

Ethnomathematics: An African American Perspective On Developing Women In Mathematics

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Abstract

This paper was written for the NCTM publication - Changing the Faces of Mathematics: Perspective on Gender. Hence, the paper is at the intersection of research and practice. The paper also speaks directly to issues of equality, inclusivity and accountability. The author borrows from gender, ethnomathematics and social context research to guide practice in mathematics teaching and learning. Specifically, the paper focuses on three principles of feminist pedagogy useful for developing mathematical power in all students but especially women students. In addition, the paper presents strategies found to be effective for discerning mathematical ideas in ones own surroundings. Many strategies presented stem from research methodologies of ethnomathematicians. These methods expand and extend ones vision of what mathematics is , who creates it and in what kind of environment mathematical thinking flourishes for women in general and African American women in particular.

Introduction

Mathematics is an important human endeavour and has many educational values aside from its technological importance. First, it offers a vast number of structures such as numbers, algorithms, shapes, ratios, functions and data that are useful in understanding physical realities. Second, mathematics is a human activity built upon intuitive understandings and agreed conventions that are not eternally fixed and that its frontier is covered by many unanswered questions. Third, mathematics encourages settling arguments by evidence and proof. Finally, mathematics demonstrates how important it is to subject a familiar thing to detailed study and to study something that seems hopelessly intricate (Buck 1965). Owing to the importance of mathematics, every society has an instinctive kind of mathematical knowledge - that is ways of counting, measuring, relating, classifying and inferring. Unfortunately, much of this knowledge has been ignored in the formal school mathematics curriculum. To a large extent educators do, in fact, determine who studies school mathematics and, by extension, who will have careers in mathematics and what the legitimate products of mathematics will be. Therefore, groups about whom educators are uninformed are bound to receive inequitable treatment in the classroom. While professional inequities also exist in deciding who will be recognised - credentialed, published, awarded foundation grants and other honours - perhaps the greatest injustice is in encouraging dependency by doing for others what they can do better for themselves. In this way, considerable

resources have been consumed by many for personal gain without making any appreciable positive impact on the conditions of those for whom they speak. The persistence of these inequities often lie in the politics of gender and race.

Against this background, in 1989 I suggested using skits at joint mathematics meetings to dramatise gender inequities - those subtle (and not so subtle) messages about who can do mathematics (Kenshaft and Keith 1991). I also suggested including race inequities. I regarded these skits as first steps in confronting inequities between men and women within the mathematical community at the professional level. For many years these skits were used to raise the awareness level of significant numbers of educators to the nature of gender inequities in the field, yet today these inequities persist within and across race and gender. This suggests that our efforts must be intensified and documented. Therefore, this paper presents strategies for providing educational experiences for all students in mathematics - especially African American females- oriented to developing mathematical power. The paper draws upon three principles of feminist pedagogy:

- (1) *Using students own experiences to build knowledge;*
- (2) *co-operative learning in the mathematics classroom;*
- (3) *developing a community of learners*

(Jacobs and Becker 1997).

Mathematically powerful students think and communicate by drawing upon mathematical ideas and using mathematical tools and techniques from their own experiences. If African American students were exposed to the kinds of experiences outlined in the NCTM Standards, then they would gain mathematical power and value mathematics as well. These experiences include a study of (1) cultural influences on the role of mathematics in our contemporary society; (2) common human activities from which mathematics derives and in which students' communities are engaged; (3) simple but powerful strategies useful in solving non routine problems; (4) mathematical methods of communicating; and, (5) methods of exploring, conjecturing and building logical arguments to support ones beliefs. All of these ideas are embedded in the five general educational goals for all students found in the K-12 NCTM Standards (NCTM 1989) . Valuing mathematics as important for success in life and perceiving that one can be successful at mathematics are important components of self confidence and vital to developing mathematical power.

Mathematics And Ethnomathematics

In its 1994-95 Policy Statement, the American Mathematical Society described mathematics as "the study of measurement, forms, patterns, and change which evolved from efforts to describe and understand the natural world" (AMS 1994).

This concept lead to the notion that mathematics is culturally neutral and subsequently to a school mathematics curriculum devoid of contexts. So while mathematics educators acknowledged the universality of truth of mathematical ideas - such as the sum of the angles of a triangle in a plane is 180 degrees - this knowledge was divorced from the cultural bases that gave

rise to it. For many reasons, such a curriculum has had devastating effects on the representation of African Americans and others in mathematical studies and careers.

