Chapter 15

PUERTO RICO: The Forging of a National Identity in Mathematics Education

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Abstract: This article reviews the history — through different political periods — and current status of mathematics education in Puerto Rico. It chronicles the struggles that have informed educational policies in the forging of a national identity in the field — policies that will hopefully foster the development of a society that values mathematical ideas.

Keywords: History of mathematics education; mathematics in Puerto Rico; history of mathematics; mathematics education; national identity.

The Colonial Experience

Puerto Rican identity has been shaped by the fact that our development as a nation has often answered to priorities and plans engineered from abroad. Given that Puerto Rico has been a colony of Spain (1493–1898) and of the United States since 1898, the nature of the state in Puerto Rico is intertwined with the Territorial Clause of Article Four of the United States Constitution. This clause assures that the United States Congress has final authority over Puerto Rico and its people. This has influenced our educational policies, which are still frequently "formulated to serve the needs of the imperial enterprise" (Navarro-Rivera, 2009).

Puerto Rico's Indigenous Taíno People

Puerto Rico's eminent historian of education, José Juan Osuna, warned that "in writing on education in Puerto Rico, the temptation is to neglect

the origins; to think of education as beginning at a later time when we have a record of school laws and of the provision made by the government" (Osuna, 1949). Ironically, Osuna himself neglected the origins of Puerto Rico by relegating the Taínos to be mere beneficiaries of the Spanish rulers' goodwill, since "no other colonizing nation of the time was concerned with their welfare as much as Spain" (Osuna, 1949). He further claimed that "we find this concern manifested in an order to the effect that the [Taíno] children in each village should get together twice a day in a house next to the church in order that the chaplain might teach them to read and write, to make the sign of the cross, and to learn the prayers of the church" (Osuna, 1949). Regrettably, Osuna and others confused education with religious indoctrination and its political goals.

Osuna considered Puerto Rico to be "a Spanish colony in blood, in religion, in customs, and in traditions" (Osuna, 1949). Nevertheless, the Taíno Genome Project contradicts the blood assumption since the genetic composition of Puerto Ricans is, on average, 15% Taíno, 21% African, and 64% European (Via, *et al.*, 2011). While European ancestry is dominant, 15% is higher than the 1/8 blood quantum required for membership among 18 Native American tribes.

The Taínos had a tributary system in place when the Spaniards arrived in 1493. It required that each *yucayeque* (community) pay a tribute in agricultural products to each regional *cacique* (chief) (Moscoso, 2003). The determination of the amount of the tribute and its relationship to the size of the village is a significant mathematical problem. In the absence of written records, its solution has been lost to history. We also know they navigated at night between the various Caribbean islands. Night navigation required some astronomical knowledge; however, the mathematical techniques they might have used again have been lost. While Puerto Ricans cannot speak of an indigenous mathematical legacy, as descendants of Incas or Aztecs can, it is clear that an operational competence existed well before the arrival of the Spanish conquistadors. Nevertheless, Puerto Ricans by and large do not identify with their indigenous ancestry, and there is no official recognition whereby someone may claim Taíno ancestry or any special rights thereof.

Colony of Spain (1493–1898)

Much of education under Spain was delegated to the Catholic Church (Navarro-Rivera, 2009), with brief intermittent periods after Spain's 1820 mutiny at Cádiz, and the subsequent *Trienio Liberal*, when the civil

government undertook the provision of public education. As with most colonial possessions, the effects of the educational revolution and the development of public education arrived late in Puerto Rico.

Under Spanish rule, the curriculum and teaching strategies were very similar to those used in Spain and the rest of Hispanic America, except where there was a strong presence of Jesuit missionaries. In general, education was dedicated to religious instruction, with basic teaching of reading and writing, along with some notions of arithmetic and algebra (Coll y Toste, 1909). Teaching and learning were based on memorization. Humanistic studies were superficial and scientific studies almost non-existent. During this period, the first *catedrático* (professor) of mathematics in Puerto Rico, José Besabé, arrived in 1822. He resigned from his post after a few months of service and was replaced by Santiago Pérez. Both professors received their education in Spain.

The Jesuit *Seminario-Colegio*, founded by the *Compañía de Jesús*, functioned from 1858 until 1886 (Gómez-Diez, 2000). The Jesuits started a secondary school in 1862 where two years of mathematics instruction was offered. Besides arithmetic and algebra, the curriculum included geometry and trigonometry based on J. M. Fernández y Cardín's textbooks. Due to irreconcilable political differences with the civil government, the Jesuits were forced to close the school in 1886 and abandoned Puerto Rico (Gómez-Diez, 2000).

