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Rainforest Mathematics

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ABSTRACT This paper addresses the contested way that ethnomathematics has sometimes been received by mathematicians and others and what that disagreement might suggest about issues in mathematics education; namely, (a) the relation of ethnomathematics to academic mathematics; (b) recent efforts to reform secondary school mathematics so that it prepares students better for entering the workplace; and (c) claims that mathematics and mathematics education are coming to share increasingly less common ground.

Note: Based on a colloquium presentation at Teachers College on 13 October 2014. The presentation was dedicated to Ubiritan D'Ambrosio, who received the International Mathematics Education Achievement Award at the Columbus Day Symposium containing the colloquium. I am grateful to Bruce Vogeli and Henry Pollak for inviting and introducing my contribution and to Bowen Liu and Hyunjung (Julie) Kim for transcribing my remarks. The remaining flaws are my own.

KEYWORDS *ethnomathematics, academic mathematics, workplace ready, mathematical modeling, common ground, National Assessment of Educational Progress, Common Core State Standards for Mathematics, Ubiritan D'Ambrosio, Martin Gardner, Michael Fried, Morris Kline*

In 1995, Addison Wesley Longman published an algebra textbook, *Addison-Wesley Secondary Math: Focus on Algebra: An Integrated Approach*, that attempted to make algebra more appealing to young students by connecting it to creative thinking and problem solving. (See Charles, Thompson, Garland, Moresh, & Ross, 1998, for a later edition.) The book started by addressing students directly, stressing the importance of working together to solve problems. The first chapter dealt with data and probability, and not until the second chapter were the language and grammar of algebra considered. Throughout the text were vignettes by workers and business people testifying to their use of mathematics in their jobs. Multicultural contexts and social issues such as air pollution and water conservation were used to frame problematic situations to be handled mathematically. Over 800 pages in length, the textbook was replete with colorful drawings and photographs.

A business school professor at Arizona State, Marianne Jennings, whose daughter was using the textbook, became quite frustrated with what she saw as the book's lack of attention to the procedures of algebra as well as the book's efforts to connect mathematics to social themes. Jennings (1996) wrote to the *Christian Science Monitor* with her complaints—calling the course "rain-forest math." Her concerns were repeated and amplified the next year in an article in the *U.S. News & World Report* by John Leo (1997) in which he condemned the textbook as exemplifying the movement being called "the new-new math." Senator Robert Byrd (1997) from

West Virginia picked up the theme and in a speech on the Senate floor cited the textbook as an example of what he called "wacko algebra." He also had the article by Leo reprinted in the *Congressional Record* along with his remarks.

Ethnomathematics

Leo's (1997) article brings up the topics of multiculturalism and ethnomathematics as features of rainforest mathematics:

> The New-New Math has become a carrier for the aggressive multiculturalism spreading inexorably through the schools. Literature from the National Council of Teachers of Mathematics, which is promoting whole math, is filled with suggestions on how to push multiculturalism in arithmetic and math classes.
>
> New-New Math is also vaguely allied with an alleged new field of study called ethnomathematics. Most of us may think that math is an abstract and universal discipline that has little to do with ethnicity. But a lot of ethnomathematicians, who are busy holding conferences and writing books, say that all peoples have a natural culturebound mathematics. Western math, in this view, isn't universal but an expression of white male culture imposed on nonwhites. Much of this is the usual ranting about "Eurocentrism." Ethnomathematics [Powell & Frankenstein, 1997], a book of collected essays, starts by reminding us that "Geographically, Europe does not exist, since it is only a peninsula on the vast Eurasian continent. . . ." Before long, there is a reference to "the so-called Pythagorean theorem." (p. 14)

A few months later, after the state of Texas had approved the textbook for use in its schools, yet another tirade appeared that blasted the book:

> Although "Rainforest" has appealing artwork, tempting chili recipes, exhilarating poetry, piercing political insights on environmental issues and fascinating myths of baffling African astronomy fabricated by European anthropologists, this textbook contains little algebra. Not only is algebra scant, but the very first page of the text advises students that creative thinking and teamwork are more important skills than calculation and computation. No algebra expression can be found in the book until page 107. (Patterson, 1997, "Rainforest Algebra–National Controversy," para. 1)