Today, mathematics reaches beyond the physical sciences and engineering into medicine, business, the life sciences and the social sciences" (AMS 1994) and mathematics education is regarded as more than a collection of abstract concepts and skills to be mastered. Philosophical arguments over the nature of mathematics are focusing on what it is that mathematicians actually do (Barton 1985). This new philosophical era brings the mathematical community itself into mathematics in such a way that it is impossible to separate mathematics from this community: its language, preconceptions, values and experience. Thus we are witnessing an end to an era in which mathematics was regarded as culturally neutral and entering an era in which mathematics is acknowledged to be a cultural product. This latter view is strongly supported by ethnomathematicians and has led to the rise of the discipline of ethnomathematics.

Ethnomathematics is a very new area of study. The concept was popularised by Professor Ubiratan D'Ambrosio of Brazil in his keynote address on the relationship between culture and mathematics at ICME 5 in 1984 in Adelaide, Australia. To understand ethnomathematics start with a group bound together by how they use certain mathematical ideas, such as artist, bankers, architects, sports figures, musicians, and seamstresses. Next, examine their language, preconceptions, values and experience with mathematical ideas - some of which may not be identified as mathematical. Their interaction with these ideas - which may result in certain products within which these ideas are hidden - is what we call their ethnomathematics.

Researchers in ethnomathematics tend to examine how people learn and use mathematics in distinct cultures and in everyday situations within cultures" (Masingila and King 1997). In this context, we may think of culture as acquired knowledge transmitted among groups. It is shared meaning but not necessarily consensus. It includes taken-for-granted values and beliefs seen in what people do, what they know, and the tools they use Malloy 1997). From this concept of culture, race is not a proxy for culture and "ethno" in ethnomathematics is not a proxy for ethnic.

Since ethnomathematics is oriented to the masses and the multitude of ways in which mathematical ideas are used on a regular basis in the community, the concept expands our understanding of what mathematics is and of who creates it. In ethnomathematics the focus is on the concepts and techniques actually used by a cultural group rather than the possible mathematical theories available (Barton 1985). The concepts and techniques are usually learned without formal schooling but are actively transmitted from one generation to another. Through this cultural interaction, there develops an instinctive kind of common mathematical knowledge among adults and children who belong to the same cultural group (Gilmer 1985). Later in this paper, this phenomenon is illustrated in the ethnomathematics of hair braiders.

An ethnomathematics curriculum would develop from activities in the learners' surroundings and move seamlessly into the school as the process of inducting young people into mathematical aspects of their culture. A mathematics curriculum oriented to the ethnomathematics of the learners' culture would respond to the needs of increasing numbers of students who feel like failures for not understanding something few of them will ever use but without which there is the perception of a bleak future for them.

Developing A Community of Learners

If we acknowledge that mathematics is not culture free, then mathematics educators might be transmitting the values of a single culture while teaching children of many cultures in the same classroom. What are the consequences of mathematics learning for children whose cultural experiences are being ignored? The consequences might be mass disaffection with the subject owing to cultural conflicts or school failure, since students develop different models for understanding mathematics based upon their cultural backgrounds and experiences. An example of the importance of cultural considerations in teaching was cited by Malloy (1997) in relating a test item whose solution was judged incorrect because the test designers and students made different assumptions. The problem was:

It costs \$1.50 each way to ride the bus between home and work. A weekly bus pass is \$16. Which is the better deal, paying the daily fare or buying the weekly pass?

On the one hand, test designers assumed that only one person would use the bus pass, the pass would not be used on weekends, and that the person had only one job. On the other hand, many African American students assumed three or four people may use the same pass at different times of the day or on weekends; or, that if one person used the pass he or she could have two jobs. Since situational mathematics is almost always culturally based, in multicultural settings care must be taken to include cultural assumptions in the statement of the problem.

Strategies for Inclusion

Listen to the Students

Indeed, our classroom cultures are our most accessible and relevant information sources for curriculum development. Effective classrooms for African Americans encourage: high levels of peer interaction, group decision making, expressiveness through appropriate wait time, physical closeness, acknowledgement, feedback, probing, and listening" (Malloy 1997). Teachers should involve themselves in the experiences of their students by exploring the students' community and extending community activities into the classroom practice. Alan Bishop contends that children are creating their own culture and not just managing the culture of their ancestors. Hence, mathematics education should be oriented more to the present and future rather than the past. We must allow students to teach us about the culture that they are creating just as we teach them about foundations upon which their culture is being built.

