THE POTENTIALS OF EMBODIED AND ETHNOMATHEMATICAL PERSPECTIVES FOR CARIBBEAN MATHEMATICS EDUCATION

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In this paper, I explore the potential value of adopting embodied and ethnomathematical perspectives in the specific context of mathematical education in Trinidad and Tobago. I suggest that ideas representing overlaps among the domains of embodied cognition and ethnomathematics are manifested in the reform-oriented mathematics curriculum documents of the Trinidad and Tobago Secondary Education Modernization Programme (SEMP), and provide a simple example of one area where such an investigation might potentially begin.

Introduction

Something interesting is happening in mathematics education and the now-adolescent discipline of mathematics education research. My primary aim in this paper is to identify and explore two of these domains of inquiry that are contributing to creating an Archimedean lever, resting on the fulcrum that is mathematics (education), which have the potential to move the world of mathematics curriculum here in the Caribbean. My secondary aim is to describe what this might mean for a small twin-island Republic of less than 1.5 million inhabitants at the southernmost end of the Caribbean archipelago.

The first people of Trinidad and Tobago were the Amerindians, and the country was subsequently colonized by the Spanish and the British. In addition, other Europeans such as the French settlers arrived. Africans were brought as slaves and, later, East Indians as indentured labourers to serve on agricultural estates. Other groups such as Chinese and Syrians arrived over the course of our history as well. The mathematics curriculum of Trinidad and Tobago, like other states in the Caribbean, has until fairly recently continued to be dominated by a "Eurocentric" view of mathematics. This is exemplified in terminal examinations that model the English school-leaving examinations, for which they are a

replacement; mathematics textbooks that give little insight into the socio-historical development of mathematics and which offer no connections to the various histories that students bring with them to school; and pedagogy that is aimed primarily at helping students to pass examinations. In this situation, mathematics education divorces mathematics from its socio-historical roots, resulting in a homogenously unpalatable discipline. Such is the enduring legacy of colonialism. In this situation, Trinidad, like other small countries in an increasingly smaller world, is concerned about the mathematical competence of its population, given high failure rates in these terminal examinations and a pervasive attitude among the population that while mathematics is important it cannot be done by most people (Trinidad and Tobago. Ministry of Education. Secondary Education Modernization Programme [SEMP], 2002). Perspectives such as ethnomathematics and embodied mathematics offer a means of beginning to redress some of these issues.

In the sections below I describe these two perspectives in detail.

Embodied Mathematics

> For Mercy has a human heart,
> Pity a human face,
> And Love, the human form divine,
> And Peace, the human dress.
> "The Divine Image," William Blake, 1789.

According to Wilson (2002), the theoretical starting point of embodied perspectives is "not a mind working on abstract problems, but a body that requires a mind to make it function" (p. 625). Embodied perspectives seek to determine the extent to which sensorimotor processing is implicated in cognition and holds the view that human cognition is body-based. Anderson (2003) argues that it is specifically this concern for the physical grounding of cognition in a body that distinguishes embodied cognition from related situated perspectives.

Lakoff and Nunez (2000) describe what they consider to be a general romance of (Western) mathematics:

- Mathematics is abstract and disembodied – yet it is real.
- Mathematics has an objective existence…

- Human mathematics is just a part of abstract, transcendent mathematics.
- …mathematical proof allows us to discover transcendent truths of the universe.
- Mathematics is part of the physical universe and provides rational structure to it.
- Mathematics even characterizes logic, and hence structures reason itself…
- To learn mathematics is therefore to learn the language of nature…
- Because mathematics is disembodied and reason is a form of mathematical logic, reason itself is disembodied. (p. xv)

This particular view of mathematics gives rise to conceptions of mathematics that privilege symbolic forms of reasoning over other types of reasoning. Such a view fits with the cognitive representationist view of cognition in which thinking is essentially the manipulation of internal "representations" of an external objective reality. Such a view does not require that mathematics have a human heart, human face, or human dress; indeed, from this view, mathematics becomes potentially disembodied. Such a view emerges from a Cartesian dualism between mind and body. Embodied Cognition, and specifically Embodied Mathematics, is a response to this cognitivist paradigm (Anderson, 2003) and rejects the basic Cartesian dualism in favour of viewing mind and body as co-implicated systems.