Colony of the United States (1898–Present)

As a result of the 1898 Spanish–Cuban–American War and the Treaty of Paris, the United States attained authority over Puerto Rico. "As a colony of the US, the major focus in the education of Puerto Rican children was the English language" and "the American way of life" (NEA, 2006). "Indeed, these were mandates of the US government" (NEA, 2006). Former presidents of the United States, including John Quincy Adams, Thomas Jefferson, and James Monroe, expressed a wish to annex Cuba and Puerto Rico. Charles Eliot, president of Harvard University, echoed those ambitions in 1898 when he stated, "I am inclined to the belief that we shall be able to do Cuba and Porto Rico some good; though to do so we shall have to better very much our previous and existing practices in dealing with inferior peoples" (Navarro-Rivera, 2009).

The new ruling power, the United States of America, "viewed state education as the most effective and efficient entity through which to undertake

the colonization of Puerto Rico" (Navarro-Rivera, 2009). In 1899 the *Junta Insular de Educación* was established to centralize the administration of education in the island (Programa, 2003). "Thus, contrary to its tradition of decentralized governance, after the 1898 war the United States chose to govern its new colonies in the same centralized manner it governed the affairs of its Native American societies" (Navarro-Rivera, 2009). Confirmation of this policy is evident in the fact that 60 Puerto Ricans were sent to the Carlisle Indian Industrial School in Pennsylvania between 1900 until its closure in 1918. The historian Osuna was among the seven Puerto Rican students who graduated from the school.

According to a Carlisle brochure from the 1920's, "a thorough training [was] given in arithmetic, but no instruction [was] given in the higher mathematics" (Maryland, 2006). In a letter by Sun Elk, a Native American student at Carlisle, "There was much arithmetic. It was lessons; how to add and take away, and much strange business like you have crossword puzzles only with numbers. The teachers were very solemn and made a great fuss if we did not get the puzzles right" (Maryland, 2006). We can conclude that the sixty Puerto Ricans at Carlisle received similar training.

The Foraker Act was passed by the US Congress in 1900, recognizing Puerto Rican citizenship; the Jones Act of 1917 conferred US citizenship on Puerto Ricans, seven years before the Indian Citizenship Act of 1924. The Foraker Act also created the position of Commissioner of Education. In his foreword to Osuna's thesis book, José Padín, who held the post from 1930 to 1937, chose a conciliating tone arguing that "American 'imperialism' [endnotes by Padín] is inescapably infected with the spirit of democracy and an unquenchable zeal to treat peoples, even dependent peoples, as ends in themselves rather than as resources to be exploited for the benefit of the dominant power" (Osuna, 1949).

The first Commissioner of Education, Martin G. Brumbaugh, relocated Puerto Rico's Normal School to Río Piedras from Fajardo in 1901 (Osuna, 1949). The Normal School became the first department of the University of Puerto Rico (UPR) upon its founding in 1903. In 1911, the College of Agriculture and Mechanic Arts was established in Mayagüez (Osuna, 1949). These two campuses became — and continue to be — the foci of intellectual life and scientific and mathematical research on the island.

"Until 1947, the President of the United States appointed the Governor, the Attorney General, the Commissioner of Education, the Treasurer, and the Justices of the Supreme Court of Puerto Rico. As far as education was concerned, 'the rules of the game', regarding the language to be used,

whether English or Spanish, the methodology and the course content were decided by the Presidential Commissioners, who usually were American educators with little knowledge of Puerto Rico, its culture and traditions" (García, 1964). In 1948 Puerto Rico had its first elected governor, Luis Muñoz Marín. Despite intentions, an educational system dominated by appointed officials acting in concert with local collaborators, fostered an intellectual dependency that hindered creativity in formulating educational policies. This problem persists today as Puerto Rico continues to debate its relationship with the United States.

Mathematics Education in the 20th Century

In *Marco Curricular* (2003), the Department of Education provided a synopsis of the historical development of the mathematics curriculum in Puerto Rico during the twentieth century. It portrays a questionably-smooth transition in the advancement of mathematics instruction that includes consideration of curricular developments but leaves out other important initiatives, like teachers' development. It is worth noting that *Marco Curricular* attempted to imitate some frameworks for mathematics

1900 1910 1920 1930	Énfasis en la enseñanza de conceptos y destrezas de aritmética
1940 1950	Énfasis en el valor puramente social de la matemática
1960	Énfasis en la significación para facilitar la comprensión y el entendimiento de las matemáticas (matemática moderna)
1970	Énfasis en el desarrollo de destrezas básicas fundamentales
1980	Énfasis en la solución de problemas pertinentes y en el desarrollo del pensamiento
1990 en adelante	Énfasis en la solución de problemas, el desarrollo de destrezas de razonamiento y pensamiento crítico

Figure 1. Curricular developments in the 20th century (Programa, 2003).

education in some US states (most notably California), especially since it was a late-comer in the list of framework documents for mathematics education. Some viewed this document as representative of the "state of the art" in the normative documents that were to guide mathematics education in Puerto Rico and the United States.

