and ethnomathematics are intrinsic in such instruments, as history shows us.

In the educational systems of the future I see mathematics, as well as ethnomathematics, inbuilt in the effort of critically providing communicative, analytic and material instruments [18]).

Production and labor will be present in every model of society of the future. The forms they will take surely will reveal the presence of high technology in everyday life. Jobs, as we understand them today, will most probably disappear [19]). The social access of minorities is directly related to their acquiring communicative, analytical and material instruments, in other ways, to the implementation of the *trivium* LITERACY–MATHERACY–TECHNORACY.

IN GUISE OF CONCLUSION

Is mathematics, as we today understand it in our curricula, prone to disappear? I believe so. Curricular organization and assessment, the pillars of current school mathematics, reveal their fragility. The propædeutical character of mathematics, responsible for curricular organization, is challenged. Signs of this are the proliferation of remedial courses and of self-contained specific training courses, such as those provided by enterprise universities. World War II revealed the efficiency of task-training, in line with Skinner's proposals. Good achievement in mathematics, as assessed by standardized and similar varieties of tests, such as SIMS, TIMSS and others, seems to be unrelated to society

[18]) Elsewhere [D'Ambrosio 1999] I called these respectively *literacy*, *matheracy* and *technoracy*.

[19]) For a discussion of labor in the future, see [Reich 1992]. Harsh views of the future of employment, revealing the inadequacy of current educational systems, can be read in [Forrester 1999].

development. The downfall of the Soviet Union and the critical view of education in the Asian countries are signs of this.

What will be the role of a mathematics teacher ? I believe mathematics teachers, understood as those who simply teach mathematics, will disappear. But there will be need for teachers who do mathematics. Even doing mathematics using only addition of three-digit numbers !

The teacher of the future will be a resource-companion of students in the search for new knowledge [20]). The more mathematics a teacher knows, a better resource he/she will be ; the more curiosity about the new, a better companion he/she will be. The characteristics of the new teacher cannot be only the result of special training. Teachers of old generations will retire and echo-boomers will become the new teachers. I trust they will be able to help build a better world.

How does this *L'Enseignement Mathématique* fit in this scenario ? Surely, there is always room for a good, respected, mathematical journal in this future. But does it fulfill the needs of a new *enseignement mathématique* ? Not in the current format.

Maybe, following the vocation of its founders — who clearly understood what was going on in the transition from the 19th to the 20th century and were able to fulfill the need of a journal with the characteristics of *L'Enseignement Mathématique* —, a second rebirth might give rise to a new transdisciplinary and transcultural journal of mathematics and mathematics education, opening its pages to historical, anthropological, and cultural issues.

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[20]) I owe much to Eliot Wigginton's project *Foxfire* for this approach.

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