Journal of Mathematics Education at Teachers College

Spring – Summer 2013

A Century of Leadership in Mathematics and its Teaching

TABLE OF CONTENTS

Preface

Articles

TABLE OF CONTENTS

Journal of Mathematics Education at Teachers College
Spring–Summer 2013, Volume 4

The Role of Ethnomathematics in Curricular Leadership in Mathematics Education

Ubiratan D'Ambrosio
University of Campinas

Beatriz Silva D'Ambrosio
Miami University

In this paper we share our reflections regarding the role of ethnomathematics in providing direction for leadership in mathematics education. Our arguments are grounded in an analysis of the world today, characterized by inequities and injustices, clamoring for a new social order. We contemplate the role of mathematics and mathematics education in improving the world for the benefit of future generations. In our vision, the Program Ethnomathematics is positioned as a theoretical framework capable of guiding practice and curriculum for a very different educational project, one that centers the children in a world of social equity and justice as well as a world in which humanity achieves equilibrium with and respect for nature and its resources. We end our reflections with some thoughts on the preparation of teachers and leaders for this alternate educational project.

Keywords: ethnomathematics, equity, social justice, world peace

Introduction

These reflections on the role of mathematics and mathematics education in schools stem from our concerns regarding the rights of children and the role of schools and curriculum in creating a world that respects these rights. We envision a school that exists to improve society and prepare children to participate in society understanding the importance of creating a world with peace and dignity for all human beings.

It is an undeniable right of every human being to share in all the cultural and natural goods needed for material survival and intellectual enhancement. This is the essence of the United Nations' *Universal Declaration of Human Rights* (1948) to which every nation is committed. The educational strand of this important statement on the rights of humanity is formulated in the document *The Dakar Framework for Action. Education for all: Meeting our collective commitment*, where six education goals, which aim at preparing all children, youth and adults for a meaningful role in society by 2015, were internationally agreed upon (UNESCO, 1990). Of course, there are many difficulties in implementing United Nations resolutions and mechanisms. But as yet this is the best instrument available that may lead to a global civilization with peace and dignity for all human beings. Regrettably, mathematics educators are generally unfamiliar with these documents.

Mathematics education has been remiss by attending exclusively to the goal of improving students' scores on standardized tests rather than engaging in the reflections needed for realizing the goal of achieving education that prepares humans to partake in creating a better world. Mathematicians' and mathematics educators' focus on children's success on tests that constitute nothing more than arbitrary measurements of acquisition of knowledge that might have been important to society centuries ago has detracted society from consideration of the really crucial goals of education. Whether the importance of the knowledge tested today can be justified and sustained is one of the components driving our personal reflections that we share with the reader in this paper. We propose in this paper to raise an awareness among leaders in mathematics education regarding the need to expand the discourse to include issues of much greater complexity that involve mathematics, its teaching, and its learning.

In this paper we propose the Program Ethnomathematics as a response to the responsibility of mathematicians and mathematics educators to explore, investigate, and propose venues to achieve peace. However, before we delve into a description of the Program Ethnomathematics, we first position ourselves for the reader, summarizing the main concerns underlying our reflections.

The main issues affecting society today are extremely multifaceted and include the following (among many others):

- National security; personal security;
- Government/politics;
- Economics: social and environmental impact;
- Relations among nations;

- Relations among social classes;
- People's welfare (including health, nutrition, and living conditions);
- Preservation of natural and cultural resources.

Mathematics, and consequently mathematicians and mathematics educators, are deeply involved with all of these issues. History tells us that the technological, industrial, military, economic and political complexes have developed thanks to mathematical instruments. History also suggests 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 humanity*. It is expected that scientists, in particular mathematicians and mathematics educators, be concerned with the most universal problem, that is, survival with dignity, and also have much familiarity with the most universal mode of thought, that is, mathematics. It is absolutely natural to expect that mathematicians and mathematics educators explore their role in the pursuit of a civilization with dignity for all, in which inequity, arrogance, and bigotry have no place. This means working together to achieve a world in peace (see D'Ambrosio, 2001; Pugwash, 1955), which must be understood broadly, including its multiple dimensions of inner peace, social peace, environmental peace, and military peace. To elaborate, we begin with a few basic questions that guide the research program as it relates to mathematics, history, education, and curriculum.