The Years 1900–1930: Emphasis on the Teaching of Arithmetic Concepts and Skills

López Yustos (1997) provided an overview of the structure of the education system around 1915. He informs us that elementary education was divided into urban and rural. The former consisted of eight grades, which granted a diploma upon completion. The latter consisted of only the first four grades, in addition to courses in agriculture and other farm-related trades taught to boys and girls. High school education was imparted in the regular high schools of San Juan, Ponce, Mayagüez, Arecibo, and Humacao, which offered complete programs. In addition, there were more than a dozen continuation schools that offered one or two years. These were established in some towns to delay the transfer of the young people to urban educative centers to complete their secondary education.

During the first years following US control, instruction was conducted in Spanish, but the medium was officially changed to English in 1904. In the majority of schools, Puerto Rican teachers used Spanish as the language of instruction, but switched to English when visited by a supervisor.

The mathematics textbook used during the first decades was *Arithmetic* by David Eugene Smith and George Wentworth. The Smith and Wentworth text was among the most popular in use in the continental schools of the period. Arithmetic skills were necessary to administrate the colony, but by reducing mathematics to the teaching of arithmetic and later on in calculus for engineers, mathematics was deprived of its innate beauty and charm.

Marco Curricular claims that the results of the "Columbia University Commission", referring to the Teachers College Commission led by Paul Monroe in the Philippines and Puerto Rico in the mid-1920s, showed that Puerto Rican students "mastered" arithmetic (Programa, 2003). The Commission Report stated:

> In our charts the comparison of Porto Rico and continental children in arithmetic is conspicuous because of the unusually

> high attainment of the pupils of the island. In arithmetic skills in the second, third, fourth, and fifth grades children of Porto Rico actually exceed those of continental schools. The attainment, for example, in the third grade in Porto Rico practically equals that in the fourth grade of continental schools (Survey, 1926).

The same document, however, states that students' mathematical achievement "from the eighth grade to the fourth-year high school represents a total gain in computational ability of less than half a year!" (Survey, 1926). That is, children were exceptionally apt in performing mathematical activities, yet opportunities for their advancement were not provided. This furthers the thesis of the pernicious effects of colonial policies. Perhaps the followers of Eliot in Puerto Rico saw advances in mathematics as appropriate for the intellectual elite at Harvard and Columbia, but not for "inferior peoples".

The Years 1930–1960

"The year 1932–1933 was a year of great activity in Puerto Rican education. The Department of Education prepared manuals for the use of the teachers and issued observations to supervisors on how to analyze the methodological needs of the teachers" (García, 1964). At the secondary level, "great pains were being taken to 'humanize' the teaching of mathematics, linking its meaning to the needs of life and initiating the student in the notions of business" (García, 1964). This emphasis was a reflection of the progressive education movement pioneered by Teachers College Columbia University professors, including members of the 1926 commission.

Marco Curricular claims there was another commission led by Columbia University professors in 1949 that recommended using "activities related to the community" (Programa, 2003). This too was a reflection of events in continental school mathematics following World War II that attempted to salvage what remained of progressive, socially relevant mathematics.

The mathematical gains reported in the 1926 report were somehow lost by 1940, possibly as a result of progressive educational policies. In June 1940, Commissioner of Education José Gallardo highlighted that "the teaching of arithmetic was so deficient in the elementary schools, that the teachers in the secondary schools had to devote a great deal of time to explaining the fundamentals of arithmetic so that students could

understand the mathematics of the grades" (García, 1964). García cites texts and policies remaining from the "progressive" period:

> In Grades 7 through 9, the text used was *Mathematics and Life*. It consisted of three books, one for each year. The first one dealt with problems of the home, like salaries, occupations, etc. The second had to do with problems of the community, such as business, bank systems, and taxes. The students of the ninth grade would use the third book, which dealt with mathematical problems at the national level: natural resources, distribution of production, tax systems, and so on. In his annual report for the year 1943–1944, the Commissioner of Education pointed out that all efforts were being made to teach mathematics in the high school from the point of view of the needs and interests of the students. The decade of 1940–1950 highlighted a process of "socialization" in the teaching of mathematics and a nationalistic flavor in the whole educational process, crowned with the wise decision in 1949 that all instruction was to be imparted in Spanish and that the teaching of English would be intensified as a second language.

This prompted Erasto Rivera Tosado and Pedro A. Cebollero in 1948 to write the first mathematics textbook in Spanish under US domination, *Aritmética Social*, which became the standard for elementary levels. "The scope, as far as methodology and course content were concerned, did not differ much then from that of the previous decade" (García, 1964).

An important event for teachers' development during this time was the 1950 creation of the National Science Foundation (NSF). "The Foundation's programs reached Puerto Rico in 1957, when a grant was made to Inter-American University for a Summer Mathematics Institute for high school teachers of science and mathematics. The institute included three formal courses: Foundations and Philosophy of Mathematics, The Teaching and History of Mathematics, and The Theory of Numbers and Mathematical Recreations" and was directed by Mariano García (García, 1964).

Soon after this institute, the Soviets successfully launched Sputnik 1. "This created in the US a sense of urgency in the necessity of improving the teaching of Science and Mathematics and as a consequence multiple NSF-sponsored activities for teachers and students were developed" by universities in Puerto Rico (García, 1964).