A proponent of this view is David Henderson. For twenty years, Henderson has taught junior and senior level geometry courses for mathematics majors

and future teachers at Cornell University. In his paper, *I Learn Mathematics from My Students*, he gives examples of new theorems and proofs - shown to him by his students - none of which had appeared in print (Henderson 1996). His teaching style was similar to that of R.H.Bing at the University of Wisconsin, under whom the author also studied. Bing taught without lectures or textbooks. Bing listened to his students and encouraged us to express our understandings and reasonings in our own words. Using this same approach, Henderson eventually discovered that he was learning from his students. The following situation confirms this view.

Consider the Vertical Angle Theorem: If l and l' are straight lines then the angle a is congruent to the angle b .

Insert Figure 1 here

In most textbooks, the proof is as follows:

If $m(a)$ denotes the measure of angle a , then $m(a) + m(c) = 180$ degrees = $m(c) + m(b)$.

Subtracting, $m(c)$ from both sides, we conclude that $m(a) = m(b)$ and thus that a is congruent to b .

Henderson recalled that several years ago, a student in his geometry course objected to this proof because to her an angle is a geometric object that is congruent to another angle if it is possible to rigidly move one angle until it coincides with the other. She offered the following proof:

Let h be a half-turn rotation about the point of intersection p . Since the straight lines have half-turn symmetry about p , $h(a) = b$. Thus a is congruent to b .

Henderson's first reaction was that her argument could not possibly be a proof. It was too simple and seemed to leave out important parts of the standard proof. The student persisted patiently for several days and his understandings deepened. Now, he acknowledges, her proof is more convincing to him than the standard proof.

Henderson drew the following conclusions on mathematics learning:

1. In order for him to be satisfied by a proof, the proof must answer his why-questions and relate his meanings to the concepts involved;
2. A proof that satisfies someone else may not satisfy him because their meanings and why-questions were different from his;
3. persons who differ the most from me (for example in terms of cultural background and gender) are most likely to have different meanings and thus have different why-questions and different proofs.

A corollary of (3) - I can learn much mathematics by listening to persons whose cultural backgrounds or gender is different than mine. In fact, Henderson defines multiculturalism as listening to and learning from others who come from different experiences. He says hearing someone else's proof may be difficult and may require considerable effort and patience on my part. He noted that Blacks showed him more new mathematics than any other group.

Henderson concluded that perhaps women and persons of colour are underrepresented in mathematics because they are not well listened to by those of us already in mathematics. **Promote Exploration** To incorporate

students interests into the mathematics curriculum, one might first have students explore activities observed in their own surroundings.

Both Bishop and Gerdes suggests where one might look in the learner's environment for clues to mathematical behaviour - the products they design, how they count, measure, locate, play and explain (Bishop 1988; Gilmer 1990; Gerdes 1997).

- **Counting** - This activity relates to what, how, and why people count and includes a variety of counting systems developed by indigenous groups.
- **Locating** - This activity relates to finding one's way around, travelling without getting lost and relating objects to each other. All societies have developed different ways to code and symbolise their spatial environment - witness the USA's highway system. Resulting conceptualisations and explanations, however, may differ from culture to culture.
- **Measuring** - This activity is concerned with comparing, ordering and valuing. Precision and systems of measuring units develop in relation to what the society values. An example is how housing costs are determined.
- **Designing** - This activity concerns all objects and artefacts which cultures create for various purposes from homelife and adornment to warfare. The designed objects often serve as models for the construction of other objects and are sources of Important mathematical ideas such as shape, size, scale, ratio, proportion and many other geometrical concepts.
- **Playing** - All cultures play. This activity connects to mathematics when it is formalised into the notion of games. The development of games involve behaviours which are rule governed in a manner similar to the rule-governed criteria of mathematics. An example is the estimation of angles and distances in basketball or the logic of moves in the game of chess.
- **Explaining**. This activity exposes connections between apparently diverse phenomena allowing for a kind of unity from which mathematical proof is derived.

By exploring how different "ethno groups" in their community conceptualise, code and symbolise mathematical ideas found in these universally significant activities, the curriculum becomes relevant to classroom learners in a very natural way and is simultaneously multiculturalised (Gilmer 1990).

Explain what to look for

As previously stated, mathematical power involves the ability to discern and investigate mathematical relationships observed in patterns and structures in ones own surroundings - using a variety of mathematical methods.

Encourage students to search first for patterns in the activity studied and next for mathematical relations embedded in these patterns. This is best done by exploring special cases in a systematic way. From this investigation, patterns may emerge that will suggest ideas for proceeding with the problem (Larson 1983).

An example of this approach is the author's study of hairstyles in African American communities (Gilmer and Porter 1998). The idea was to determine what the hair braiding and hair-weaving enterprise can contribute to mathematics teaching and learning and what mathematics can contribute to the enterprise.

