"Africa Counts" and Ethnomathematics

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In this article I will discuss my motivation for writing *Africa counts: number and pattern in African culture* [Zaslavsky, 1973/1979], as well as the tribulations and successes that I experienced in the course of writing the book. Then I will relate some of my efforts over the past years to introduce multicultural perspectives into the mathematics curriculum at the elementary and secondary levels. At present, multiculturalism is just beginning to gain popularity in the United States. How does this trend manifest itself in the curriculum materials that are available? What needs to be done to infuse ethnomathematical perspectives into mathematics education?

Motivation for "Africa counts"

My book *Africa counts: number and pattern in African culture* grew out of demands in the 1960s by African-American students and the community for an African studies program. Not that they specifically requested African mathematics. I doubt that they even considered mathematics when they requested the inclusion of African history, literature, and culture, as well as the Swahili language, in the curriculum of our secondary school. Few people think of mathematics in this connection. Isn't mathematics culture-free? Isn't mathematics the same all over the world?

At that time I was teaching mathematics in a secondary school just north of New York City, in a district that had voted in 1951 to integrate the schools by busing, three years before the historic Supreme Court decision on school desegregation. The district soon became a magnet for educators throughout the country seeking information and models for the integration of their schools' population.

Not only did the administration engage African scholars to teach Swahili, African literature, and African history, but in 1969 a college professor came to the district after school hours to offer a course in African history to interested members of the faculty. For my term paper in the course I decided to research the development of mathematics in Africa south of the Sahara.

To my amazement, the library catalogs that I consulted had no listing for "African mathematics." How could this be? In the history course I was learning that large centralized kingdoms and advanced cultures evolved centuries ago in various parts of Africa, while much of Europe was in the Dark Ages. Certainly Africans had developed counting systems and systems of weights and measures for trade and other purposes. They must have employed mathematical principles to construct their massive buildings as well as more modest homes. They had used geometry to design lovely textiles and other works of art. No, the card catalogs had no listing for mathematics under these subheadings.

Evolution of "Africa counts"

One solution to the problem of gathering information would be to live in an African village for several years and learn all I could about the way people applied mathematics. Then I would do the same in other areas. But life was too short for such a course of action.

I knew that Dr. W. E. B. DuBois, the great African-American sociologist, had initiated work in Ghana on the *Encyclopedia Africana*. Although he had died in 1963 at the age of ninety-five, work on the *Encyclopedia* had continued. In fact, I had just read that the first volume was to be published. I wrote to the Secretariat in Ghana about my project, but the reply was disappointing. They could furnish no information on the subject of African mathematics, "a field that needs much research."

Surely historians in the area of African studies would be able to furnish the necessary information? Our own professor mentioned the work of Joseph Greenberg, one of the foremost authorities on African languages. I wrote to him and to several others. By the end of the semester, I was able to present carbon copies of my letters and replies like "I don't know, but you might contact so-and-so or read such-and-such," or "I have heard of a game based on mathematical principles." I received credit for the course, but still had very little information. I faced a real challenge!

At that point I decided to write a form letter requesting information about the subject I later called "African sociomathematics," the applications of mathematics in the lives of African people, and, conversely, the influence of African institutions on the evolution of their mathematics. Topics included numbers and numeration systems; beliefs about numbers; applications of mathematics to measurement, record-keeping, and trade; the geometry of architecture; form and pattern in art; mathematical games of strategy and games of chance. I sent this letter to authorities in African studies and history of mathematics, both in the United States and abroad. Among them was the historian of mathematics Howard Eves, then editor of the "Historically Speaking" section of *The Mathematics Teacher*, a journal of the National Council of Teachers of Mathematics. He was most encouraging, and offered to publish an article on this important subject if I should collect enough material to write it. The article appeared in April 1970 [Zaslavsky, 1970a].

At that time Eves was consulting editor for the Prindle, Weber and Schmidt (PWS) Complementary Series of paperback books devoted to enrichment materials for mathematics education and instruction, and I was invited to write a book of about a hundred pages on the subject of African mathematics. What better motivation to continue my research! At the same time I was asked to write an article on this subject for the first issue of a new journal launched by PWS [Zaslavsky, 1970b; see also Zaslavsky, in press].

With the publication of the article in *The Mathematics Teacher*, letters began to pour in from the United States and other countries, suggesting further contacts and recommending relevant readings. Meanwhile I was scanning hundreds of books and articles written by anthropologists, historians, missionaries, and colonial officers who had been stationed in the African colonies of European powers. In order to govern these lands, the authorities needed to know something of local practices, including applications of mathematics.