The Years 1960–1990: Emphasis on Meaning to Facilitate the Comprehension and Understanding of Mathematics

The first elected governor, Luis Muñoz Marín, took office in 1949. At that time only half of school-age children attended school. During the first decade of the Muñoz administration the main educational effort was on universal school attendance. Between 1944 and 1962, public spending on education quadrupled in real terms, resulting in a massive expansion of schools, teacher hiring and the purchasing of books, materials, and equipment. In 1954 all children of school age started first grade. Once universal attendance was attained for elementary school children, Governor Muñoz declared the 1960s the "Decade of Education", switching the focus from quantity to quality.

Action on teachers' development was also motivated by the results of a study reported in 1959–1960, which showed that of 7,294 elementary school teachers on the island, 99.4% had not taken any courses in mathematics beyond their own high school preparation in this field. "Since August, 1961, the College of Education of the University of Puerto Rico is requiring six credits in mathematics of all students. This means that even those students who become elementary school teachers after pursuing only two years of college will have some training in college mathematics. The special course designed for this purpose was prepared by the Department of Mathematics in collaboration with the College of Education" (García, 1964).

From 1960 to 1968, Angel G. Quintero Alfaro, first as Under Secretary and then as Secretary of Education, developed a series of innovative projects designed to improve teaching from an activity in which students were passive recipients of knowledge, to an active endeavor more pertinent to the students' reality. As part of his reform, new educational materials were developed and teachers received professional development on how to use them. In the case of mathematics, new materials being developed in the United States were adopted since they differed from the basic skills approach (Quintero Alfaro, 1972). Following the lead of Edward G. Begle's School Mathematics Study Group, the New Math was introduced with an emphasis placed on mathematical terminology (mainly set theoretic), and its symbolism, and its uses. Given the difficulties that students had with this approach, soon the materials were changed to those developed in the newly created Curricular Centers, where teachers in collaboration with university professors created educational materials and helped to

implement new teaching strategies in the classroom. Eugene Francis, a professor at the University of Puerto Rico at Mayagüez (UPRM), excelled in this endeavor starting a series of initiatives, both with teachers and with students, that have had a profound impact on the development of the teaching of mathematics.

The highlight during this era was the Department of Public Instruction's realization of the importance of providing for the academic needs of the mathematically and scientifically talented. As a result, the Department founded the specialized school *Centro Residencial de Oportunidades Educativas de Mayagüez* (CROEM) in 1967. CROEM is still considered one of the best public secondary schools on the island, and has an academic relationship with the Mayagüez Campus of the University of Puerto Rico. CROEM is part of three specialized mathematics and science schools, which include two later additions: University Gardens (grades 9–12) and Brígida Álvarez (grades 7–9).

In 1967, the Mathematics Commission of the College Entrance Examination Board created an algebra and trigonometry course, which *Marco Curricular* claims to be a "college-level" course. In 1968, courses in probability, statistics, and analytic geometry were introduced at the secondary level, as well as algebra courses for ninth-graders or talented eight-graders (Programa, 2003).

During the 1970s, a remedial curriculum was developed for students with "limitations" in the learning of mathematics at the elementary level. The *Proyecto Calendario Escolar Continuo*, which divided the year into five "quinmestres" was put in effect. Together with the quinmestres, a series of "Back to Basics" curricular materials were created that divided the curriculum into units to address the individual differences of students, with an emphasis on basic skills (Programa, 2003). Each student could then complete the various units at his or her own pace.

Marco Curricular claims that "studies conducted toward the end of the 70s revealed the risk" of students having only some mechanical facility with basic skills but no understanding of them or knowledge of their applications (Programa, 2003). The Mathematics Program of the Department of Education of Puerto Rico sponsored several projects to develop materials and methodologies that promoted discriminating learning in mathematics. At the University of Puerto Rico, with funding from NSF, Manuel Gómez established a Resource Center for Science and Engineering that promoted methodologies for teaching and assessment emphasizing critical thinking in mathematics. A component of the Center worked with secondary

teachers and talented science and mathematics students. Eugene Francis, in Mayagüez, and Ana Helvia Quintero, in Río Piedras, jointly coordinated this effort. They promoted the development of materials for the teaching and learning of mathematics written by UPR professors that emphasized problem solving and critical thinking. The materials used in the Summer Camps for talented youth and in the professional development for teachers are still used today.

The 1990s and Onwards: Emphasis on Problem Solving, the Development of Reasoning Skills, and Critical Thinking

The reform movement in Puerto Rico was bolstered by a $10 million NSF grant in support of the Puerto Rico Statewide Systemic Initiative (PRSSI) and by the National Council of Teachers of Mathematics (NCTM) 1989 Standards and the 2000 Principles and Standards for School Mathematics. *Marco Curricular* states that it has been "nourished" by NCTM's documents. They formed the framework for the 1996, 2000, and 2007 versions of the Puerto Rico standards. The 2007 *Estándares de Contenido y Expectativas de Grado* developed under the direction of Jorge López at the University of Puerto Rico in Río Piedras, are improvements on the highly criticized 2000 version; however, it remains to be seen how the recent Common Core State Standards in the United States will impact the local standards.

