How Mathematics Education can help in shaping a better World?

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ABSTRACT

As educators we influence the new generations that, in two decades, will be in charge of World affairs. I address our responsibility, as Mathematics Educators, in preparing them to shape a new civilization, in which social justice and Peace with dignity for all prevail. This needs an universal ethics synthesized as 1. respect for the other/the different; 2. solidarity with the other/the different; 3. cooperation with the other/the different. History tell us that Mathematics is the dorsal spine of Modern Civilization, hence Mathematics and Mathematics Education have everything to do with the State of the World. In an era of increasing globalization in all sectors of society, the ethics of respect, solidarity and cooperation is absolutely necessary. In this talk I will discuss why and how the universal ethics of respect, solidarity and cooperation, synthesized above, is intrinsic to the Program Ethnomathematics. Through Ethnomathematics we may be effectively contributing to achieve social justice and Peace with dignity for all.

Keywords

Peace, Social Justice, Ethics, Globalization, Ethnomathematics.

THE STATE OF THE WORLD

The main issues affecting society nowadays can be synthesized in

- national security; personal security;
- government/politics;
- economics: social and environmental impact;
- relations among nations;
- relations among social classes;
- people's welfare;
- the preservation of natural and cultural resources.

Mathematics, mathematicians and mathematics educators are deeply involved with all these issues. History tells us that the technological, industrial, military, economic and political complexes have developed thanks to mathematical instruments, and that mathematics has been relying on these complexes for the material bases of its continuing progress.

It is also widely recognized that mathematics is the most universal mode of thought and that survival with dignity is the most universal problem facing mankind.

It is expected that scientists, in particular mathematicians and math educators, who have much familiarity with the most universal mode of thought, be concerned with the most universal problem, that is, survival with dignity. It is absolutely natural to expect that they, mathematicians and math educators, look into the relations between these two universals, that is, into the role of mathematicians and math educators in the pursuit of a civilization with dignity for all, in which inequity, arrogance and bigotry have no place. This means, to achieve a world in peace (D'Ambrosio 2001).

My current concerns about research and practice in math education fit into my broad interest in the human condition as understood in the history of natural evolution (from the Cosmos to the future of the human species) and to the history of ideas.

For over two decades, I have been formally involved with the Pugwash Movement and the pursuit of Peace (in all four dimensions: individual, social, environmental and military). This movement originated from the Russel-Einstein Manifesto of 1955 (Pugwash 1955). Paradoxically, the amazing progress of Western Civilization did not bring progress in the four dimensions of Peace. On the contrary, it provided more powerful material and intellectual instruments for the violations of Peace, in all these four dimensions.

My research program is to establish the responsibility of mathematicians and mathematics educators in offering venues for Peace. The Program Ethnomathematics, which will be discussed below, is a response to this.

Let me begin with a few basic questions, which guide my research program on mathematics, history, education and on the curriculum.

We need a reflection on the nature of mathematical behavior. How is mathematics created? How different is mathematical creativity from other forms of creativity?

To face these questions, there is need of a complete and structured view of the role of mathematics in building up our civilization, hence tp look into the history and geography of human behavior.

I emphasize that History is not only a chronological narrative of events, focused in the narrow geographic limits of a few civilizations which have been successful in a short span of time. The course of the history of mankind can not be separated from the natural history of the planet. History of civilization has developed in close and increasing interdependence with the natural history of the planet.

WHY TEACH MATHEMATICS?

The title of this section is the same as Session in the Third International Congress on Mathematical Education/ICME 3, held in Karlsruhe, Germany, 1976, when I was responsible for the session on "Objectives and Goals of Mathematics Education: Why Study Mathematics?". The main focus of the session was a critical perception of the objectives of education through history, in different civilizations (D'Ambrosio 1979).

We find, in every civilization and in all the times, some form of education. From initiation practices through complex education systems, the major goals are always:

- to promote creativity, helping people to fulfill their potential and rise to the highest of their capability, but being careful not to promote docile citizens. We do not want our students to become citizens who obey and accept rules and codes which violate human dignity.

- to promote citizenship, transmitting values, and showing rights and responsibilities in society, but being careful not to promote irresponsible creativity. We do not want our student to become bright scientists creating new weaponry and instruments of oppression and inequity.