Six of the most prominent claims about embodied cognition are examined by Wilson (2002). For example, she examines the claim that "We off load cognitive work onto the environment" (Claim 3). The argument put forward here is that we reduce cognitive workload by strategically leaving information in the environment rather than fully encoding it, and can alter the environment in order to reduce cognitive work further. She considers the following example that:

> counting on one's fingers, drawing Venn diagrams, and doing math with pencil and paper…are both situated and spatial … The advantage is that by doing actual, physical manipulation, rather than computing a solution in our heads, we save cognitive work. (p. 629)

She goes on to state that when such activities become decoupled from their embodied situations they can be "used to represent abstract, non-spatial domains of thought" (p. 629).

Another claim that is analysed is that "Cognition is for action," which considers the adaptive role of cognition. She gives the example of memory, citing Glenberg (1997, p. 1) who "argues that the traditional approach to memory as 'for memorizing' needs to be replaced by a view of memory as 'the encoding of patterns of possible physical interaction with a three-dimensional world'" (Wilson, 2002, p. 631). This makes sense, she argues, since we "conceptualize objects and situations in terms of their functional relevance to us, rather than neutrally, or as they really are" (p. 631). Such a strategy provides problem-solving flexibility, which is an adaptive behavior.

The final claim that is evaluated is that "Off-line cognition is body based." Here she considers the proposition that cognitive structures that evolved for perceptual or motor tasks can appear to be "co-opted and run off-line, decoupled from the physical inputs and outputs that were their original purpose, to assist in thinking and knowing" (Wilson, 2002, p. 633). She gives examples from research on mental imagery, working memory, episodic memory, implicit memory, and reasoning and problem solving. She finds strong evidence for this particular claim from the domains listed previously and concludes that "it appears that off-line embodied cognition is a widespread phenomenon in the human mind…[that may reflect] a very general underlying principle of cognition" (p. 635).

Lakoff and Nunez (2000), working from the embodied perspective, bring the body back into mathematics. Their essential claim is that "mathematics as we know it is limited and structured by the human brain and human mental capacities. The only mathematics we know or can know is a brain-and-mind based mathematics" (p. 1). The mechanism by which they seek to explain the origins of complex, abstract mathematical ideas in sensorimotor activity is the cognitive linguistic device of conceptual metaphor. According to the authors, conceptual metaphor is a fundamental:

> cognitive mechanism for allowing us to reason about one kind of thing as if it were another.…It is a grounded, inference-

> preserving cross-domain mapping – a neural mechanism that allows us to use the inferential structure of one conceptual domain to reason about another. (p. 6)

They provide plausible mechanisms by which concepts in mathematics could be developed based on metaphorical relations. However, their approach is criticized by Schiralli and Sinclair (2003) who state that, "by focusing almost exclusively on metaphor, *Where Mathematics Comes From* undermines, or at least fails to explain, the acts of understanding needed to move towards conceptual mathematics" (p. 88). The important contribution, though, of Lakoff and Nunez's work, I think, is the explicit attention and focus it brings to the question of the role of the human body and evolutionary mechanisms in the process of mathematicizing. I agree with their statement that "mathematical ideas…are often grounded in everyday experience. Many mathematical ideas are ways of mathematicizing ordinary ideas" (p. 26) and that such ideas in many instances are rooted in sensory experiences.

Drodge and Reid (2000) also use embodied cognition to frame their argument for a mathematical emotional orientation. Their view draws attention not so much to cognitive action but to the ways in which cognition and emotioning (which is body-based) are intertwined. According to Picard et al. (2004), investigations of the way in which the body and cognition interact is a growing area of research. For example, they claim that through using the Logo Turtle:

> children learn important geometric ideas in a more 'body syntonic' way, imagining themselves as the turtle as it draws out geometric patterns, and thus leveraging their intuitions and experiences of their own bodies into more formal knowledge and into a more personal relationship with mathematics. (p. 262)

They refer to other projects at the MIT Media Lab, which "have contributed to expanding the range of ways in which the body can be morphed into mathematics [including] knot-tying, piano playing, jiggling, skiing, and dance…in which the body in motion can support intuitive, emotionally deeply interconnected conceptual realms" (p. 262). Such research demonstrates, at a very practical level, the importance of the body in doing and learning mathematics.