Almost a year later in the *New York Review of Books,* Martin Gardner (1998) weighed in with a review of the Charles et al. (1998) textbook, together with reviews of a yearbook of the National Council of Teachers of Mathematics (Trentacosta & Kenney, 1997) and a Public Broadcasting Series of videotapes on mathematics (Glover, 1998). All three were seen by Gardner as evidence that mathematics was not being taught well in the precollege grades. Like Leo (1997), Gardner was disturbed by the attention being given to ethnomathematics, which he defined as "math as practiced by cultures other than Western, especially among primitive African tribes" (p. 9). Gardner went on to distinguish ethnomathematics from mathematics itself:

> Knowing how pre-industrial cultures, both ancient and modern, handled mathematical concepts may be of historical interest, but one must keep in mind that mathematics, like science, is a cumulative process that advances steadily by uncovering truths that are everywhere the same. Native tribes may symbolize numbers by using different base systems, but the numbers behind the symbols are identical. Two elephants plus two elephants makes four elephants in every African tribe, and the arithmetic of these cultures is a miniscule portion of the vast jungle of modern mathematics. A Chinese mathematician is no more concerned with ancient Chinese mathematics, remarkable though it was, than a Western physicist is concerned with the physics of Aristotle. (p. 9)

Gardner's critique has been echoed in subsequent exchanges among mathematicians and mathematics educators concerning implications of ethnomathematics for the school mathematics curriculum (e.g., Adam, Alangui, & Barton, 2003; Rowlands & Carson, 2002, 2004).

Ethnomathematics had been brought onto the international scene by Ubiritan D'Ambrosio's (1986) memorable opening plenary address in 1984 at the Fifth International Congress of Mathematics Education (ICME-5) in Adelaide, Australia. No one who heard that address will ever forget it. Ubi took the term *ethnomathematics,* which up to that time had been just floating around, and nailed it down for all of us with his clear exposition and colorful illustrations (see also Ascher, 1991; D'Ambrosio, 1997). I remember how people flocked around him after the address, eager to learn more about his ideas.

At the subsequent ICMEs, there have been lectures, sessions, and working groups on ethnomathematics. The community has also produced newsletters, study groups, journals, doctoral dissertations, and books. Five international conferences on ethnomathematics have been held to date: in Spain, Brazil, New Zealand, the United States, and Mozambique.

> Ethnomathematics [has become] an important part of school mathematics because teachers understand the value of taking into account the mathematical systems of the cultures from which students come or in which they are interested (Gerdes, 1996; Skovsmose, 2006). (Kilpatrick, 2008, p. 31)

The issue concerns the role ethnomathematics should play in school mathematics. On one side are those who see it as needing to replace what might be called *academic mathematics:* the formalized, abstract subject deriving largely from ancient Greece. On the other side are those who, while perhaps acknowledging the value of connecting mathematics to the learner's culture, object to redefining mathematics as a social-cultural system.

The conflict over ethnomathematics can help illuminate three contemporary issues in mathematics education; namely, (a) the relation of ethnomathematics to academic mathematics; (b) recent efforts to reform secondary school mathematics so that it prepares students better for entering the workplace; and (c) claims that mathematics and mathematics education are coming to share increasingly less common ground. In what follows, I discuss each of these in turn.

Academic Mathematics?

The advocates of ethnomathematics have sometimes taken strong stands against what they consider an oppressive discourse: mathematics as a racist, classist, misogynistic, colonial, and Eurocentric subject. Rather than characterize traditional mathematics that way, I prefer to call it *academic mathematics* and see it as culturally embedded, just as the mathematics of traditional cultures is. Rather than rejecting academic mathematics and replacing it by something else, I would argue that it is capable of being seen and taught in ways that integrate it with the learner's culture. In education practice, mathematics can and should be approached as

> an integration of the mathematical concepts and practices originating in the learners' culture with those of conventional, formal academic mathematics. The mathematical experiences from the learner's culture are used to understand how mathematical ideas are formulated and applied. This general mathematical knowledge is then used to introduce conventional mathematics in such a way that it is better understood, its power, beauty and utility are better appreciated, and its relationship to familiar practices and concepts made explicit. (Adam et al., 2003, p. 332)

At the same time that one grants "conventional, formal academic mathematics" a place in the curriculum, one needs to acknowledge that it represents "an unusual, stunning advance over the mathematical systems characteristic of any of our ancient traditional cultures" (Rowlands & Carson, 2004, p. 337).

> It is one thing to violently replace an existing culture with another; it is something altogether different to offer the learner many cultural systems and to identify frankly their relative merits. There is a way out of the antagonistic formulation that has characterized so much of the educational policy debate over the past half century, and that is to consider much more deeply the notion that an educated person is one who can claim mastery of multiple, incommensurable ways of knowing. This is the heart and soul of multicultural education, and, ironically, it was also the heart and soul of liberal education when that standard was better understood. (p. 338)

There is neutral, common ground between ultra- and anti-ethnomathematics that needs to be explored so that learners can take advantage of its potential contributions. Academic mathematics today leans heavily toward the pure, abstract, and formal. Without losing those qualities, it needs to be leavened with understandable, compelling applications from the learners' culture as a means of attracting those learners and keeping them from abandoning its study.