The big challenge we face in education is the encounter of the old and the new. The old is present in the societal values, which were established in the past and are essential for life in a community. Since the modern state, this is intrinsic to the concept of citizenship. And the new is intrinsic to the promotion of creativity, which points to the future.

I answer the question "why teach mathematics?" simply saying that the utmost goal of Mathematics Education is to cooperate in building up a civilization in peace, which is free of inequity, arrogance and bigotry and gives the opportunity to every individual to reach the full realization of its capabilities.

The strategy of education systems to pursue goals is the curriculum. Curriculum is usually organized in three strands: objectives, contents, and methods. Every educational moment can be identified with the objective (why), contents (what) and method (how). This traditional approach must accept that three components are in solidarity, just like a point in space, This is, indeed, a cartesian model of the curriculum. This model implies accepting the social aims of education systems, then identifying contents that may help to reach the goals and developing methods to transmit those contents. Traditionally, contents are dictated by the inner structure of mathematics and give origin to methods and subordinate vague social aims to achievement of the contents.

Let us more closely look into what is going on in teaching mathematics. We immediately recognize the assumption of a form of universality, since what we observe happens in all countries at all levels. This universality is justified by arguments that I will discuss below.

The character of universality of Mathematics dominates contemporary reflections about the curriculum. Indeed, rationality is universal and mathematics is an expression of rationality. Rationality is the support for the development of strategies to deal with space and time, and ways, modes and styles of comparing, classifying and ordering, evaluating and measuring, inferring and concluding. These strategies have been developed, in very specific form, in the various natural and cultural contexts of the World. The same as religion, language, art, dressing, cuisine, medicine, they all are strategies to deal with daily life problems and situations and to explain observed facts and phenomena.

In the natural and cultural context of the Mediterranean Basin, specific strategies were developed in Sumer, in Egypt, in Israel and in Babylon and, through the dynamics of cultural encounters, were absorbed and incorporated by the Greeks to their own strategies. This gave rise to a very specific strategy, generating a concept relying on a specific concept of proof. This is the essence of what we call Greek Mathematics, which is characterized by practical achievements, for example, constructing war machines and architecture, and by theoretical aspects, that is, relying on proofs as criterion for truth. But Greek Mathematics strongly favored theory. This is clear when we analyze the works of Archytas of Tarentum (Ruffman 2007). Romans absorbed, again thanks to dynamics of cultural encounters, Greek Mathematics; Although we see significant mathematics theoretical achievements in the Roman Empire, for example Diophantus and Claudius Ptolemaeue, in Alexandria, the Romans instead privileged practice. This is clearly seen in the classical book on Roman science De Architecture, by Vitruvius, written in the 1st century BCE (Loeb 1931). With the emergence of Christianity, in the 4th century, Greek Mathematics and Philosophy were ignored. After the Crusades, 12th and 13th centuries, Greek Mathematics, which was preserved, commented and expanded by Muslim scholars, particularly by al-Kwarizmi and its Algebra, was incorporated to the Roman intellectual centers and to the quotidian. Indeed, Greek Mathematics, thanks to Arabic contributions, became a new mathematics which flourished in the European Lower Middle Ages.

A relevant feature of this new mathematics was allying numerical reasoning to the qualitative reasoning typical of theoretical Greek Mathematics. This new mathematics made its way into Education and became the central component of the curriculum throughout Europe. It was responsible for the extraordinary development of European Commerce and Economics, Science and Technology. This still prevails. Since the 17th century, this new mathematics, which is result of the dynamics of cultural encounters in the Mediterranean Basin since Antiquity became the mathematics of every European country. We clearly recognize this as the European Mathematics. Extant local mathematics can be noticed (for example, among the Euskaldunak, in Spain, the Gypsies, all over Europe, and other minorities), but they have no importance in the general European scenario.

Conquest and Colonialism, since the 15th century, imposed European education to the entire World, and with it European Mathematics. A tacit assumption of the universality of European Mathematics prevailed in the teaching of mathematics. Although it is accepted that no religion is universal, no language is universal, no cuisine or medicine are universal, European Mathematics is regarded as universal. This is clearly challenged by the eminent Japanese algebraist Yasuo Akizuki (1960, p.289), what was went unnoticed by mathematics educators, when he says that

> "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."