But what else does drawing attention to the body in mathematics offer to Caribbean educators? A recognition of the important role of the body in mathematical cognition serves to re-establish a sensuality of mathematics that "cold" cognitive approaches eschew. Another benefit is the potential awareness that comes from asking the question of whose body is actually represented or not represented in mathematical discourse, and how such presence or absence is felt and experienced by real bodies, a perspective that resonates with postmodern critiques of mathematics education (Walshaw, 2004) and issues of social justice in mathematics education (Burton, 2003). This perspective also draws attention to the fact that much of human activity which might not be seen as formal academic mathematics probably involves implicit mathematical ideas, for example, recursion and pattern formation. As such, these body and sensory experiences, which are already familiar to learners, could be used to establish connections to more formal mathematical ideas. The Divine Image of mathematics may not be transcendent but might have a human form after all.

Ethnomathematics

Selin (2000), in the introduction to the book *Mathematics Across Cultures,* states that "every culture has mathematics," which she defines as "the study of measurements, forms, patterns, variability and change" (p. xvii). Barton (1996), however, reminds us to be cognizant of the fact that "the category mathematics is not common to all cultures" (p. 216). The origin of activities and questions that we might consider mathematical under this definition of mathematics is related to the practical necessities of everyday life in different societies at different times, as well as religious and ritualistic connections; what D'Ambrosio (2000) refers to as the "needs of survival and transcendence" (p. 80). In this section I will try to answer the questions of "What is ethnomathematics?"; "How does one 'do' ethnomathematics?"; "What are the main debates and controversies in this area of inquiry?"; and "What are the potential implications for teaching, learning, and society?"

What is Ethnomathematics?

The difficulty in providing a simple answer to the question, "What is Ethnomathematics (EM)?" identified by Rowlands and Carson (2002), is

a reflection not merely of the differences of opinion among the many advocates of EM but, more importantly, also represents a healthy diversity of interests, foci, methodologies, and agendas of the various researchers and practitioners.

Barton (1996), for example, examines developmentally the evolving perspectives on EM of D'Ambrosio, Gerdes, and Ascher and posits the following definition of EM:

> Ethnomathematics is a research programme of the way in which cultural groups understand, articulate and use the concepts and practices which we describe as mathematical, whether or not the cultural group has a concept of mathematics. (p. 214)

From which he concludes that:

> Ethnomathematics does not consist of the mathematical ideas of other cultures, nor is it the representation of these ideas within mathematics…ethnomathematics is an attempt to describe and understand the ways in which ideas which the ethnomathematician calls mathematical are understood, articulated and used by other people who do not share the same conception 'mathematics'…like anthropology, one of the difficulties of ethnomathematics is to describe another person's world with one's own codes, language and concepts. (p. 215)

Eglash (1997) adds the following observations:

> Ethnomathematics is typically defined as the study of mathematical concepts in small-scale or indigenous cultures. (p. 79)

> Its epistemological basis is not restricted to methods of direct translation…but also includes the types of pattern analysis used in the modeling approach….Unlike mathematical anthropology, however, this research generally strives to include conscious intent as an important component of the analysis. (p. 81)

> Ethnomathematics emphasi[zes] the possibilities for indigenous intentionality in mathematical patterns. (p. 85)

> …ethnomathematics differs epistemologically from non-Western mathematics by not limiting itself to direct translations of

> Western forms and instead remaining open to any mathematical pattern discernable to the researcher. (p. 87)

Rowlands and Carson (2002) suggest that:

> The emphasis in EM seems to be on the 'doing' of mathematics, in the sense of cultural groups and peoples creating their own mathematics out of their everyday lives, rather than the teaching/learning of mathematics as a formal academic discipline. (p. 84)

Adam, Alangui, and Barton (2003) write that:

> ethnomathematics recognizes the uniqueness of traditional cultures by highlighting aspects of their complex knowledge systems and showing them to be living and dynamic, and valuable and valid in their own terms and context.

