Paulo Freire's Contribution to an Epistemology of Ethnomathematics*

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> …our task is not to teach students to think—they can already think; but to exchange our ways of thinking with each other and look together for better ways of approaching the decodification of an object.
> (Freire, 1982)

From an epistemological perspective, a key underlying assumption in the emerging field of ethnomathematics is that, through interacting in a myriad of daily-life activities, people already think and, more specifically, they think mathematically. To understand their ways of thinking mathematically, we need to reconsider and redefine conventional notions of mathematical knowledge. We need to learn about how cultural practices—daily practice, language, power, and ideology—to constitute people's views of mathematics and their ways of thinking mathematically. Learning about these views and ways of thinking are opportunities to deepen our mathematical, epistemological, and pedagogical knowledge. We need to reclaim the hidden and distorted histories of the contributions of all cultures to mathematics.[1] Further, to enable students to discover that they already think mathematically and, therefore, can learn "school" or "academic" mathematics, we advocate connecting their mathematical understandings with a deconstructed history of mathematics and with the "academic" mathematics they are studying.

In this essay, we start with a discussion of Paulo Freire's theories about the nature of knowledge and introduce an intellectual tradition that underlies the concept of ethnomathematics. We proceed to argue that his epistemology informs the theoretical basis of ethnomathematics. Then, we categorize and elaborate areas central to ethnomathematics. In concluding, we indicate implications for further investigations of mathematical knowledge and its connections to cultural and political action.

A theme that emerges throughout our reflections is the need to reconsider dichotomous categories so commonly made in much of Western academic

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* This homage is largely drawn from our previous work (Frankenstein & Powell, 1994) on Freire's epistemology and how various aspects of it can help frame intellectual strands in ethnomathematics. Our book, *Ethnomathematics: Challenging Eurocentrism in Mathematics Education* (1997), continues to update and extend these ideas.

[1] See, for example, the contribution of Powell and Temple to the proceedings of the roundtable on the interaction of ethnomathematics and urban environments as well as Powell and Temple (2001).

thought that rests on Enlightenment thinking. For Freire (1970, 1982) this means breaking down the dichotomy between subjectivity and objectivity, between action and reflection, between teaching and learning, and between knowledge and its applications. For Fasheh (1988) and Adams (1983), this means that thought which is labeled "logic" and thought which is labeled "intuition" continuously and dialectically interact with each other.[2] For Lave (1988), this means understanding how "activity-in-setting is seamlessly stretched across persons acting" (p. 154). For Diop (1991), this means that the distinctions between "Western," "Eastern," and "African" knowledge distort the human processes of acquiring and creating knowledge from interactions with each other and with the world. Further, we argue in this essay that underlying all of these false dichotomies is the split between practical, everyday knowledge and abstract, theoretical knowledge. Understanding these dialectical interconnections, we believe, leads us to connect mathematics to all other "disciplines" and to view mathematical knowledge as one of many products resulting from humans trying to understand and act effectively in the world. We see ethnomathematics as a useful way of conceptualizing these interconnections from both theoretical and curricular perspectives.

PAULO FREIRE'S EPISTEMOLOGY

The epistemology of Paulo Freire is in direct opposition to the dominant educational paradigm of positivism. In this philosophical paradigm, here in agreement with Freire, proponents view facts or states of affairs as objective, existing totally outside of human consciousness. The problem, however, is that positivists claim that knowledge, though a product of human consciousness, is itself also neutral, value-free, and objective. Further, knowledge is completely separate from how people use it. Learning is the discovery of static facts and their subsequent description and classification (Bredo & Feinberg, 1982). In contrast, critical education theorists critique the positivist paradigm by attending to what is omitted. For instance, Giroux (1981) states that

> [q]uestions concerning the social construction of knowledge and the constitutive interests behind the selection, organization, and evaluation of "brute facts" are buried under the assumption that knowledge is objective and value free. Information or "data" taken from the subjective world of intuition, insight, philosophy and nonscientific theoretical frameworks is not acknowledged as being relevant. Values, then, appear as the nemeses of "facts," and are viewed at best as interesting, and at worst, as irrational and subjective emotional responses (pp. 43-44).

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[2] Further, D'Ambrosio (1987) challenges the static notion that "there is only one underlying logic governing all thought" and Diop (1991, p 363) illustrates how the interactions between "logic" and "experience" change our definition of "logic" over time.

Likewise, Freire insists that knowledge is not static; that there is no dichotomy between objectivity and subjectivity, or between reflection and action; and that knowledge is not neutral.