Centros Regionales de Adiestramiento en Instrucción Matemática (CRAIM), a division of the Mathematics Department of the University of Puerto Rico in Río Piedras directed by Jorge López, devoted a significant effort to teacher training and the development of didactic materials. CRAIM was instrumental in the translation and adaptation of some of the units of the *Mathematics in Context* series for middle school, developed by Thomas Romberg, *et al.* of the University of Wisconsin at Madison. The units were translated into Spanish and adapted for Puerto Rico. The materials were piloted in a fifth grade of the Jesús Sanabria Cruz public school in Yabucoa with very dramatic results (all students except two ranked in the upper 10% in mathematics understanding according to the standardized tests administered by the Department of Education). CRAIM also developed a complete set of materials for elementary schools as a joint project with Koeno Gravemeijer of the Freudenthal Institute of the University of Utrecht in The Netherlands. Moreover, CRAIM developed

materials and activities for talented students, thus contributing to the development of an initiative originated by Eugene Francis related to mathematical olympiads.

The Department of Education (DEPR) has had a notable ambivalence with respect to the methods used to train students for competitions in mathematics. The best students were typically from private schools while the funds for student training in this area were controlled by the DEPR, which naturally is reluctant to invest the monies in the training of students who are not in public schools. This situation has been partly responsible for the often mediocre showing of Puerto Rican students in international competitions. Local competitions, however, were organized very successfully by *Programa de Matemática* and Eugene Francis at their start, and later taken over by CRAIM and by Luis Cáceres in Mayagüez. Finally, CRAIM developed the series *Tesoros de la Matemática* for the DEPR, which consisted of interesting topics in mathematics written informally by the best mathematicians of Puerto Rico for the consumption of students and teachers of mathematics.

Education of Teachers

As noted earlier, the University of Puerto Rico was founded in 1903 from a Normal School. In 1901, this Normal School required only a 6th grade diploma for admission. It offered a two-year program to prepare elementary school teachers, and a four-year program to prepare school principals (López Yustos, 1997). The training of school principals was vital because, at the time, the function was being carried out by unprepared English teachers from the United States whose major qualification was that they could communicate with the Commissioner of Instruction. By 1920 the university continued to offer these programs but had expanded to offer two-year programs for teachers of home economics, two-year programs for high school teachers, and a one-year program that trained teachers for rural schools. There were 117 students in the program for rural teachers and 110 in the program for regular teachers. These programs aimed to correct the extreme shortage of teachers. In 1959, the UPR had campuses in Río Piedras, Mayagüez and San Juan (currently the Medical Center) that emphasized the humanities, engineering, and health sciences, respectively. The UPR system had 14,869 students that year. Of those, 11,654 were registered at the Río Piedras campus, out of which 3,441 were in the School of Education (López Yustos, 1997).

While the number of mathematics educators has risen consistently over the last century, a very restrictive education system, resembling that of North America — but with weak mathematics requirements from the Puerto Rico Department of Education — have combined to create the general perception that teachers do not have sufficient background to teach mathematics content. "During the year 1957–1958, 75.5% of junior high school mathematics teachers in public schools of Puerto Rico did not have a single credit in college mathematics, and 32.7% of senior high school teachers had not taken a single course at college level" (García, 1964). Professional development programs for mathematics teachers were urgently needed. The NSF-sponsored Institute of Mathematics, created by the Inter-American University in 1957, served 35 high school teachers. Besides the three aforementioned courses it offered, it hosted a conference series led by Dr. Derrick Lehmer, chairman of the Department of Mathematics of the University of California at Berkeley. This was the beginning of professional development programs for teachers supported by federal organizations. While initially most teacher training was done by CRAIM and the Resource Center in Río Piedras, professional development programs for mathematics teachers are now island-wide, reaching thousands of mathematics teachers and receiving both state and federal funding.

Luis Cáceres and Arturo Portnoy, from UPR-Mayagüez, have pioneered several educational projects for both teachers and talented students. Their teacher development program, *Alianza para el Fortalecimiento en el Aprendizaje de las Matemáticas* (AFAMaC), is of special interest. In 2004, Leida Negrón, then director of the Mathematics Program in the Department of Education, approached Cáceres with the idea of designing a professional development model that would comply with some new requirements of the NSF Mathematics and Science Partnership. In 2005 he created a program with three main points:

(1) Focus on content — Based on the simple premise that one cannot teach something one does not understand, AFAMaC has focused on insuring that the participating teachers gain an in-depth understanding of the mathematical and scientific concepts needed to be an effective teacher.
(2) Substantial contact hours — Realizing that teachers need the support of and exposure to mathematical professionals, AFAMaC offers 160 contact hours of workshops during an academic year, 80 of which take place in the summer.