> The (mathematical) ideas of (traditional) peoples are not static but develop through time. Such knowledge may provide us with new concepts and problems in mathematics. (p. 328)

> EM is not a philosophy, much less a 'pedagogic philosophy'. Rather it is a lens through which mathematics itself can be viewed. (p. 329)

Doing Ethnomathematics

Barton (1996) lists and describes four activities considered relevant to EM projects:

1. **Descriptive Activity** — The first task of an ethnomathematician is to describe those practices or conceptions which are under consideration…a description which is…within the context of the other culture (p. 222)

2. **Archaeological Activity** — One way to bring out mathematical aspects is to trace backwards in time to uncover the mathematics which lies behind the current practice or conception. (p. 222)

3. **Mathematising Activity** — A second way of exposing the mathematical aspects in an EM study is by mathematising, i.e., by translating the cultural material into mathematical terminology, and relating it to existing mathematical concepts.…As well as interpretative

mathematising, it is possible to work with the interpreted mathematics and extend it in a mathematical way. (p. 223)

4. **Analytic Activity** — Having described and developed mathematical ideas from other cultures, researchers seek to find out why the practices are like they are (p. 223)

Several good examples of this process can be found in the works of Ascher (2002), Eglash (1997), and Gerdes (1999).

Mathematizing or Re-mathematizing?

Pimm (2001) asks a very important and relevant question that any ethnomathematical study should consider:

> in what sense are we mathematising the work and in what way…are we remathematising it? In other words to what extent did mathematics consciously play a role in the creation of the piece in the first place; to what extent is mathematics designed in?" (p. 32)

Though Pimm asks these questions of art, given the fact that the first reaction to much of what is considered ethnomathematics is an aesthetic and affective response to the objects as a whole and not as a mathematical work, his comments are well suited. For example, in Ascher's (2002) report of the kolam tradition of the Tamil Nadu region of India, we observe, for example, in one piece (Figure 1) that a 90° rotational symmetry is not an interesting aesthetic artefact but the result of a recursive embodied process in which the individual repeats a pattern after moving her body. Here, our observation of the symmetry is a re-mathematization of the process of construction. However, the observation that the figure is an Eulerian graph is a mathematizing activity since nowhere in the drawer's mind is this intended. This is unlike the African sand drawings described by Gerdes (1999), where the intent is specifically to produce patterns that have the Eulerian characteristic.

Thus, ethnomathematical activity can involve both mathematization and re-mathematization of the artefacts and practices of different cultures, though it is the latter, the discovery or creation of correspondences

between the original intent of diverse cultures of peoples with our own mathematical language and culture, that respects the integrity of both sets of traditions.

Figure 1. Pulli kolam (adapted from Ascher, 2002). Used with permission of Sabrina McMillan Solomon.

Debates and Controversies

There is considerable debate within the ethnomathematical field itself and among ethnomathematicians, mathematicians, and mathematics educators. Two of the issues have already been raised, namely, the inherent problems of meaning in defining "mathematics" and "culture," and the question of whether or to what extent what is being done or observed in diverse cultures is a mathematization or a re-mathematization.

D'Ambrosio (1997) identifies another issue; that "ethnomathematics is frequently treated as pedagogical revisionism" (p. 13). It is this issue that partially occupies Rowlands and Carson's (2002, 2004) critique of ethnomathematics. They ask the question, "What would an

ethnomathematics curriculum look like and where would formal academic mathematics fit in such a curriculum?" (Rowlands & Carson, 2002, p. 80), and posit four possibilities, which they then interrogate. Their conclusion that "ethnomathematics runs the risk of attempting to equalize everything down to the poverty of the 'builders and well-diggers and shack-raisers in the slums'" (p. 98) and that "formal, academic mathematics would not exist in a curriculum informed by ethnomathematics" (p. 91) is challenged by Adam, Alangui, and Barton (2003) in a response to the previous article. Adam, Alangui, and Barton state emphatically that

> Ethnomathematics is not out to displace or replace mathematics. At best, ethnomathematics forces us to reflect on our practice as mathematics educators, to reflect on our discipline, and to be aware of how it has contributed to a culture of "intolerance, discrimination, inequity, bigotry, and hatred. (D'Ambrosio, 2001) "(p.329)

They offer five pedagogical possibilities for an ethnomathematically informed curriculum of which their support is largely for:

> 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…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…a curriculum of this type allows learners to become more aware of how people mathematize and use this awareness to learn about a more encompassing mathematics. (p. 332)

Given that education in general and mathematics and science education in particular are steeped in socio-political struggles (Eglash, 1997), this debate on the pedagogical position that EM can and should take will probably not be soon resolved.