During a trip to London, Kenya, and Tanzania I made valuable contacts and gathered more material. Whenever possible I would check the information in the available literature with people of the ethnic background I was investigating. When I returned to the United States I continued this practice by interviewing African graduate students, who were only too happy to share their knowledge. Their African schooling had informed them about ancient Greece and modern Europe, while African history and culture were not considered worthy of study.

Most of all, I am indebted to Donald W. Crowe, mathematics professor at the University of Wisconsin, for his tremendous contribution to the book. He had taught mathematics in Nigeria and had participated in the early 1960s in the American group organized to bring "new math" to African countries. His collection of materials based on local mathematics practices had been rejected by the group as too unsophisticated, and I was the fortunate recipient. Additionally, he used a semester in London to research several topics for me, arranged for translation of an Arabic-language manuscript on magic squares, selected appropriate photographs at the British Museum, wrote a section on transformation geometry for the book [Crowe, 1973], and helped in innumerable other ways.

A surprising number of Americans made suggestions about one or more of the topics I had listed in my letter. Several told me about reference works giving number words in hundreds of African languages. "But I am not interested in listing number words in hundreds of African languages," I would reply. Of greater interest and value would be the principles guiding the growth of numeration systems in the major language families. For example, in the Bantu languages of southern and eastern Africa, numeration systems were based on grouping by tens, with higher numbers formed by a process of multiplication and addition, as in English. Many West African numeration systems, on the other hand, used twenty as the basis for grouping, with five and ten as secondary bases.

Economic considerations generally governed the extent of counting. Ironically, profit-hungry European merchants were responsible for the expansion of some numeration systems. They flooded the market with cowrie shells, the most common type of currency in West Africa, causing severe depreciation of the currency and pushing up the prices of commodities, including the live "commodities" destined to work as slaves in the Americas and elsewhere. Osifekunde, a Yoruba (southwest Nigeria) sold into slavery in Brazil in the early nineteenth century, recalled that the average price of a slave at the time was two "bags," or 40,000 cowries. European traders were amazed by Africans' facility in counting hundreds of thousands of shells, their skill in carrying out mental calculations, and their ability to recall the numbers involved in transactions years after they had taken place [Zaslavsky, 1973/1979, pp. 74, 208-209, 224-226, 246].

Books and articles on the history of mathematics were of little value in my research. If they mentioned Africa at all, it was generally to recount the quaint practices of the people who were least advanced mathematically. I must mention two exceptions among pre-World War II publications. A footnote in D. E. Smith's *History of mathematics* [1923, p. 14] mentioned the work of the Austrian anthropologist Marianne Schmidl (misspelled "Schmidt"), "the standard authority on the number systems in Africa." In her 1915 articles she warned: "One must be extremely cautious about accepting the accounts of the inability of "primitive" people to count in higher denominations. ("Primitive" must be taken here, as elsewhere, with a grain of salt!)" This was the only instance I found in works from that period where the author placed quotation marks around the word "primitive." In response to my inquiry, I learned that she had been murdered during the German occupation, a victim of Hitler's policy of extermination of the Jews [Zaslavsky, 1973/1979, pp. 14-16, 307].

The other exception is an obscure book by O. F. Raum, *Arithmetic in Africa* [1938]. Dr. Raum taught in Tanganyika (now Tanzania) and at Fort Hare University, the only institution of higher learning open to Black South Africans at that time. He described the mathematical practices and games of various African peoples, and expressed a strong belief in their mathematical abilities. He stated that good teaching "lays down the importance of understanding the cultural background of the pupil and relating the teaching in school to it" [Raum, 1938, p. 5]. I was privileged to carry on a correspondence with Dr. Raum, then living in retirement in Germany.

If the colonial authorities had possessed a genuine interest in educating African students, they certainly would not have banned the universal African game in its many versions, called *oware, ayo, omweso, bao,* and dozens of other names [Zaslavsky, 1973/1979, pages 116-136]. Known also by the generic name *mancala,* it is considered by some game experts to be one of the best mathematical games in the world. European observers often commented on the speed and finesse exhibited by the players.