A reflection on the nature of mathematical behavior constitutes an important component of the Program Ethnomathematics. How is mathematics created? How different is mathematical creativity from other forms of creativity? To address these questions there is need for a complete and structured view of the role of mathematics in building up our civilization, hence a look into the history and geography of human behavior.

A view of history that will support our understanding of the nature of mathematical behavior is one that is more than a chronological narrative of events, focused on the narrow geographic limits of a few civilizations that have been successful in a short span of time. Instead we propose a historical perspective that acknowledges that the course of the history of humanity cannot 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.

With respect to education, for us the major goals are:

- to promote creativity, helping people to fulfill their potentials and rise to the height 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 that 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 students to become bright scientists creating new weaponry and instruments of oppression and inequity.

The big challenge we see lies in the encounter of the old and the new. The old is present in behavior, knowledge and societal values, which were established in the past and are essential to the concept of citizenship. The new are new ideas, new behavior, and new approaches to knowledge. They are the bases for the promotion of creativity, which is necessary for the emergence of new concepts of humanness. This is the essential point in the Pugwash Manifesto (1955), of Bertrand Russell and Albert Einstein, "We have to learn to think in a new way" (para. 5).

Curriculum is the strategy of education systems to pursue goals created, negotiated, and accepted by society. It is usually organized in three strands: objectives, contents, and methods. This Cartesian organization 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.

But what are the goals and objectives of education? The process of reaching consensus on the objectives of education is political, but very rarely has mathematics content and methodology been examined with respect to this dimension. In fact, some educators and mathematicians claim that content and methods in mathematics have nothing to do with the political dimension of education.

The Political Dimension of Mathematics Education

Currently, our children live in a world convulsed by wars. Mathematicians and mathematics educators can counteract society's frame of mind that tolerates war (D'Ambrosio, 1998). A discussion of mathematics curriculum with this objective would focus the education of our children on developing their creative problem-solving abilities to participate in the proposal of new and unique strategies for achieving world peace.

There is an expectation about our role, as mathematicians and mathematics educators, in the pursuit of peace. Anthony Judge, the director of communications and research of the Union of International Associations, expressed how others see mathematicians:

> Mathematicians—having lent the full support of their discipline to the weapons industry supplying the missile delivery systems—would claim that their subtlest thinking is way beyond the comprehension of those seated around a negotiating table. They have however failed to tackle the challenge of the

> packing and unpacking of complexity to render it comprehensible without loss of relationships vital to more complex patterns. As with the protagonists in any conflict, they would deny all responsibility for such failures and the manner in which these have reinforced unsustainably simplistic solutions leading to further massacres (Judge, 2000, Mathematicians section, para. 5).

Judge's statement challenges mathematicians and mathematics educators to understand and explain the role of mathematics in the current state of the world. It further challenges mathematicians and mathematics educators to assume a stance and responsibility for the possible change in the world order. To accept this challenge would entail mathematicians and mathematics educators assuming leadership in the political discussions of the role and objectives of mathematics in the education of children for a new world order.

The Ethical Dimension of Mathematics Education

Another dimension of mathematics education that warrants attention is one of ethics. We find it difficult to separate a discussion of the ethics of mathematics education from the politics of mathematics education, since, in fact, the two are intimately related and cannot be teased apart. Still, for the purposes of this discussion we address separately from the discussion of politics the issues regarding the ethics of diversity of human beings and the role of ethics in education. The essence of the ethics of diversity is respect for, solidarity with, and cooperation with the other (the different). This leads to quality of life and dignity for all. We include in this discussion of ethics the respect for the planet and its resources.

Large sectors of the population of the world today, in both developed and developing nations, are excluded from the political, economic and cultural life of society. Large sectors of the population do not have access to full citizenship. Some do not have access to the basic needs for survival. This is the situation in most of the world and occurs even in the most developed and richest nations.