The acceptance of the universality of European Mathematics displaces all other ways of quantifying, of measuring, of ordering, of inferring. Although it is undeniable that European Mathematics is the imprint and support of the entire technological, industrial, military, economic and political behavior of the entire World, to exclude other modes of thinking, using the wording of Akizuki, may be detrimental. This was soon recognized by the pharmaceutical industry. Regrettably, the general public believes that Homo rationalis, as an evolved species of Homo sapiens sapiens, is characterized by proficiency in European Mathematics. This is intrinsic to the mounting social phenomenon of exclusion.

I have been using the concept of filters in education, particularly when referring to the prevailing evaluation and degrees system in schools and society as a whole. Important discussions on these matters are due to Alexander Grothendieck: La Nouvelle Eglise Universelle and Pierre Samuel: Mathématiques, Latin et selection des elites, in Jaulin 1974, respectively pp.11-25 and pp.147-171.

These views are supported by the results of the conference on "Comparative Studies of Mathematics Curricula – Change and Stability 1960-1980", chaired by Hans-Georg Steiner, which took place in Osnabruck, 1980, sponsored by the Institute for the Didactics of Mathematics (IDM) and the International Mathematics Committee of the Second International Mathematics Study of the International Association for the Evaluation of Educational Achievement (IEA) (Steiner, 1980).

The universality, which was the reason for calling the Osnabruck conference, can be challenged with a proper interpretation of a phrase of Ian Westbury, 1980, p.23:

> "One task of the curricular system in mathematics education is to ensure that the stock of resources for an appropriate general education contained within the culture of mathematics, as this culture is conceived and practiced within industry, higher education and learned societies, is searched and made available to our students. It also implies that one result in this search should be represented in the curricula in mathematics that appropriate numbers of our students experience."

The same challenge goes for the stability in time. In his remarkable conference in the International Congress of Mathematicians, in Paris in 1900, David Hilbert challenges the permanence of curriculum. The quote below (see Hilbert 1902, p.437) clearly states that much of current curricula should be discarded:

> "History teaches the continuity of the development of science. We know that every age has its new problems, which the following age either solves or casts aside as profitless and replaces by new ones."

This affects much of our mathematics curriculum, particularly contents. It is time to recognize that much of what we teach to our students is, in the words of Hilbert, profitless and should be replaced by new contents.

Frequently, some topics of the curriculum are justified with the argument that we have to teach subject A to be able to understand subject B, which is needed to follow subject C, and so on. This propaedeutic concept of a linear organization of the programs is one of the many myths in Mathematics Education, which are based on obsolete learning theories.

A QUALITATIVE SHIFT IN MATHEMATICS EDUCATION.

Beginning with the social critique that intensified at the end of the last century, the social dimension of mathematics education became the object of intense study. International congresses, conferences, and commissions, all affirming the universality of the discipline, have provided forums for these reflections.

In the Third International Congress on Mathematical Education/ICME 3, already mentioned above, the discussion on "Why teach mathematics?" focused on the objectives of mathematics education from a socio-cultural and political perspective. Contrary to ICME 1 (Lyon, 1968) and ICME 2 (Exeter, 1972), when there was no input from the then called Third World countries, ICME 3, in Karlsruhe, had an important presence of participants from all over the World. This created an ambience favorable to question, more profoundly, the position of mathematics in education systems. Central in the discussions was the negative effects that can result from a mathematics education that is poorly adapted to distinct socio-cultural conditions. This was a major qualitative shift proposed since ICME 3.

The qualitative shifts were discussed in two major conferences, held in 1978, sponsored by UNESCO, on "The Development of Mathematics in Third World Countries" organized by Mohamed El-Tom, in Khartoum, Sudan (El-Tom 1979); and a conference on "Mathematics and the Real World" organized by M. Niss and B. Booss at the University of Roskilde, Denmark, in 1978. This latter was held immediately preceding the International Congress of Mathematicians in Helsinki, Finland (Booss and Niss, 1978), and gave origin to a satellite session of the congress on "Mathematics and Society." I believe this was the first time an international congress of mathematicians created space to question mathematics itself, and its epistemological character. This questioning was also present in the Fourth International Congress on Mathematical Education/ICME 4, held in Berkeley in 1980 (Steen and Albers, 1981).