One of the issues around which debate focuses is that of the pre-eminent place given to Greek rationality in modern mathematics. According to

D'Ambrosio (1997), "much of the research in Ethnomathematics today has been directed at uncovering small achievements and practices in non-Western cultures that resemble Western mathematics. Western mathematics remains the standard of rationality…" (p. 15). This is taken up by Rowlands and Carson (2002), who see an attempt among some ethnomathematicians to downplay the Greek contribution to mathematics and rationality. This claim is refuted by Adam et al. (2003), who instead point out that:

> ethnomathematics recognizes the pre-eminence of Greek rationality in modern mathematics and seeks to understand this. One way to do so is to see that Greek rationality is only one form of rationality and that the particular form of mathematics that traces its trajectory through the Greek tradition (and a few others) serves particular functions and has particular consequences. (p. 330)

The role of rationality is discussed by Turnbull (2000) as he argues for an understanding of knowledge systems as inherently local as opposed to universal. He states that

> rationality is a deeply problematic concept. It is profoundly embedded in the hidden assumptions of late twentieth century Occidentalism about what it is to be a knowing, moral, sane individual…but there are no universal criteria for rationality.…Rationality consists in the application of locally agreed criteria in particular contexts. (p. 46)

Like the problems of definition and of pedagogy, the centrality of rationality, of the sort espoused in the Greek tradition, is one that both mathematics and ethnomathematics must continue to wrestle with. However, what can be gained by relaxing the constraint of rationality (as is espoused and practised in the Western mathematical and scientific traditions) is the potential for the creation "of a shared knowledge space in which equivalencies and connections between differing forms of rationality can be constructed" (Turnbull, 2000, p. 53).

There is also a concern, voiced by Rowlands and Carson (2002), that despite the noble aim of EM in attempting to provide equity for all students, "ethnomathematics cannot guarantee any fundamental change

in terms of equity and so if the status quo remains then this notion of 'equity' is misplaced and can only serve to maintain the divisions that exist in society" (p. 86). However, the question can be turned on itself and we might ask, "To what extent does traditional mathematics guarantee changes in terms of equity?" The main point of many in the ethnomathematical field seems to be that traditional mathematics as it is practised ignores important and essential human needs, and indeed continues to serve as a de-historicizing, de-humanizing, colonizing agent. Arguments about guarantees of equity in this form serve as a red herring to deeper issues. Neither EM nor formal academic mathematics can guarantee changes in equity. What can be achieved by EM is an appreciation of what is mathematical about other people's (and one's own) practices.

Does EM empower or disempower students (Rowlands & Carson, 2004)? This is another fundamental issue in the EM debate. Evidence presented by Adam et al. (2003) suggests that "students who have been taught using such an ethnomathematical curriculum perform better on conventional mathematics tests…[and] that learning in context does make mathematics more meaningful to learners" (p. 333). However, what Rowland and Carson are concerned with is whether or not EM denies students access to the "cultures of power" (Delpitt, 1988). They write, "what [will] this will do for learners, especially when their peers in more conventional educational settings continue to undergo the more customary induction into the world's now ubiquitous formalized cultural systems…" (p. 86). This position, to an extent, belittles EM as an educational project, and the position is rendered less potent with the studies referred to by Adam et al. (2003). Of course, additional studies that are able to make the case that EM does allow students to gain access to the cultures of power are needed.

The question, "To what extent is formal academic mathematics disempowering?" should also be asked. The fact that "many people who study geometry, trigonometry, algebra, calculus, and so forth seldom use these branches of mathematics professionally, yet the effect of this learning is regarded by many as a benefit in and of itself" (Rowland & Carson, 2004, p. 336) is not sufficient grounds to claim a privileged position for formal academic mathematics.