While an explanation for this situation is often traced back to the colonial periods, there are no gains in blaming one or another for this state of affairs, nor to attempt to redo the past. Instead, it is important, through historical studies, to understand the past, to identify errors, to correct some, and to avoid repeating others. To accept inequity, arrogance, and bigotry is irrational and may lead to disaster. As the first author has amply discussed in other papers (particularly in D'Ambrosio, 2009), mathematics has everything to do with this state of the world. A new world order is urgently needed. Our hopes for the future depend on learning—critically—the lessons of the past.

To propose directions to counteract ingrained inequitable practices in schools and society is the major challenge of educators, particularly of mathematics educators. This has been a concern of some mathematics education researchers and practitioners. The ethical dimension of mathematics education requires increased efforts and work toward greater social justice in society. The progress mathematics educators are making in this realm is laudable, as indicated by the large number of publications and important research on equity in mathematics education (Forgasz & Rivera, 2012) and in teaching mathematics for social justice (D'Ambrosio, 2012; Gutstein, 2006; Stinson & Wagner, 2012). However, the acceptance of this work by school leaders and curriculum leaders is yet to be seen.

The ethics of mathematics education includes concerns regarding the role of mathematics in solving the problems related to the respect for the planet and its resources. The appeal of Mikhail L. Gromov, laureate of the Abel Prize 2009, must receive the attention of mathematicians and mathematics educators:

> But in fifty years from now, the Earth will run out of the basic resources, and we cannot predict what will happen after that. We will run out of water, air, soil, rare metals, not to mention oil. Everything will essentially come to an end within fifty years. What will happen after that? I am scared. It may be okay if we find solutions, but if we don't then everything may come to an end very quickly! Mathematics may help to solve the problem, but if we are not successful, there will not be any mathematics left, I am afraid! (Gromov, 2010, p. 401)

Surely, this appeal by Gromov was instrumental in guiding several scientific associations to collaborate on the design and articulation of the project Mathematics of the Planet Earth 2013 (see www.mpe2013.org). The project resulted from the joint initiative of the International Mathematical Union (IMU), the International Council of Scientific Unions (ICSU), the International Council of Industrial and Applied Mathematics (ICIAM), UNESCO, and the more recent addition of the International Commission of Mathematics Instruction (ICMI). The project´s aim is to promote the collaboration of scientists, teachers, and students in understanding the issues threatening the planet and, consequently, the future of humanity. The seriousness and complexity of these issues demands a transdisciplinarian approach to research and education. The great challenge is to find mechanisms to engage students in the exploration of proposals for action to face these urgent issues. Student involvement in important issues regarding the well-being of humanity and the preservation of the planet and its resources must become one of the main goals of their educational experience.

The Program Ethnomathematics

Preliminary to the Program Ethnomathematics as a pedagogical practice, the first author proposes a new concept of curriculum, synthesized in three strands: *literacy, matheracy*, and t*echnoracy* (D'Ambrosio, 1999b). The three provide, in a critical way, the communicative, analytical, and technological instruments necessary for life in the twenty-first century. Let us discuss each one.

Literacy is the capability of processing information, such as the use of written and spoken language, of signs and gestures, of codes and numbers. Clearly, reading has a new meaning today. We have to read a movie or a TV program. It is common to listen to a concert with a new reading of Chopin. Also, socially, the concept of literacy has gone through many changes. Nowadays, reading includes competency with numeracy, the interpretation of graphs and tables, and other ways of being informed by text, understanding "text" in its broadest sense. Reading even includes understanding the condensed language of codes. These competencies have much more to do with screens and buttons than with pencil and paper. There is no way to reverse this trend, just as there has been no successful censorship to prevent people from having access to books in the past 500 years. Getting information through the new media supersedes the use of pencil and paper, and calculators are an integral part of defining one's numeracy. The use of numbers and the four operations, as well as the description of forms and measurements, is knowledge that can be acquired through everyday practices. In fact, scholars have shown that little formal instruction is needed for the acquisition of basic quantitative literacy. The theoretical and abstract concepts of mathematics belong to another dimension of knowledge and are dealt with in the next strand of the proposed curriculum.