The Fifth International Congress on Mathematical Education/ICME 5, in Adelaide, Australia, in August 1984, showed a definitive tendency toward socio-cultural interests in mathematics education. Questions about "Mathematics and Society", "Mathematics for All", the increasing emphasis on the "History of Mathematics and its Pedagogy", and discussions of the goals of mathematics education subordinated to the general goals of education, were in the program. Surely, ICME 5 marked a qualitative shift in the tendencies of mathematics education. Besides the participation of anthropologists and sociologists in the reflections about mathematics education, a concern with the political dimensions of mathematics education and with the state of the World became part of a new concern in mathematics education.

It is impossible to ignore that the repercussions of the student movement of 1968, which was impregnated by a kind of academic cultural mystique, were felt during the 70s. Much of this mystique had a noticeable influence in the developments of research in mathematics education in the seventies and eighties. But this has not yet been properly studied.

Since the end of World War II, the major goal of education for the masses has been an equal education for all, independent of social and economic class. This should be provided by all governments. This goal dominated the political ideals and aspirations of countries. Thirty years later the illusory, and at times negative, effects of such aspirations are felt in many countries. Such disillusion also contributed to a climate of doubt, which interferes with the necessary qualitative shift.

This is an issue not only affecting less developed countries, but also in countries with advanced industrial development. Now, the increasing population of immigrants in the more developed countries, calls for priority to face socio-cultural issues and to question the universality of accepted canons of mathematics education.

THE POLITICAL AND ETHICAL DIMENSIONS OF MATHEMATICS EDUCATION

As it is generally accepted, the curriculum is organized in three strands: objectives, contents, and methods. It is the classical "Why-What-How". The political dimension of education is sometimes immersed in the discussion of objectives of mathematics education, but very rarely has mathematics content and methodology been examined with respect to this dimension. Indeed, some educators and mathematicians claim that content and methods in mathematics have nothing to do with the political dimension of education.

Since mathematics conveys the imprint of Western thought, it is not an absurd to consider a possible role of mathematics in framing a state of mind that tolerates war. This is similar to the debate about the eeffects of violent video games on aggressive behavior. For more on this, see Anderson (2001). Our responsibility, as mathematicians and mathematics educators, is to offer venues of peace (D'Ambrosio 1998). The possibility that we are conveying to our children the acceptance of the inevitability, and even normality, of a World convulsed by wars is disturbing. There is an expectation about our role, as mathematicians and mathematics educators, in the pursuit of peace. I discussed this role in a recent study commissioned by the Center for Global Nonkilling, in Honolulu (D'Ambrosio 2009).

It is undeniable that mathematics provides an important instrument for social analyses. Western civilization entirely relies on data control and management. "The world of the twenty-first century is a world awash in numbers" (Steen 2001, 1). Social critics will find it difficult to argue without understanding and analyzing data. Obviously, to make good use of these instruments, which are provided as contents, we must master them, but it is equally important to have a critical view of their potentialities and of the risk involved in misusing them. The critical view is not incorporated in contents and methods. Practically all attention is given to skill and drilling, which is supported by inadequate testing systems.

This concept of curriculum won't do anymore for our times. I propose a new concept of curriculum, based in three strands, literacy, matheracy, and technoracy, to bring the qualitative change. This is discussed in (D'Ambrosio 1999b).

To be effective in building up a civilization that rejects inequity, arrogance, and bigotry, education must give special attention to the redemption of peoples that have been for a long time subordinated and must give priority to the empowerment of the excluded sectors of societies.

The Program Ethnomathematics contributes to restoring cultural dignity and offers the intellectual tools for the exercise of citizenship which erases arrogance, inequity and bigotry in society. Ethnomathematics enhances creativity, reinforces cultural self-respect, and offers a broad view of mankind. In everyday life, it is a system of knowledge that offers the possibility of a more favorable and harmonious relation between humans and between humans and nature (D'Ambrosio 1999a).