(3) Sustainability — Professional development ought to be continued for several years and the results must be evident in the academic achievement of the participating teachers' students.

From 2004 to 2009 another major initiative, the *Alianza para el Aprendizaje de Ciencias y Matemáticas* (AlACiMa) developed alongside AFAMaC. The result of an NSF $35 million grant, AlACiMa had considerably more funding sufficient to impact education across Puerto Rico. They engaged 155 K-12 schools by offering professional development to teachers and creating 28 professional resource centers (AlACiMa, 2010). An interesting component of AlACiMa is that they "adopted the concept of learning communities" as a core principle. Participants at all levels were encouraged constantly, through workshops and other activities, to reflect upon their own learning (AlACiMa, 2010). "While the main thrust of AlACiMa was the professional development of in-service mathematics and science teachers," AlACiMa also included interventions "to strengthen the preparation of pre-service teachers" (AlACiMa, 2010). The funding for the program was provided by an NSF grant. Once that grant ended, the program has continued with alternate sources of funding — basically federals funds from the Puerto Rico Department of Education. It should be noted that grant termination is the foremost problem with government-funded initiatives.

Comparison of Mathematics Achievement in Puerto Rico and the United States

The National Assessment of Educational Progress (NAEP) consists of a series of standardized tests with assessments in mathematics and other subject areas. An English language version is administered nationally in the United States and a Spanish language version is administered in Puerto Rico. In 2003 and 2005, it served as a common metric for the US and Puerto Rico by reporting three achievement levels for students: basic, proficient and advanced. Table 1 (Baxter, *et al.*, 2007), presents results in mathematics for fourth and eighth graders in public schools of the United States, of Puerto Rico and of Mississippi (the state with the lowest scores) for 2005. The results in 2003 were similar.

In 2007, the last year for which results are available for Puerto Rico, comparisons using the above metric between the US and Puerto Rico were no longer made. Comparisons of the raw scores by subject area for fourth

Table 1. Comparison of NAEP results in 2005 for the US, Puerto Rico and Mississippi.

	Puerto Rico	United States	Mississippi
Percent of fourth grade students with basic level or better	11%	79%	69%
Percent of fourth grade students with proficient level or better	0%	35%	19%
Percent of eighth grade students with basic level or better	6%	68%	52%
Percent of eighth grade students with proficient level or better	0%	28%	14%

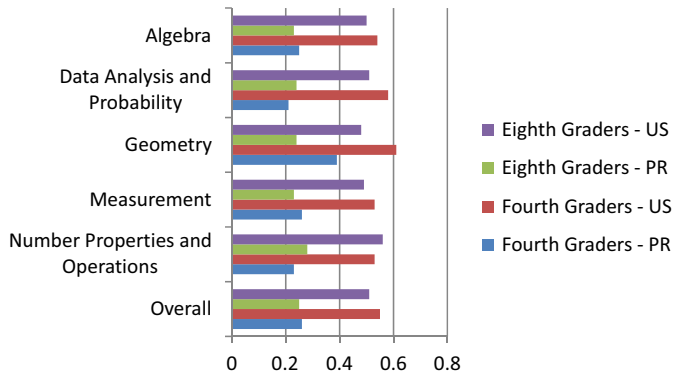

Figure 2. Comparison of NAEP results in 2007 for fourth and eighth graders in the US and Puerto Rico.

and eighth graders in the United States and Puerto Rico are shown in Figure 2 (Dion, Kuang & Dresher, 2008). These data speak to the worrisome state of mathematics education in Puerto Rico and the lack of preparedness of many secondary school students to enter STEM fields at the university level.

Some Geopolitical Aspects

In the early 1940s, a new law was passed that created the Superior Teaching Council that went on to become the Council on Higher Education: the governing body for all institutes of higher education in Puerto

Rico. In 1947, the initiative "Operation Bootstraps" advanced the right of universal education. Over the course of the next several decades, this resulted in new private and public university campuses in order to meet the greater demand for teachers and other professionals. In 1965, a law was passed that significantly expanded the powers to the Council on Higher Education, which included the power to "adopt and to promulgate the norms for the accreditation of private higher education" (López Yustos, 1997). Accreditation of the Council on Higher Education was necessary to obtain federal funds. Federal support has become indispensable to the private universities of Puerto Rico. As a result, antagonism developed between private and public universities as private institutions felt that their initiatives would only be approved if they resembled those already in place at public universities.

This antagonism between private and public universities, as well as the role of government in the UPR system, continues to be felt today. Puerto Rico's political background has resulted in divided political parties and turbulent power transitions which can affect mathematics education. Despite consistent recommendations from accreditation agencies that the University of Puerto Rico be shielded from politics, when a new governor of Puerto Rico is elected, this commonly results in the replacement of the president of the UPR system, followed by all campus rectors and faculty deans. In cases where the board of regents does not accommodate the government agenda, the legislative branch has passed laws that realign the board of regents in order to pursue its political needs. A recent case occurred in 2010, when the New Progressive Party increased the number of members from 13 to 17 to force a majority. This was bound to change after the general election of 2012, when the New Progressive Party lost to the Popular Democratic Party. Hence, immediately upon assuming power in 2013, legislation was passed that dissolved the former board of regents replacing it with a new "government board". The new board again has 13 members; however, its members now answer to the ruling Popular Democratic Party (Banuchi, 2013).