Matheracy is the capability of inferring, proposing hypotheses, and drawing conclusions from data, as in statistics, which is much more than the manipulation of numbers. It is a first step toward an intellectual posture, which is almost completely absent in our school systems. Regrettably, even conceding that problem solving, modeling, and projects can be seen in some mathematics classrooms, priority is usually given to the manipulation of numbers and operations. Getting the correct results is most often the goal of mathematical activity. Matheracy is closer to the way mathematics was present in both classical Greece and other indigenous cultures. The concern was not with counting and measuring, but with deeper understanding of facts and phenomena, with the resource of numbers and figures as symbols. Examples are the divination arts and philosophy, present in all cultures. Matheracy has a focus on deeper reflection about humans and society, nature and the imaginary, as practiced in restricted circles of intellectuals, such as the academies and the equivalent in other cultures. By including matheracy as a curricular strand we would engage the population at large in these deeper reflections.

Technoracy is the critical familiarity with technology. Of course, the operative aspects of it are, in most cases, inaccessible to the lay individual. But the basic ideas behind technological devices, their possibilities and dangers, their limitations, and the morality supporting the use of technology, are essential issues to be raised among children at a very early age. History shows us that ethics and values are intimately related to technological progress.

The theoretical framework that establishes the foundation for this new concept of curriculum is the Program Ethnomathematics. To build 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 constitute excluded sectors of societies. This is the real meaning of empowerment, a phrase commonly used in education.

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

The Program Ethnomathematics offers the possibility of harmonious relations in human behavior and between humans and nature. It has, intrinsic to it, the *ethics of diversity*:

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

The practice of the ethics of diversity is the only hope we have for achieving a just social equilibrium. We contend that educational practices should be driven by and grounded in the ethics of diversity if education is to contribute to achieving a new social order.

Readers may be wondering whether ethnomathematics is research or practice. Ethnomathematics arises from research, and this is the reason for calling it the Program Ethnomathematics. But equally important, indeed what justifies this research, are the implications for curriculum innovation and development, teaching, teacher education, policy making, and the effort to erase arrogance, inequity and bigotry in society.

Interest in ethnomathematics starts with a concern for understanding the human condition as related to the history of natural evolution (from the Cosmos to the future of the human species) and to the history of ideas, particularly the history of the explanations about creation and natural evolution. Included is a quest to understand the founding myths of Western civilization, linking research on the history of monotheistic religions (Judaism, Christianity, Islamism) and the history of techniques, of arts, and of how mathematics permeates all this.

To better understand the foundations of Western civilization we look into these foundations in non-western civilizations, to compare and to examine possible connections. This represents the "dynamics of cultural encounters." Of course, this is a very ambitious project, impossible to be accomplished by an individual. Access to scholarship, current and classical, and to the collective works of colleagues and students contributes to the research program.

Reflections that result in the tenets of the research program emanate from research on established forms of knowledge (communication, languages, religions, arts, techniques, sciences, mathematics) and in a theory of knowledge and behavior that we refer to as the "cycle of knowledge." This theoretical approach recognizes the cultural dynamics of the encounters, based on the "basin metaphor," discussed in D'Ambrosio (2000). All of these studies constitute the historical and epistemological dimensions of the Program Ethnomathematics, which can bring new light into our understanding of how mathematical ideas are generated and how they evolved through the history of humanity. At the heart of this work is the recognition of the unique contributions to the mathematical knowledge base of humanity made by all cultures and of the importance of the dynamics of cultural encounters.

Culture is understood in its most encompassing form, and includes art, history, languages, literature, medicine, music, philosophy, religion and science. Research in ethnomathematics is necessarily transcultural and transdisciplinarian, which is an integrated process of inquiry leading to new conceptual and methodological approaches. Transdisciplinarity extends existing theories and methods to understand and solve problems and situations of natural and social nature. The encounters are examined in their broadest forms, 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 reflections on space and time, on classifying and comparing, which are proper to the human species, are contextual. This results in different codes and techniques of measuring, quantifying, inferring, and in the emergence of different styles of abstract thinking.