It has, intrinsic to it, the Ethics of Diversity:

- respect for the other (the different);
- solidarity with the other;
- cooperation with the other.

A frequently asked question is: Is Ethnomathematics research or practice?

Ethnomathematics is fundamentally research in History and Philosophy of mathematics, and this is the reason for calling it the Program Ethnomathematics. But it has obvious pedagogical implications, particularly for curriculum innovation and development, for teaching and teacher education and for policy making.

The Program Ethnomathematics has, intrinsic to it, new historiographical approaches to the history of ideas. Basically, the Program Ethnomathematics goes deeper into non-Western civilizations and into comparative studies of civilizations. It is important the research on established forms of knowledge (communications, languages, religions, arts, techniques, sciences, mathematics) in different cultural environments. Indeed, the Program Ethnomathematics draws from a broad theory of knowledge, which I call the "cycle of knowledge" and from the dynamics of cultural encounters, based on what I call the "basin metaphor". All this links to the historical and epistemological dimensions of the Program Ethnomathematics, which brings new light into our understanding of how mathematical ideas are generated and how they have evolved through the history of mankind. For an explanation of this historiographical approach see (D'Ambrosio 2000).

It is fundamental to recognize the contributions of other cultures and the importance of the dynamics of cultural encounters. Culture is understood in its widest form, and includes art, history, languages, literature, medicine, music, philosophy, religion and science. Research in ethnomathematics is necessarily transcultural and transdisciplinary. The encounters are examined in its widest form, to permit exploration of more indirect interactions and influences, and to permit examination of subjects on a comparative basis. Although academic mathematics developed in the Mediterranean Basin, expanded to Northern Europe and later to other parts of the World, it is difficult to deny that the codes and techniques to express and communicate the reflections on space, time, classifying, comparing, which are proper to the human species, are contextual. Among these codes are measuring, quantifying, inferring and the emergence of abstract thinking.

Basically, research in the Program Ethnomathematics starts with three basic questions:

- How are ad hoc practices and solution of problems developed into methods?
- How are methods developed into theories?
- How are theories developed into scientific invention?

At this moment, it is important to clarify that my view of ethnomathematics should not be confused with ethnic-mathematics, as it is mistakenly understood by many. This is one of the reasons why I insist in referring to the Program Ethnomathematics. The ethnic component of Ethnomathematics is the ethnographic study of mathematics of a certain social group and culture and it is based on gathering empirical data on the form of mathematics practiced in the social groups and culture. Data collection is often done through participant observation, interviews and questionnaires. The Program Ethnomathematics goes beyond the ethnographical approach. It tries to explain how is this mathematics generated, socialized, organized and transmitted in these social groups and cultures. It tries to understand and explain mathematics as well as religion, art, cuisine, dressing, football and several other abstract and practical manifestations of the members of the respective social groups and the peoples of the cultures.

Of course, the Program Ethnomathematics was initially inspired by recognizing ideas and ways of doing that reminds us of Western mathematics. What we call mathematics in academia is a Western construct. Although dealing with space, time, classifying, comparing, which are proper to the human species, the codes and techniques to express and communicate the reflections on space, time, classifying, comparing, are undeniably contextual. I gained an insight into this general approach while visiting other cultural environments, during my work in Africa, in practically all the countries of continental America and the Caribbean, and in some European environments. Later, I tried to understand the situation in Asia and Oceania, although with no field work. Cultural Anthropology is a strong support for the research.

As I said above, it is important to insist that the Program Ethnomathematics is not ethnic mathematics, as some commentators interpret it. Of course, one has to work with different cultural environments and, as an ethnographer, try to describe mathematical ideas and practices of other cultures. This is a style of doing ethnomathematics, which is absolutely necessary. These cultural environments include not only indigenous populations, but labour and artisan groups, communities in urban environments and, in the periphery, farms, professional groups. These groups develop their own practices, have specific jargons and theorize on their ideas. This is an important element for the development of the Program Ethnomathematics, as important as the cycle of knowledge and the recognition of the cultural encounters.