Nineteenth and early twentieth century works reflected the European attitude toward Africans as "primitive savages." In his 1896 publication *The number concept,* L. L. Conant, grandfather of a future president of Harvard University, dismissed the extensive West African numeration systems, including the complex Yoruba system, with these words:

> Nor on the other hand, is the development of a numeral system an infallible index of mental power, or of any real approach toward civilization. A continued use of the trading and bargaining faculties must and does result in a familiarity with numbers sufficient to enable savages to perform unexpected feats in reckoning. Among some of the West African tribes this has actually been found to be the case; and among

> the Yorubas of Abeokuta the extraordinary saying, "You may seem very clever, but you can't tell nine times nine," shows how surprisingly this faculty has been developed, considering the general level of savagery in which the tribe lived [quoted in Zaslavsky, 1973/1979, pp. 9-10].

The Yoruba numeration system is fascinating. Not only is it based on grouping by twenties, but it involves subtraction to a great degree. For example, the Yoruba expression for sixty-five means "five from ten from four twenties," or $(4 \times 20) - 5 - 10$. Yet the Yoruba people, including nonliterate market women, have been dealing with it for centuries. When I commented to a young Yoruba instructor at the University of Ibadan (Nigeria) that his number system was very interesting, he looked at me in surprise. I explained: "For example, the number words for forty-five mean "five from ten from three twenties."" He repeated the words in the Yoruba language, then remarked: "You know, you are right. I never thought about it!" However, a Yoruba graduate student informed me that in his region number words are formed by adding on to a lower number rather than by subtracting from a higher number.

A problem I had to resolve was the choice of a particular dialect of a language for inclusion in the book. For example, the references I consulted for the Igbo language listed five different local dialects. To resolve the problem, I asked an Igbo-speaking sociologist: "Which number words would be used in radio broadcasts?" Through the mass media, languages are becoming standardized.

If I had limited my research to merely copying number words in hundreds of African languages, I—and my readers—would have missed all these fascinating aspects of counting.

Not only was I learning number words in African languages, but I was discovering aspects of the English language of which I had been unaware. For example, American and European authors often use the word "dialect" in referring to an African language, as though Africans are incapable of developing genuine languages. An African ethnic group numbering millions is called a "tribe," a denigrating term that would not be applied to a much smaller European population. Africans live in "huts," not houses or dwellings. Once I became aware of these demeaning terms, I was shocked to find that their usage is still common even today.

Errors abounded in the writings of early twentieth century European writers. For example, one author stated that the Yoruba people had a five-day market week—four named days and an unnamed day of rest. More careful investigation would have revealed that the Yoruba count the days inclusively. When one speaks of a certain period of time, one includes both the first and the last unit in the interval. Markets are said to take place every five days, or once a week based on a four-day week. There is no unnamed day of rest! As I read these books and articles, I sometimes wondered whether local informants were "pulling the leg" of their interrogators as they related the practices of their people.

Finally the manuscript was ready for publication—several hundred pages, in addition to numerous photographs, drawings, maps, and diagrams. By this time the PWS Complementary Series of paperbacks had been scrapped, and *Africa counts* appeared virtually alone in a sea of college mathematics textbooks. The PWS production department went out of their way to produce virtually a "coffee table" book. Eventually the hardcover edition went out of print. At present only the paperback edition is available, and, I am happy to say, becoming more popular as time passes.

Multicultural mathematics in the curriculum

What a wealth of mathematical ideas and concepts I had discovered in the course of my research! I had never before realized the extent to which every society develops its own particular mathematics. So many factors are involved—heritage, environment, religious beliefs, technological advances, artistic inclinations, how people make their living—all have an effect on the development of their mathematics.

Some of these developments have found their way into the school curriculum. We speak of "Hindu-Arabic" (more properly "Indo-Arabic") numerals and "Roman" numerals, yet most students have no idea as to their origin. To them, mathematics springs full-blown out of a textbook or a teacher's head. Students are not given the opportunity to recognize the role of human beings of various cultures in the creation of mathematical ideas.

I decided to adapt several African mathematical practices to classroom use. Conditions were favourable; I had a sabbatical year off from teaching, my district welcomed innovation, and several middle grade and secondary level teachers were happy to let me experiment with their classes. Some of the outcomes are described in Zaslavsky [1991a].

Among the topics I chose for these curriculum units was an aspect of graph theory that intrigued me and everyone who encountered it. Dr Crowe had contributed the material for inclusion in *Africa counts*. According to the Belgian ethnologist Emil Torday [1925], Bushongo (Bushoong, Kuba, Bakuba) children drew such figures in the sand in imitation of their parents' fishing nets and embroidery patterns (Figure 1). The challenge was to draw these designs without removing the finger from the ground or going over a line segment more than once—a unicursal graph, in mathematical terms. Torday declared it an impossible task, yet these African children carried it out with ease. (See Ascher, 1991, pp. 33-37 for a discussion of the mathematical aspects.)