At this moment, it is important to clarify that these views of ethnomathematics should not be confused with ethnic-mathematics, as it is understood by many. Of course, ethnic specificities are contemplated. This is why it is important to use the broader concept of the Program Ethnomathematics. This program works to explain mathematics, while it also explains religion, culinary, dress, football, and several other practical and abstract manifestations of the human species. 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, classification schemes, and comparisons, which are characteristic of the human species, the codes and techniques to express and communicate the reflections on these behaviors are undeniably contextual. Insights into this general approach resulted from the first author's visits to the cultural environments in Africa, in practically all the countries of continental America and the Caribbean, and in some European environments. Later, the emergent reflections were applied to other cultures in Asia and Oceania, although with no fieldwork.

More recently, since 2011, both authors have participated in project MACIMISE (Mathematics and Culture in Micronesia: Integrating Societal Experiences), a project funded by the National Science Foundation (Dawson, 2013). MACIMISE is a project within the realm of the Program Ethnomathematics. It uses ethnomathematics as the theoretical framework providing the foundation for curriculum units developed for and implemented with the children and teachers of the Micronesian Islands. The ethics of diversity drives the work with elders of the Micronesian Island communities to reveal and explore cultural practices, and to understand and value local language and codes, systems and strategies, ways of thinking and operating, as well as techniques and tools. This research produces material that is used to revive indigenous cultural practices, to recover respect and pride for local scientific and mathematical knowledge, while at the same time serving to raise the elements that ground the development of curricular units for mathematics instruction.

While the work with different cultural environments to describe mathematical ideas and practices of other cultures is an important component of the Program Ethnomathematics, it is important to expand the view of cultural groups beyond ethnic groups. The different cultural groups that are studied in the program include, indigenous populations, but also labour and artisan groups, communities in urban environments and in the periphery, farm communities, and all different types of professional groups. These groups develop their own practices, have specific jargons, and theorize 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.

To express the ideas, which have evolved into a research program (partially inspired by Lakatos, 1976), a neologism emerged, *ethno + mathema + tics*. This caused much criticism, because it does not reflect the etymology of "mathematics." Indeed, the *mathema* root in the word ethnomathematics has little to do with "mathematics" (which is a neologism introduced in the XIV century).

The Program Ethnomathematics links to the study of curriculum, through the modern *trivium*: literacy, matheracy and technoracy, discussed earlier. As such it serves as an instrument to work towards peace, ethics, and citizenship.

Basically, research in ethnomathematics starts with three basic questions:

1. How are *ad hoc* practices and solution of problems developed into methods?
2. How are methods developed into theories?
3. How are theories developed into scientific invention?

It is important to recognize the special role of technology for the human species and the implications of this role 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).

Preparing Teachers and Leaders for the Future

The challenge of preparing teachers and leaders for the future is one that demands collaboration and reflection by the mathematics education community. A society with equity and justice begins in classrooms. Classrooms today mirror the ills of society at large, with oppression of students, power relations that segregate students, and evaluation procedures that add to the anguish of students and further differentiate those who will lead from those who will be oppressed.

Teacher education and leadership preparation that change the social order in classrooms and prepare teachers in the ethics of diversity, one of the components of the Program Ethnomathematics, is in our view a first step. Building classrooms where the social order is one of respect, solidarity, and collaboration will go a long way towards the education of children who can envision these human relations in the world around them. These classrooms will be collaborative environments in which children and teachers work together to think critically and use problem-solving strategies for the annihilation of inequities and social injustices, and for the preservation of nature and its resources.

Details about the preparation of teachers and leaders for schools for the future go beyond the scope of this paper, but the teacher preparation and leadership development programs will necessarily be driven by the same ethics of diversity as we envision for schools. Several scholars have begun to explore programs that develop a disposition of teachers and leaders to reconceptualise goals for education and consider the well-being of all humanity as the main concern of education (see, for example, the special issue on equity of the *Journal of Mathematics Teacher Education*, Chapman, 2012, and the special issue on identity and power of the *Journal for Research in Mathematics Education*, Langrall, 2013). The difficulty of the work of mathematics teacher educators to rethink teacher preparation is explored by D'Ambrosio and Kastberg (2012). Working within an ethics of caring (Hackenberg, 2005) the authors come to understand the difficulty of giving voice and giving reason to future teachers. They acknowledge that only upon truly embracing the knowledge of others (in particular, future teachers and educational leaders) can they begin to work collaboratively with them in preparing them to contemplate a new educational project.