The final issue is one of presentation. There is a concern among some (e.g., Eglash, 1997) that some EM pedagogical projects, by singling out minority students, may increase their alienation or sense of Otherness from formal mathematics or may present aspects of a culture in a trivialized or romantic fashion. Within this, we might situate Rowland and Carson's (2002) concern that an ethnomathematical curriculum might be merely an "excursion into geometrical aesthetics" (p. 92). However, given the diversity of EM projects this seems unlikely.

Implications for Teaching, Learning, and Society

Some of the implications of EM for teaching and learning have been suggested above. However, I wish in this section to explore as well the wider implications of this endeavour. First, though, I situate my own opinion with that of Adam et al. (2003), who state that "ethnomathematics is not a pedagogic philosophy. Rather it is a lens through which mathematics itself can be viewed" (p. 329), and extend it to include D'Ambrosio's (1997) view that such a lens must also be used to look on other sociocultural constructions in general.

The EM literature says very little explicitly about instruction. Rowlands and Carson (2002), in their defence of formal academic mathematics, suggest and investigate four possibilities for an EM influenced curriculum. These are, EM as a substitute for formal academic mathematics; EM as a supplement in order to promote an appreciation of other human cultures; EM as an entry point to formal mathematical ideas; and EM as a consideration in the design and preparation of learning situations. They do, however, state that:

> ethnomathematics would make a valuable contribution to the curriculum if it demonstrated how mathematical ideas grew out of the needs of various peoples. However, the emphasis would need to be on the historical and cultural development of mathematics rather than the ideas of various peoples. (p. 91)

This position is criticized by Adam et al. (2003) as an attempt to "tak[e] mathematics in its present form as a given, and ask merely that we be sensitive to cultural difference as mathematicians and mathematics educators (p. 334). They suggest, instead, five possibilities for an EM influenced curriculum, "premised on the belief that the cultural aspects

of the students' milieu should be infused in the learning environment in a holistic manner" (p. 331). Their particular preference has been stated previously.

What EM appears to offer educators is, firstly, a sensitizing concept that at the least offers the promise of greater cultural sensitivity and respect for cultural diversity among students. Secondly, it offers mathematics educators new perspectives from which to view their discipline.

With respect to learning, Adam et al. (2003) have noted that EM has already contributed to new mathematical knowledge. For example, Ascher (2002) reports on the contributions of the study of kolam traditions to computer science. This substantiates the claim of Barton (1997) that "ethnomathematics includes a dialogue between the ideas of another culture and the conventional concepts of mathematics. This dialogue is likely to lead both to new areas of application for mathematics, and to new mathematics through adaptation to new ideas" (p. 217). Thus, what is to be learnt involves not only new knowledge, but new ways of looking at and new perspectives on knowledge itself.

The larger EM project is a socio-political one involving a postmodern critique of both the social construction of science, mathematics in particular, and the consequences of the particular sociocultural construction that dominates most of the discourse in the West. According to Adam et al. (2003), "there is more to ethnomathematics than recognizing the failings of mathematics as a discipline. Its philosophy also implies that we recognize its potential to turn an unjust situation around" (p. 329). The ultimate aim of the EM project is to contribute to a new ethics of "respect, solidarity and responsibility" (D'Ambrosio, 2001) and, ultimately, to a more peaceful coexistence for all of humanity.

At a very fundamental level, EM aims to challenge hegemonic conceptions of what counts or should count as mathematical. Barton (1997), for example, states that "part of the purpose of ethnomathematics is to challenge the perceived universal nature of mathematics, and to expose different mathematical conceptions" (p. 216). To this end, then, he states that

> mathematics must be changing.…It must admit the possibility of other mathematical concepts which are not subsumable by

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existing ones, or by some new, overarching generalization.…Unless mathematics can change in a radical way, there is no point to examining the way other people view things which we call mathematical. If there is only one view of mathematical phenomena, then why try and find another one? (pp. 218–219)

For example, Wood (2000) examines the changing views on mathematical proof;

modern mathematicians are in considerable conflict about the status and usefulness of proof.…Much has been made of the Greek concept of proof as the basis of modern mathematics to the extent that many writers have disparaged the Indians for their supposed haphazard ideas of proof.…Indian mathematics does prove theorems though not in the same way as Greek deductions from axioms. (p. 8)

D'Ambrosio (1997) identifies the central role that EM has to play in this challenge when he states that "ethnomathematics places us in an advantageous position to look into the nature of mathematical knowledge, the questions about which cannot be resolved within the framework of Western mathematics itself" (p. 14). Ethnomathematics' first challenge is to one of its parental domains, mathematics itself.