One encouraging sign is contained in the Common Core State Standards for Mathematics (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). Among the so-called standards for mathematical practice is "model with mathematics," which opens up the possibility of connecting the problems learners encounter in everyday life to the mathematics they are learning in school. Attention to learners' social and cultural background is the most promising contribution that ethnomathematics can make to mathematics education.

Workplace Ready?

"College and career ready" is the new mantra for assessment agencies such as PARCC (Partnership for Assessment of Readiness for College and Careers; http://www.parcconline.org/), Smarter Balanced (http://www.smarterbalanced.org/achievement-levels/), ACT (http://www.act.org/standard/), and the Educational Testing Service (https://www.ets.org/k12/common assessments/college_career/). That mantra seems to have arisen in response to questions about how well high schools are preparing students to enter college or career-training programs. In particular, people are apparently increasingly concerned as to what the mathematics requirements for high school graduation should be and, more generally, whether high school mathematics is adequately preparing students for adult roles.

In 2004, the National Assessment Governing Board (NAGB), which conducts the National Assessment of Educational Progress (NAEP), undertook a series of research studies to explore how well the NAEP might function as a tool to predict students' academic preparedness for entry into post-secondary education or job-training programs. From March to July 2011, the Board undertook a project to conduct a set of so-called judgmental standard-setting (JSS) studies for the 12th-Grade NAEP. The JSS studies constituted NAGB's first effort to set cut scores on NAEP to represent minimal academic preparedness for credit-bearing college courses or job-training programs. They addressed the question of whether students required the same academic knowledge, skills, and abilities to be minimally prepared for "college and career." The college course studied was the first entry-level, credit-bearing, post-secondary course that a student would take, and the five job-training programs studied were automotive master technician; licensed practical nurse (LPN); pharmacy technician; computer support specialist; and heating, ventilation, and air conditioning (HVAC) technician.

In the JSS studies, panels of instructors in each program attended a four-day workshop in which, after becoming familiar with the NAEP 12-grade framework and test items, they developed and refined descriptions of borderline preparedness in mathematics for entering their program, worked through a set of NAEP mathematics items to identify the knowledge and abilities being assessed, examined a sequence of NAEP mathematics items ordered by difficulty, placed a bookmark in the sequence at the location of the cut score, and by examining booklets showing student performance on the items and iterating the process, arrived at an agreed-on cut score on a pseudo-NAEP scale as well as an agreed-on borderline preparedness description (for details of the studies, see Kilpatrick, 2012; Measured Progress, 2012; WestEd, 2011).

The JSS studies revealed a difference between the perspectives of the college preparedness group and the five occupational groups in the type of mathematics they expected. The instructors of the introductory college mathematics courses found much more in the NAEP framework and test items that they expected students to know and be able to do than the instructors in any of the occupational groups did. The occupational groups were much more inclined to identify as expected those framework objectives and test items that dealt with applications of mathematics than the college preparedness group did. The Grade 8 objectives in the framework were much better suited to the mathematics needed for the occupations in the JSS studies than the Grade 12 objectives were.

From October 2012 to June 2014, NAGB undertook a follow-up College Course Content Analysis (CCCA) study, which used artifacts (syllabus, textbook, class assignment or assessment) from 60 courses at almost that many colleges to identify the prerequisite knowledge, skills, and abilities (KSAs) that were deemed necessary if students were to be prepared to qualify for entry-level, credit-bearing courses that satisfy general education requirements in mathematics. The sample of institutions was representative of the United States as a whole, and the course titles included precalculus/calculus, college algebra, finite mathematics, and statistics (for details of the study, see Educational Policy Improvement Center, 2014a, 2014b).

In the CCCA study, instructors of the relevant courses examined the artifacts and coded them for the KSAs they saw as being prerequisite. The reviews for each course were summarized into a content map, which was put into a narrative description by so-called experts who had worked on the NAEP framework. It turned out that most of the prerequisite KSAs were reflected in the NAEP framework, but they tended to be specific to a given course title and were not common across all courses. The prerequisite KSAs tended to be more focused on applied mathematics than the NAEP items were.