This study led the author to hair salons in African American communities where hairstylists were observed at work. Hairstylists were interviewed along with their customers. One case revealed rectangular tessellations of the scalp using a pattern which started at the nape of the neck and increased by one rectangle at each successive row leading away from the neck. The pattern is illustrated in Figure 2a.

INSERT FIGURES 2A, 2B, AND 2C HERE

In Figure 2b, the dots are places where braids emanated - roughly at the point of intersection of the diagonals of the rectangles. When asked why this pattern was used, the hairstylist said this is a space filling pattern used to hide the side of the rectangle at the previous level where the hair was parted on the scalp. See Figure 2c. Upon examining this space filling pattern, I realised that the number of braids might be a more equitable pricing unit for hair braiding than a flat rate as hair braiding is labor intensive. The hairstylists interviewed in the study, however, had no idea of the number of braids completed. This could easily be determined mathematically using the simple formula:

$$S = 2+3+4+\dots+n = [(n+2)(n-1)]/2$$

where S is the number of braids and n is one more than the number of rows.

Hence for the four rows above, the total number of braids is

$$(5+2)(5-1)/2 = 28/2 = 14 .$$

When using microbraids in hairstyles, where upwards of 700 braids may be involved, a formula for unit pricing by braids might be especially useful in pricing such styles.

In another case, the customer's scalp was tessellated using triangles. Hair strands within the triangle were brought to the centre of the circle inscribed in the triangle. At that position, braiding commenced (See figure 3a). Braids so formed were said to be less likely to swing with head movements than braids formed by bringing hair strands in the triangle to a vertex of the triangle that points forward (See figure 3b).

INSERT FIGURE 3A AND 3B HERE

The topic of hairstyles in mathematics is natural when we consider what cultural groups design. Many styles involve interesting geometrical designs on the scalp like spirals and circles (Sagay 1983). Many such styles are cross-gender and cross-cultural. In addition, this topic provides insight into some cultural values that form the basis of hair braiding and hair weaving traditions in African American communities. For generations, African Americans were told that "nappy" hair was bad and were made to feel that the only way to attain "good" hair was to straighten it. Strong chemicals and heat treatments used to straighten the hair often resulted in damaged, unhealthy hair that would not grow. Customers we interviewed felt good about having a beautiful hairstyle without altering the natural texture of

their hair. Beyond beauty, the hair braiding enterprise is an important source of income for African Americans. At the age of eleven, one stylist said she was the neighbourhood braider and could always earn money. Concepts of time use, price setting, costs of supplies and equipment are all important sources of mathematical problems for the classroom derived from this topic (Gilmer and Porter 1998).

Teach from the Students' Vantage Point

A study of learning styles of Canadian women in the trades and technologies might inform the teaching and learning of African American females in similar fields and in mathematics as well (Gilmer 1989). Women reported that they learn best if presented with an overview of the material during which they can:

- (1) relate it to themselves
- (2) see a demonstration, and
- (3) shift back and forth between application and discussion.

They observed that their learning takes the following sequence:

- (1) Understand the value of what I need to learn;
- (2) Hear what I need to learn;
- (3) See what I need to learn;
- (4) Talk about what I need to learn;
- (5) Do what I need to learn.

Relational learners were one of three types of learners in the study. In fact, 93% of the students assessed were relational learners. Feelings set the condition for learning in this group and play a role in how fast students learn. At first these students may work to satisfy the instructor. Later, they work to satisfy personal goals. Their learning is prompted by linking new material to things already known. This allows them to draw upon discreet or intuitive knowledge. They rely upon verbalisation to convey ideas and are best served if they move into application or hands-on work after some but not all information has been presented. Application makes the learning concrete for relational learners.

Learners in this study were classified on the basis of three faculties - mental, relational or emotional, and physical. Mentally-centred learners were said to focus on the ideas and rely upon articulation skills to convey what is learned. For them, instruction need not be relevant to their daily experience. Mentally centred instructors are said to rely on verbal skills, lecture, and analysis in teaching. At Fanshawe College, the site of the Canadian study, there were no mentally-centred learners among the students and instructors assessed. Yet, the study notes that mentally-centred instructional forms have been adopted widely by teachers, most of whom are not mentally-centred learners. This could have serious implications for the quality of teaching. Seven percent of the students assessed were physical learners. Members of this group prefer brief, orderly, concise presentations of material or directions. They apply their learning methodically. They learn by doing and by being given enough time to stick to a task until it is completed. They learn through repetition and work well on details. A sense of belonging within the group is important to these learners. Such learners may be good

at mathematics and science. The majority of Japanese and Chinese learners are said to be physically centred.