It is important to recognize the special role of technology in the human species and the implications of this for science and mathematics. Thus, the need of History of Science and Technology (and, of course, of Mathematics) to understand the role of technology as a consequence of science, but also as an essential element for furthering scientific ideas and theories (D'Ambrosio 2004).

Once the role of technology in the development of mathematics is recognized, reflections about the future of mathematics propose important questions about the role of technology in mathematics education. Besides these more immediate concerns, there are long term concerns. Of course, they are all related to social behavior and to Ethics. It is important to recognizing that the universal ethics of respect, solidarity and cooperation is intrinsic to Ethnomathematics, Hence, Ethnomathematics favors the pursuit of Peace in its four dimensions (inner peace, social peace, environmental peace and military peace), which depends on the universal ethics.

THE FUTURE OF MATHEMATICS EDUCATION.

The increasing presence of technology in modern civilization leads, naturally, to question about the future of our species.Thus, the importance of the emergent fields of Primatology and Artificial Intelligence, Cybernetics and Human Consciousness, This is synthesized in the concept of fyborgs (which are a kind of "new" species, i.e., humans with dependence on implanted technological devices, such as an electronic pacemaker). Most of our children will be fyborgs when, around 2025, they become decision makers and take charge of all societal affairs. Educating these future fyborgs calls, necessarily, for much broader concepts of learning and teaching. The role of mathematics in the future is undeniable. But what kind of mathematics?

Understanding how, historically, societies absorb innovation, is greatly aided by looking into fiction literature (from iconography to written fiction, music and cinema). It is important to understand the way material and intellectual innovation permeates the thinking and the myths, and the ways of knowing and doing of non-initiated people. In a sense, how new ideas are diffused making abstruse theories and artifacts easier to understand to a non-specialized public. In this respect, fiction is in vantage as compared to other forms of narrative. To convey mathematical ideas through fiction, as well as metaphors, may be a good strategy for education.

How communities deal with space and time is mainly to understand how space and time became sacred in their history. The resources for the sacralization of chronology and topology are, essentially, of mathematical nature.

We have to look into the cultural dynamics of the encounter of generations (parents and teachers and youth). This encounter is dominated by mistrust and cooptation, relying on testing and evaluation practices, which dominate our civilization. In mathematics education, this is particularly disastrous. Mathematics is, usually, seen by youth as uninteresting, obsolete and useless. And they are right. Much of the traditional curriculum is uninteresting, obsolete and useless.

Standardized Testing is the main support of traditional contents. There is more concern with attaining pre-established goals of proficiency than to enhance creativity. Enormous effort and resources are aimed at rising the scores of Standardized Testing. In the opinion of Anthony Ralston (Ralston 2002)

> "rising scores on standardized tests are not only not a sign of significant learning (in mathematics and other subjects) but, as well, they hide continuing serious deficiencies in the mathematical learning of children. Still worse, they give politicians and, it must be said, some educationists something to crow about when nothing good is happening. Worst of all, they give parents a false sense that the learning of their children is improving when it is not."

The arguments to justify Standardized Testing are based on claims of the importance of current math contents are fragile. Myths surround these claims. Tests penalize creative and critical education, which leads to intimidation of the new and to the reproduction of this model of society. This favors the promotion of docile citizenship and irresponsible creativity. This is the goal of great financial corporations. This is discussed in my paper (D"Ambrosio 2009).

It is important to understand children and youth behavior and their expectations. History gives us hints on how periods of great changes affect the relations between generations. Regrettably, education, in general, is dominated by a kind of "corporate" attitude, in the sense that there is more concern with the continuity of a model of society than in giving space for the new, which needs the creativity of the youth. Traditional subjects are an instrument to achieve societal sameness. This is particularly true with Mathematics Education.

Bertrand Russell and Albert Einstein, in the most critical period of the Cold War, said "We have to learn to think in a new way." (Pugwash 1955). Paraphrasing them, we need a new thinking in Mathematics Education, bringing to our practice the interests, the dynamics and the new mathematics of the contemporary quotidian and stimulating creativity of the new generations. If we do so, there is much space for the growth of Mathematics in the curriculum. Otherwise, there lies before us the risk of Mathematics not having a place in the curriculum of the future.

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