The JSS and CCCA studies revealed that Grade 12

NAEP, both in its framework objectives and test items, addresses the formal academic mathematics found in advanced high school mathematics courses that prepare students to major in mathematics or science in postsecondary institutions. Grade 12 NAEP, however, is not well suited to predicting whether students who are planning to take only the mathematics needed to satisfy general education requirements are prepared for entry-level courses. Any effort to use NAEP mathematics to predict whether twelfth graders are "college and career ready" would need to revise the framework and the item pool to address social and cultural aspects of school mathematics likely to be reflected in entry-level courses for college and career-training programs. In other words, the academic mathematics reflected in the Grade 12 NAEP needs to be modified to make it more imbued with ethnomathematics.

Common Ground?

In May 2012, a symposium was held at Ben Gurion University on the occasion of Ted Eisenberg's retirement from the mathematics department there. For years, Ted had been lamenting what he saw as the growing distance between mathematicians and mathematics educators. The symposium took the notion of what appeared to be a vanishing common ground between the two and elaborated on it. Papers from that symposium were gathered into a book entitled *Mathematics & Mathematics Education: Searching for Common Ground* (Fried & Dreyfus, 2014). Although the papers touched on a variety of themes, most addressed directly or indirectly the role that mathematics as a discipline plays in mathematics education and mathematics education research.

In his introduction to the book, Michael Fried (2014) made the following observation:

> Over the last century or so, and for better or for worse, this simple notion of where the core of mathematics education lies [namely, close to and aligned with mathematics as an academic discipline] has been offset by goals and interests allying it, as an academic field, more closely with psychology of learning, cultural differences, and social justice, among others, than with mathematics itself. (p. 3)

Like Martin Gardner, Fried makes it sound as though mathematics education has gone much too far in the direction of multiculturalism, equity, and ethnomathematics.

I see the issue differently. In my view, what appears to be movement away from mathematics by mathematics education "is something of an illusion caused by the enormous growth of the field of mathematics education" (Kilpatrick, 2014, p. 340).

> I think it is the wrong metaphor to say that the fields of mathematics and mathematics education have moved apart. The centers of gravity may be further apart than they used to be, but I do not think it is reasonable to conclude that the fields are more separated than in the past. (p. 340)

In my experience, once mathematicians and mathematics educators get acquainted and start working together on a common project, they discover that they have much common ground. An example occurred in 2004 and 2005, when Richard Schaar, a mathematician with Texas Instruments, brought together a small group of mathematicians and mathematics educators to engage in what turned out to be a productive conversation about the common ground they shared. The document they produced (Ball et al., 2005), after a day-long meeting in December 2004 and one in June 2005, contains three agreed-on premises and seven agreed-on statements about controversial issues in school mathematics. All the participants were surprised and pleased by the consensus they were able to achieve.

As another example, I chaired a committee of the National Academy of Sciences that produced a book called *Adding It Up* (Kilpatrick, Swafford, & Findell, 2001). That committee had 16 members: mathematicians, mathematics teacher educators, teachers, and people from business. When we started, none of us knew all the others. Some of us knew a few other members, but we did not know everyone. After 18 months of work, we were able to come up with a consensus document because no one was up front making pronouncements. Instead, we were sitting around the table engaged in a common task, which was to figure out what it is that children need to know about mathematics from kindergarten to Grade 8. Not everyone started out happy with everything the others proposed, but we were able to produce a document on which we all could agree.

A final example comes from a time, 1973, when I was on the Teachers College faculty. Morris Kline, a mathematician from New York University, was one of the most vocal critics of the new math. He and I were invited to be on a radio program here in New York City; it was a call-in show but we did not get many calls. So during the commercial breaks and the time when calls might have been coming in, I was able to talk to him. He had been my teacher one summer at Stanford University, so I knew him pretty well. He had just published a book, *Why Johnny Can't Add* (Kline, 1973) and was promoting it. I told him (off microphone) that I did not think the title fit the book very well, because it was about secondary and not elementary school mathematics. He agreed, telling me that his publisher had made him use that title but that he did not think it was very suitable. Although Morris and I disagreed sharply about the new math movement, we were able to find some common ground.

Final Comment

In the 21st century, school mathematics ought to connect the formal, abstract, generalized mathematics of the academy to the social and cultural backgrounds of the learners. Our ancestors developed the mathematics of Plato and Euclid, and they developed the mathematics of the rainforest. Both traditions support the multi-faceted structure that underlies and drives modern society. Mathematics is both a finished product and a work in progress. It has a polished deductive aspect and simultaneously a human face. School mathematics needs to honor that complexity.

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