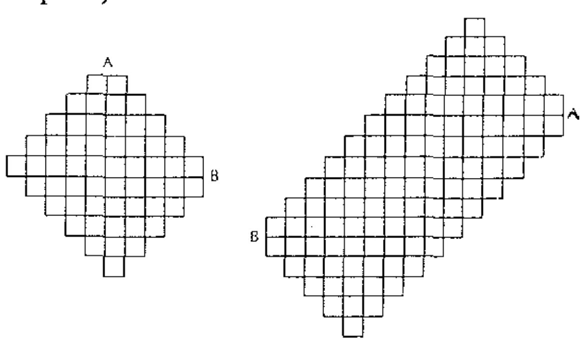

Figure 1

Not only were the American children exposed to a branch of mathematics that was entirely new to them, they also learned to respect the achievements of their African counterparts. Some sixth-grade (age eleven) children decorated their classroom walls with networks large enough to fill sheets of drawing paper. Older students tried to generalize about the types of graphs that were traceable with one sweep. The students were surprised to learn that this topic, which they regarded as fun rather than mathematics, was vital to their own lives in the form of networks of roads and television stations and the efficiency with which their garbage is collected. Adults, too, are fascinated by the topic, and I often start my workshops for teachers with this activity. The study of such graphs presents an excellent opportunity to incorporate several mathematical concepts—pattern, similarity, symmetry, and, as Gerdes [1988] illustrates, a geometric method to determine the greatest common divisor of two numbers. Both Marcia Ascher [1991, pp 31-65] and Paulus Gerdes have written extensively on graphs in several different cultures.

One of my curriculum units dealt with the question of the shape of a house. Many people build round houses, a shape that is simple to engineer and affords the largest floor space for a given quantity of materials for the walls. Students were challenged to find the largest area that could be enclosed by a given perimeter [Zaslavsky, 1991a]. Students might regard this type of dwelling as a "primitive hut." On the other hand, when they learn to view it as a structure that is best suited to the environment, available labor power and materials, and other conditions that influence styles in construction, they can appreciate how the builders arrived at solutions to the many problems they encountered.

I showed the students slides of many types of African homes, both round and rectangular, and told relevant stories. They were intrigued by the anecdote about the young Kenyan woman who had just acquired land on which she and her husband had built several rectangular structures to serve as kitchen, bedroom, and dining room. Her grandmother refused to visit her "house with corners," claiming that she would get lost in such a house. Having spent her life in a round house with a center pole, the grandmother could not adjust to a different shape. What a contrast to these young Americans, with their styles that seem to change every week! This glimpse into the beliefs of an older Kenyan woman gave them important insights on the lives of people in other societies.

I posed another question to these students. If, indeed, a round house is most economical of materials, why don't we build such homes? Children faced with this question become more attentive to the types of structures in their own environment. They consider the building materials (round planks?), the shape of the furniture (a rectangular bed against a curved wall?), replaceable parts, and other questions. Some teachers might want to discuss reasons for the lack of housing suffered by too many people in our society. Math education is more than the completion of a page of exercises in a workbook

The Ishango bone has captured the imagination of many people, particularly mathematics historians and African-Americans intent on reclaiming their African heritage. This incised bone, discovered in the 1950s on the shore of Lake Edward in Zaire, was described as a record of prime numbers and doubling (perhaps a forerunner of the ancient Egyptian system of multiplication by doubling). Alexander Marshack later concluded, on the basis of his microscopic examination of the bone, that it represented a six-month lunar calendar [Zaslavsky, 1973/1979, pp. 17-19]. The dating of the Ishango bone has recently been reevaluated, from about 8000 B.C.E to perhaps 20,000 B.C.E. or earlier [Marshack, 1991, page 32]. Thus far the oldest such incised bone, discovered in southern Africa and having twenty-nine incisions, goes back about 37,000 years [Bogoshi, Naidoo, and Webb, 1987]. The number twenty-nine also suggests a lunar calendar.

What needs to be done

Why is it important to introduce ethnomathematical perspectives into the mathematics curriculum?

Students should recognize that mathematical practices and ideas arose out of the real needs and interests of human beings. They should know that a great deal of the mathematics that they learn in elementary and secondary school originated in Asia and Africa centuries before Europeans were aware of more than the most elementary aspects of mathematics. Students of many different backgrounds can take pride in the achievements of their people, whereas the failure to include such contributions in the curriculum implies that they do not exist.