These three types of learners differ mainly in their initial processing of information. One group processes with mental energy, another with interactive energy, and the other through the energy of body and action. The study concludes that relationally and physically centred learners in non-traditional programs could be well served by employing interactive instructional styles and hands-on applications early in the learning process, with movement back and forth among theory, discussion and application. This learning process might also serve African American females well in their study of mathematics!

Challenges To Inclusive Communities

People who receive status from their kids performing well in school do not like the idea that other kids' performance might be raised to the level of their own kids (Kohn 1998). They are not concerned that all children learn but that their children learn. They see school not as a place for learning but as a place for accumulating credentials. Often these are predominately white, middle-class parents of high achieving students. These parents might be some of the community's most outspoken and influential members. They have learned how to work within the law and how to use the law skilfully. They are typically involved in three types of controversies: (1) the type of instruction, (2) student placements, and (3) the awards systems. Instead of instruction leading to active discovery and problem solving by a community of learners as outlined in the NCTM standards, these parents favour a return to a skill and drill mathematics curriculum and an individualistic competitive credentialing model of school which may boost their kids' SAT scores thereby enhancing their acceptance into the most elite colleges. With their substantial political power, they fight efforts to create more heterogeneous and inclusive classrooms - preferring instead ability grouping, gifted and talented programs, honours courses and a tracking system that keeps virtually every child of colour out of advanced classes. In San Diego, California they vigorously opposed a program to provide underachieving students with support that will help them succeed in higher level courses. Finally, they favour practices that distinguish one student from another such as letter grades, weighted grades, honour rolls and class ranks so that only a few will be recognised at awards ceremonies. In Buffalo, New York, for example, parents of honour students squashed an attempt to replace letter grades with standards-based progress reports. Arguably, their agenda has little to do with meeting children's needs. What remains unrecognised by some privileged parents is that it is enrichments such as hands-on learning, student-designed projects, computers, and field trips and not selective placements that produce better results for their children.

In commenting upon the belief that the elite twenty percent do not care about the remaining 80 percent, as long as life is good for them and their children, Thacher (1997) noted that in the East, Asian countries focus less on skills in early elementary education than on social collaboration. Teaching in Japan and China puts primary emphasis on the importance of young children's learning to work together across social gaps. These schools for the

most part avoid tracking in the early years. The heavy emphasis on skills and academic results is delayed to the more advanced stages of education. In his own school, Chinese missionaries in the 1930's brought a balanced emphasis on hard work and socialisation. They held a deep conviction that childhood is an end in itself. Thacher claims that in the face of a materialistic culture, they managed to put these values of simplicity and friendliness in the school's mission statement, - "as radical as they must have sounded to affluent suburban parents." In addition, they have been able to cling to these values ever since". Such values are needed today to reverse numerous obstacles to developing a community of learners.

Conclusions

The educational philosophy of Clarence Stephens - one of my undergraduate mentors at Historically Black Morgan State University in Baltimore, Maryland - had a profound impact on my own career. He challenged his students to learn how to learn for he believed we may encounter some teachers who could not teach us. He cautioned teachers in the mathematics department to suspend disbelief with respect to students whose past records have been undistinguished and to inspire all students to achieve at a higher level. He claimed that the secret to getting students to succeed is to keep up morale. Finally he felt that in an effective learning community there must be total support for students and teachers alike.

To elaborate on Stephens' concept of an effective learning community, I believe the school community must develop a strategy to encourage, challenge, and train its members to know each other. In particular, the school community must have a plan to assure equitable support for marginalised students. Parents typically lacking in wealth, self-confidence, or political savvy must be provided with knowledge and skills which will make them more effective advocates for themselves and their children.

Empowering students involves considering their beliefs about themselves and their learning environment and their active participation in co-creating their learning environment. The instructional approaches of both Stephens and Henderson empower students. Specifically, these approaches allow everyone an opportunity to understand and respect another's knowledge and ways of knowing.

In this way students develop self- confidence in mathematics. Two important components of self-confidence are: (1) valuing mathematics as being important for success in life; and, (2) perceiving that one has the ability to be successful at mathematics (Fleener, *et.al.*). The mathematical power needed to develop self-confidence includes the ability to discern and investigate mathematical relationships observed in patterns and structures in ones own surroundings - using a variety of mathematical methods. In this way mathematics may be viewed as the process of inducting young people into mathematical aspects of their culture.

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