The second challenge that emerges from EM is a historiographical one (D'Ambrosio, 1997, 2000, 2001). According to Selin (2000):

until the past few decades histories of mathematics have virtually ignored the mathematics of non-European cultures.…This neglect grew from the colonial mentality, which ignored or devalued contributions of the colonized peoples as part of the rationale for subjugation and dominance. (p. xvii)

This is a situation that is being partially rectified by ethnomathematics and other ethnosciences.

Finally, the most ambitious goal of EM is a contribution to solving what Rowlands and Carson (2004) call the most pressing issue on the planet

today, "that of figuring out how peoples of varied cultural allegiances are to get along" (p. 329). D'Ambrosio (2001) states that:

> I see mathematics playing an important role in achieving the high humanitarian ideals of a new civilization, with equity, justice and dignity for the entire human species….But this will depend on our understanding how deeply related are mathematics and human behavior. (p. 327)

Though I disagree with his statement that "the *most universal problem* – that is survival with dignity – must have something to do with the most universal *mode of human thought* – that is mathematics" (p. 328), which seems to set up a false analogy, I do agree with his statement that it is, "the failure to reestablish the lost interconnection of the sciences, technology and human values is causing unavoidable conflicts. This is apparently true with mathematics, in which the acknowledgement of human attributes is conspicuously absent from its discourse" (p. 329). It is precisely because such discussions of mathematics, ethics, and values are seldom classed together that there is a need to engage in this discussion. It is precisely because our conceptions of mathematics are limited that the ethnomathematical project is necessary. It is precisely because the stakes are so high that such re-connections are urgent.

The SEMP Mathematics Curriculum of Trinidad and Tobago

Some of these ideas representing the overlapping of the domains of embodiment and ethnomathematics are manifested in the reform-oriented mathematics curriculum documents of the Trinidad and Tobago Secondary Education Modernization Programme (SEMP). For example, some of the stated goals of education outlined in the SEMP curriculum guide include:

- Providing opportunities for all students to develop spiritually, morally, emotionally, intellectually and physically;
- Providing opportunities for all students to develop an understanding and appreciation of the diversity of our culture; and
- Providing opportunities for all students to develop an appreciation for beauty and human achievement in the visual and performing arts.

(SEMP, 2002, Section 1:5-6)

These goals are further elaborated in six essential learning outcomes, three of which are Aesthetic Expression, Citizenship, and Problem Solving. In achieving these learning outcomes, eight core subjects have been identified, of which mathematics and visual and performing arts are two. The stated goals of the mathematics curriculum include:

- To make mathematics relevant to the interests and experiences of the students and to prepare students for the use of mathematics in further studies
- To cultivate creativity and critical thinking in applying mathematical knowledge and concepts to solve routine and non-routine problems
- To develop skills in inquiry by the use of mathematics to explain phenomena, and by recognition of the influence of mathematics in the advancement of civilization
- To promote appreciation of the role of mathematics in the aesthetics and to make mathematics fun
- To encourage collaboration among students and to promote positive attitudes and values in students through the completion of mathematical tasks
- To provide opportunities for students to experience the structure of mathematics and to appreciate the elegance and power of mathematics
- To provide students with a range of knowledge, skills and techniques relating to number, geometry (space and shape), algebra, measurement, relations, functions, and statistics in a manner relevant to the technological advancements of the 21st century. (SEMP, 2002, Section 2:3)

Some connections to the other core curriculum areas are suggested in Section 2:5-7 of the curriculum document. For example, suggested connections between Mathematics and Visual and Performing Arts include:

- Understanding timing and sound in music, which are based on basic mathematical concepts in number and trigonometry

- Observing the beauty in art and nature, which is based on the concept of symmetry in geometry
- Drawing, designing and dancing, which are dependent on acquiring skills in geometry and fundamental mathematics
- Producing art and craft which require the use of calculations, spatial sense and fundamental concepts in mathematics
- Sequencing of dance steps and patterns in dance, which are dependent on geometrical and number concepts and skills

From the above excerpts, one sees an explicit desire to expand the scope of what is considered relevant to mathematical and, indeed, humanistic instruction. In the next section, I will suggest some potential areas for study where some of the ideas explored regarding ethnomathematics and embodied perspectives might fruitfully intersect with domains or aspects of culture of Trinidad and Tobago, and discuss some of the potential implications.