References

Chapman, O. (Ed). (2012). Foregrounding Equity in Mathematics Teacher Education [Special issue]. *Journal of Mathematics Teacher Education, 15* (1).

D'Ambrosio, B. & Kastberg, S. (2012). Giving reason to prospective mathematics teachers. *For the Learning of Mathematics, 32*(3), 22–27.

D'Ambrosio, U. (1998). Mathematics and peace: Our responsibilities. *Zentralblatt für Didaktik der Mathematik, ZDM, 30*(3): 67–73.

D'Ambrosio, U. (1999a). Ethnomathematics and its first international congress. *Zentralblatt für Didaktik der Mathematik,* ZDM, 31(2): 50–53.

D'Ambrosio, U. (1999b). Literacy, matheracy, and technoracy: A trivium for today. *Mathematical Thinking and Learning, 1*(2): 131–53.

D'Ambrosio, U. (2000). A historiographical proposal for non-western mathematics. In Selin, H. (ed.). *Mathematics across cultures: The history of non-western mathematics*, pp. 79–92. Dordrecht: Kluwer Academic Publishers.

D'Ambrosio, U. (2001). Mathematics and peace: A reflection on the basis of western civilization. *Leonardo, 34*(4): 327–32.

D'Ambrosio, U. (2004). Ethnomathematics and its place in the history and pedagogy of mathematics. In T.P. Carpenter, J.A. Dossey, & J.L. Koehler, (Eds.), *Classics in mathematics education research* (pp. 194–199). Reston VA: National Council of Teachers of Mathematics.

D'Ambrosio, U. (2009). Nonkilling mathematics. In J.E. Pim (Ed.), *Toward a nonkilling paradigm* (pp. 239–268). Honolulu: Center for Global Nonkilling.

D'Ambrosio, U. (2012). A broad concept of social justice. In D. Stinson & A. Wagner (Eds.), *Teaching mathematics for social justice: Conversations with educators* (pp. 201–213). Reston VA: National Council of Teachers of Mathematics.

Dawson, A.J. (2013). Mathematics and Culture in Micronesia: The structure and function of a capacity building project. *Mathematics Education Research Journal, 25*(1): 43–56.

Forgasz, H. & Rivera, F. (Eds.). (2012). *Towards equity in mathematics education: Gender, culture, and diversity.* Berlin Heidelberg: Springer-Verlag.

Gromov, M. (2010): Interviewed for M. Raussen & C. Skau, *Notices of the AMS, 57*(3), 391–409.

Langrall, C. (Ed.). (2013). Equity [Special issue]. *Journal for Research in Mathematics Education, 44*(1).

Gutstein, E. (2006). Reading and writing the world with mathematics: Toward a pedagogy for social justice. New York: Routledge.

Hackenberg, A. (2005). A model of mathematical learning and caring relations. *For the Learning of Mathematics, 25*(1), 44–47.

Judge, A. (2000). And when the bombing stops: Territorial conflict as a challenge to mathematicians. *Union of International Associations*. Retrieved March 3, 2013, at http://www.uia.org/uiadocs/mathbom.htm

Lakatos, I. (1976). *Proofs and refutations*, Cambridge: Cambridge University Press.

Pugwash (1955). *Pugwash Conferences on Science and World Affairs*. Retrieved March 6, 2013, at http://www.pugwash.org/about/manifesto.htm

Stinson, D. & Wagner, A. (Eds.). (2012). *Teaching mathematics for social justice: Conversations with educators*. Reston VA: National Council of Teachers of Mathematics.

United Nations. (1948). *Universal Declaration of Human Rights*. Retrieved March 06, 2013 at http://www.un.org/Overview/rights.html

UNESCO. (1990). *World Declaration on Education for All*. Retrieved March 08, 2013, at http://unesdoc.unesco.org/images/0012/001211/121147e.pdf