An interesting case study of how government intervention can impact mathematics education involves changing the admission standards of the UPR in 1993. The initial admissions standards were a balance between standardized test scores and grades. As this formula often favored better prepared students from private schools, public universities felt that they were handling the majority of Puerto Rican students from low income families and wanted more financial support from the government and political

pressure mounted to make the UPR system more accessible to students from lower income families. As a result, the admission standards were adjusted to emphasize grades more than standardized test scores. To assess how this has impacted secondary school and university mathematics, two professors from the Department of Mathematical Sciences at the University of Puerto Rico at Mayagüez (UPRM) compiled data from the UPRM which is being published for the first time in this article. Mayagüez is the major engineering campus of the UPR system; hence changes in the mathematics preparedness of secondary school students in Puerto Rico should be quite evident and easily observed at this campus.

Figure 3 shows the rise in the admission index as a result of this change in the formula. Figure 4 shows mathematics achievement, as measured by the Puerto Rico College Board Mathematics Achievement test, since this change was implemented. The admission index would show that the students are becoming better prepared while the math achievement scores indicate that they are becoming less prepared. One cause for this contradiction could be grade inflation. As grades rather than knowledge have become the

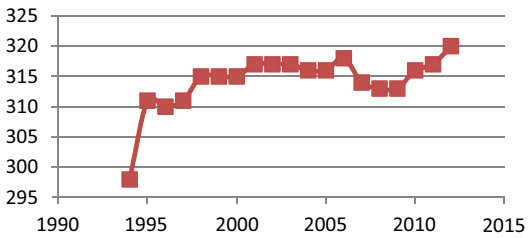

Figure 3. Average admission index for entering freshmen at the UPRM since 1994.

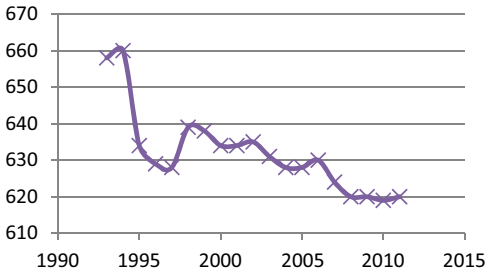

Figure 4. Average math achievement test scores at the UPRM since 1994.

Table 2. Distribution of high school GPAs by math grades received by freshmen at the University of Puerto Rico at Mayagüez from 2008 to 2011.

Grade	Observations	Average High School GPA	Standard Deviation	Minimum	Maximum
A	673	3.87	0.21	2.61	4.00
B	936	3.77	0.29	2.26	4.00
C	1408	3.69	0.33	2.19	4.00
D	388	3.61	0.36	2.43	4.00
F	878	3.54	0.39	2.29	4.00
W	1480	3.62	0.37	2.30	4.00

key to admission to the university and obtaining a better life, secondary school teachers may be giving higher grades for worse performance.

Table 2 shows the average high school grade point average for freshmen who receive an A, B, C, D or F in their freshmen year math courses. The graph indicates that while almost everybody appears to have been an A-grade student in high school, almost half are destined to achieve D's, F's or W's in their freshman year mathematics courses.

High school students tend to focus on getting into the university and to worry about doing well in university courses only later, once they are at university (if at all). The data indicate that this change in admission standards seems to have shifted the incentive for students, teachers and parents away from knowledge and towards higher grades. The data show that high school GPAs have gone up but mathematical knowledge has gone down. It is not the intention of the authors to address the use of standardized tests but rather the consequences that can result when political expediencies rather than long term development motivate mathematics education policies. As a result of its turbulent political background, Puerto Rico can be vulnerable to such phenomena.

Gender Issues

In the United States, the NAEP exam results indicate that males perform better than females in mathematics. This difference, however, is not seen in Puerto Rico where females perform as well as males. In fact, females perform approximately 5 points higher on average in the Geometry and Spatial Sense section. This lack of a gender gap continues to be seen in post-secondary

institutions. Based on data from Río Piedras and Mayagüez, approximately 36% of graduates in engineering programs are women and approximately 60% of graduates from other science and mathematics programs are women. While obviously there is still a gap in engineering fields between male and female graduates, it should be noted that this gap is far less than anywhere else in the United States. There appears not to be as significant a gender issue in Puerto Rico with respect to mathematics education as there is in most other countries in the Western Hemisphere.

Mathematical Olympiads

Eugene Francis and the *Asociación Puertorriqueña de Maestros de Matemática* (APMM) introduced Mathematics Olympiads to Puerto Rico through local competitions in the different educational districts of Puerto Rico and a championship in which the finalists from the regional competitions would participate. Francis organized the tests with the Olympiad problems and was in charge of the grading and the results. At the time of his death he was working on a book of problems that were to include all of the championship Olympiad problems with solutions for teachers and students interested in these mathematical activities.