Potential Areas for Curriculum Study

What I am suggesting is, emerging from the perspectives on ethnomathematics and embodied mathematics, that aspects of the culture of Trinidad and Tobago and, indeed, the cultures of the wider Caribbean, become a focus for mathematical inquiry both among students and researchers. Such a project connects the needs of today with the history of yesterday. It is my hope that such a project might lead to a greater valuing of aspects of "West Indian" culture and a recognition of the importance of reclaiming one's historio-mathematical heritage while simultaneously recognizing how one goes about continuing to create such a heritage.

I limit my initial proposal to aspects of life in Trinidad that are socioculturally situated, though recognizing that they could be extended to other areas such as the natural environment. This limiting should not deter readers from other Caribbean territories and elsewhere from applying the ideas to their own cultural situations, but it is meant to focus the discussion in the one culture with which I am familiar.

Culturally, Trinidad and Tobago is as diverse as its population. Each ethnic and religious group has retained some of its practices. However, of greater interest to me are art forms that are endemic hybrids of the coincidences of proximity and history of diverse groups. As such, my initial proposal is further limited to aspects of the arts that might be considered local. Two areas of inquiry are thus immediately suggested: the Carnival and the steelband. The latter is discussed in Khan (2008). In this paper, I restrict the discussion to that of the Carnival.

Carnival

Carnival is a two-day street festival involving costuming, music, and dancing. Each of these areas offers possibilities for mathematical inquiries. For example, from casual observation there appears to be a lot of relevant mathematics in the process of creating costumes. Some of this is related to patterns and geometric motifs, symmetry, and tessellations. Creating a costume is not a matter of knowing academic mathematics, but it is an embodied experience of bending wood and wire to the will to create beauty. With respect to choreography, this too might be seen as a type of embodied mathematics—how human movements are enhanced and imbued with mathematical meaning through the elaboration of costuming. One might consider the trajectories, or the surfaces that can be shaped by different types of costumes as the masquerader inhabits the 'mas' and moves through space. Consider the following quote on the Calalloo Company's (a performance art group) website, which speaks to the embodied and ethnomathematical frameworks:

> The challenge of mobility in mas is to transmit the movement of the performer to his apparel, to magnify it, and see it articulated in the far reaches of the structure, yards away from the body. As mas is performed to music, the essential movement of the masquerader is his dance. The greatest kinetic potential, then, is to base the mobility of the costume on that movement, so that the mas expresses the dance, and the rhythm of the music can be read high in the air.

In addition to using mathematics in the design of costumes, one might deliberately design costumes to allow for the exploration, display, and embodiment of mathematical ideas. This might include some of the ethnomathematical studies of Ascher (2002) and Gerdes (1999).

Carnival is but one area where the culture of Trinidad and Tobago might productively meet with the goals of mathematics education outlined previously. Other areas could involve a more traditional exposition linking the diverse contributions of Indian, African, Asian, and European mathematicians to mathematical knowledge. Given the multicultural nature of Trinidadian classrooms and the still colonial view of mathematics, such a project, I believe, could assist in developing a wider appreciation of what is mathematical about one's own sometimes taken-for-granted cultural situation. The mathematics of Carnival could be part of a larger project, for example, involving a study of mathematics in the major festivals including Hosay, Divali, and Phagwa. Such studies, I believe, might contribute positively to fostering an understanding and appreciation of the diversity of the culture of Trinidad and Tobago, allow students to develop an appreciation for beauty and human achievement in the visual and performing arts, and make mathematics more relevant to local interests and experiences. In this regard, it is possible that a uniquely Trinidadian mathematical identity might begin to be fashioned, one in which the words of the national anthem, "every creed and race find an equal place" ring more true than they do at present.

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