Students should learn how mathematics impacts on other subject areas—social studies, language arts, fine arts, science. Most important, they should have the opportunity to see the relevance of mathematics to their own lives and to their community, to research their own ethnomathematics.

There is now some interest in the United States in a multicultural, interdisciplinary approach to mathematics education. Textbook publishers are beginning to infuse the contributions of previously underrepresented ethnic/racial groups into the curriculum. At present these infusions take the form of optional supplementary materials or a few pages here and there in an otherwise unchanged textbook, often written by people with little knowledge of or sensitivity to the culture they are describing. Besides the fact that teachers may choose to ignore these additions, they generally have little impact on the lives of the students. Why, for instance, would third grade children want to learn Igbo number words? Comparing and contrasting other ways of counting with our Indo-Arabic system does have merit, as does the study of the Igbo base-twenty numeration system in the context of their culture, provided the publisher furnishes the requisite information and teachers are knowledgeable about guiding such a discussion.

Mathematics education should recognize students' out-of-school mathematical experiences, their own ethnomathematics, as exemplified by Robert Moses' Algebra Project. Moses, a leader in the civil rights struggle in the 1960s, has as his goal for all students to study algebra, the gateway to tomorrow's jobs. Starting in the sixth grade, the curriculum builds on life experiences to make the subject accessible to young people who might not be considered likely candidates for abstract mathematics. Imagine learning about positive and negative numbers by riding the transit system to the city center and back!! After the trip, children draw or make models of their experience, then write about it and discuss it with classmates in small groups, devise their own mathematical language to describe it, and eventually develop symbols to represent it. According to one rural Mississippi teacher, the idea is to acquaint children with numerical equivalents for distance, direction, time, and space in their own living, breathing environment As Moses says: "You immerse the child in a physical event he understands, and show that child how to take from that event the mathematics he needs" [Jetter, 1993; Moses *et al.*, 1989].

Beyond taking into account their out-of-school experience, mathematics should help students to pinpoint and take action on the societal factors that stand in the way of their living fulfilled lives [Zaslavsky, 1993b; Gross *et al*, 1993; Shan & Bailey, 1991] Why are some schools falling apart, while others enjoy all possible luxuries? Why is the jobless rate of young African-Americans several times as high as that of whites? How can we preserve the environment and save our planet from destruction—and who authorizes that destruction? In other words, mathematics should be empowering.

Besides the revised textbooks described above and supplementary materials put out by some major commercial textbook publishers, several recent publications for elementary and secondary classrooms include a multicultural and/or ethnomathematical perspective. Among them are Gilmer, Soniat-Thompson, & Zaslavsky (1992);Alcoze *et al.*, (1992); Gross *et al.*, (1993); Shan & Bailey (1991); Zaslavsky [1991(a,b), 1993(a,b,c,)] For an annotated bibliography of multicultural issues in mathematics, contact Dr Patricia Wilson, Mathematics Education Department, University of Georgia, 105 Aderhold Hall, Athens, GA 30602, USA; (404)542-4194. The International Study Group on Ethnomathematics publishes a semiannual newsletter; contact the president, Dr Gloria Gilmer, 9155 North 70th Street, Milwaukee, WI 53223; USA; (414)355-5191.

These beginnings are important, but not sufficient How can a genuine ethnomathematical perspective be incorporated into the curriculum? I believe that, as a minimum, the following factors must be considered:

- The entire mathematics curriculum must be restructured so that mathematical concepts and ethnomathematical aspects are synthesized. Rather than a curriculum emphasizing hundreds of isolated skills, mathematics education will embody real-life applications in the form of projects based on themes and mathematical concepts. Texts and other materials will reflect these perspectives
- Teachers at all levels must be well-grounded in mathematics and at the same time be familiar with the interface between mathematics and other subject areas. They will need the initiative and the time to work with other teachers, with parents and the community in planning lessons that are relevant specifically to their students Preservice and inservice education should incorporate these perspectives.
- The revised curriculum will require various methods of assessment—on-going assessment of projects, evaluation of portfolios, etc. Simplistic multiple-choice tests will be abolished or downplayed
- Research must be conducted and the results made available to teachers on the ways in which underserved and underrepresented students, particularly females and people of color, can best learn mathematics. Classroom management should reflect this knowledge. The practice of tracking (streaming) students by so-called "ability level" must be abandoned.

The incorporation of ethnomathematical perspectives calls for a complete turn-around from the way mathematics is now taught in many classrooms. Carrying out a change of such magnitude is a slow process. Let's get started!

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