This work has been continued and has, in fact, expanded significantly. In 2001, *Olimpiadas Matemáticas de Puerto Rico* (OMPR) was pioneered by Cáceres and Portnoy as an initiative for identifying and nurturing mathematical talent across the island. The number of participating students has grown steadily since its inception; currently over 6,000 students participate each year.

OMPR has been able to awaken interest in mathematics and STEM disciplines in general. During the last decade, Mayagüez has become a major hub of mathematical activity on the island. Hundreds of students and parents drive for hours across the island to attend the different sessions OMPR holds throughout the year. As a measure of success, besides having earned over 60 international medals and other awards, OMPR prides itself in the fact that many of their former Olympians are accepted by premiere universities in the United States. For example, in 2010, 10 OMPR students were accepted at MIT and in 2013 seven students were granted early admissions. Cherry Gong, who represented both Puerto Rico and the United States at the International Mathematical Olympiad (IMO), graduated from Harvard in 2011 and is pursuing doctoral studies in

mathematics at MIT. Apparently, MIT is the preferred institution of the current Puerto Rican generation of Olympians. In 2010, George Arzeno, now also at MIT, earned the first gold medal for Puerto Rico at the IMO. These college students have created a support network to help younger students gain access to some of the best mathematical institutions and minds.

As part of their efforts, OMPR hosted the *Olimpiada Centroamericana de Matemáticas* in 2010. In 2014 they will host the International Kangaroo Mathematics Contest and in 2015 the *XXX Olimpiada Iberoamericana de Matemáticas*. OMPR also has shared its model of competition with other countries in the region. One of the main results in this connection is that Jamaica has begun a program based on OMPR.

The success of OMPR is a harbinger of a new era of "liberating pedagogy" that will increase the number of mathematicians and scientists — future Fields Medalists and Nobel Laureates — from Puerto Rico. This will be the pride of a people.

Math Circles

Although support and admiration for the accomplishments of OMPR are widespread, some educators have expressed philosophical reservations about competitions. Robert Kaplan, for example has written:

> Nothing, you'd think, would be more foreign to a mathematician than transforming his art into a contest. [...] Where has the leisure gone in which young mathematicians used to think through difficult thoughts? [...] Is the goal of understanding to be replaced by merely triumphing over some roomful of other people? [...] Isn't man against the gods a higher drama than man against man?

In this spirit, Héctor Rosario from the University of Puerto Rico at Mayagüez founded the Puerto Rico Math Circle in 2012. This initiative grew out of the need to provide continuous support for students who wish to engage in high-caliber mathematical thinking. In 2013, the University of Puerto Rico at Mayagüez and the Puerto Rico Math Circle hosted *Circle on the Road*, the annual gathering of math circles in the United States. This project is promoted by the National Association

of Math Circles and sponsored by the Mathematical Sciences Research Institute.

To the advocates of mathematics competitions, Harvard mathematician Barry Mazur has proposed the following variant, as recorded by Kaplan and Kaplan (2007):

> If there are to be competitions, might they not be in a more fruitful style? Barry Mazur asks why all — or the most telling — questions couldn't be of the form: "What do you think about this?" He calls the present form of competitions "closed": here is the problem we have made for you, solve it. He suggests instead an "open form": tell us something of your own; surprise us.

Rosario has proposed a week-long conjecture-based mathematics competition. According to a former director of the National Association of Math Circles, David Auckley, and the current president of the World Federation of National Mathematics Competitions, Alexander Soifer, no such contest exists. In such a competition — more like a fellowship — students would be introduced to some "open form" topic, and be asked to produce conjectures springing from it. Naturally, they would need to prove or disprove their claims.

Conclusion

In their concluding remarks to *Out of the Labyrinth: Setting Mathematics Free*, Robert and Ellen Kaplan appeal to the human condition: "We have an inborn urge to know, to make, and to enjoy the world around us, that neither fatigue nor fear can long suppress," so let us "rise out of the labyrinth and see the whole world spread below us" (Kaplan and Kaplan, 2007). Puerto Rico has taken some steps to liberate mathematics and its education from the hesitance instilled by centuries of colonialism. Still, much has to be done to improve the curriculum material as well as the teacher preparation programs. In order to be successful, we cannot limit ourselves to replicating the approach of the United States; that attempt at replication has not been effective, as the results of international studies consistently show. Puerto Rico must transcend the effects of imperial hubris if it wishes to advance a culture that values mathematical ideas. That should be the goal of our mathematics education agenda.

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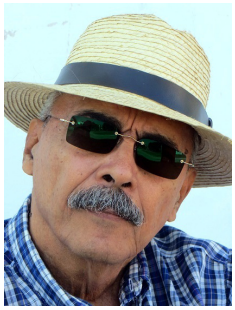

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