For Freire, knowledge is continually created and re-created as people act and reflect on the world. Knowledge, therefore, is not fixed permanently in the abstract properties of objects, but is a process where gaining existing knowledge and producing new knowledge are "two moments in the same cycle" (Freire, 1982). Embedded in this notion is the recognition that knowledge requires subjects; objects to be known are necessary, but they are not sufficient.

> Knowledge…necessitates the curious presence of subjects confronted with the world. It requires their transforming action on reality. It demands a constant searching.…In the learning process the only person who really learns is s/he[3] who…re-invents that learning (Freire, 1973, p. 101).

Knowledge, therefore, is a negotiated product emerging from the interaction of human consciousness and reality; it is produced as we, individually and collectively, search and try to make sense of our world.[4]

Necessarily, then, the human act of sense-making implies the subjectivity of our descriptions of the world. However, contrary to the view that subjective statements contain no connection to objective reality and that there exists objective statements about the world, unpolluted by subjective perspectives, Freire insists that subjectivity and objectivity are not separate ways of knowing.

> To deny the importance of subjectivity in the process of transforming the world and history is…to admit the impossible: a world without people.…On the other hand, the denial of objectivity in analysis or action…postulates people without a world…[and] denies action itself by denying objective reality (Freire, 1970, pp. 35-36).

Because of the unity between subjectivity and objectivity, people cannot *completely* know particular aspects of the world—no knowledge is finished or infallible.[5] As humans change, so does the knowledge they produce. In connection with this, Lerman (1989) theorizes that objective statements are

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[3] One of Freire's first comments at the Boston College course he taught (1982) concerned his debt to the many American women who wrote to him praising *Pedagogy of the Oppressed* but criticizing his sexist language. He has changed his language; we, therefore, change his quotes in this respect.

[4] Matthews (1981) traces Freire's emphasis on the social nature of thought to Karl Mannheim's philosophy that strictly speaking it is incorrect to say that individuals think; it is more correct to insist that they participate in thinking further than what others have previously thought.

[5] In the words of McLaren (1990), "[e]mancipatory knowledge is never fully realized, but is continually struggled for" (p. 117).

publicly-shared social constructions. At particular moments in history, communities of people discuss, debate, revise, adopt, and challenge concepts and theories. Thus knowledge, "objective" beyond the visions of individual subjects, does not have the "transcendental existence" that positivists ascribe to knowledge (Lerman, 1989, p. 219).[6] Through constant search and dialogue, we continually refine our understandings and theories of reality and, in so doing, act more effectively.

An inseparable component of understanding the world through action is reflection. In a dialectical manner, reflection leads to new action. That is, action and reflection are not separate moments of knowing. For, on the one hand, reflection that is not ultimately accompanied by action to transform the world is meaningless, alienating rhetoric. On the other hand, action that is not critically analyzed cannot sustain progressive change. Without reflection, people cannot learn from each other's successes and mistakes; particular activities need to be evaluated in relation to larger collective goals. Only through praxis—reflection and action dialectically interacting to re-create our perception and description of reality—can people become subjects in control of organizing their society.

This praxis is not neutral. Knowledge does not exist apart from how and why it is used, and in whose interest. Even, for example, in the supposedly neutral technical knowledge of how to cultivate potatoes, Freire asserts that

> there is something which goes beyond the agricultural aspects of cultivating potatoes.…We have not only…the methods of planting, but also the question which has to do with the role of those who plant potatoes in the process of producing, for what we plant potatoes, in favor of whom. And something more. It is very important for the peasant…to think about the very process of work—what does working mean? (Brown, 1978, p. 63).

In Freire's view, people produce knowledge to humanize themselves. Overcoming dehumanization involves resolving the fundamental contradiction of our epoch: domination against liberation. Ethnomathematics contributes to this struggle by theorizing a more liberatory conception of mathematics.

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[6] Lerman rightly admits the fallibility of knowledge. Further, he argues that this is empowering because it forces us to engage in comparing theories and evidence, and in refining our criteria for making judgements among competing theories:

> Certainty has a tendency to lead one to say "That's it, no more discussion, we have the answer." Fallibilism, a view which accepts the potential refutation of all theories, and counter-examples to all concepts, allows one to ask how does one know that this answer is better than that one, what might constitute a notion of 'better,' might they not both be possible, as with Euclidean and non-Euclidean geometries, or arithmetics with or without the Continuum Hypothesis (1989, p. 217).

ETHNOMATHEMATICAL KNOWLEDGE

Ethnomathematics indexes a research program, a new conceptual category in the discourse on the interplay among mathematics, education, culture, and politics. Its theorization was initiated by, mathematician and educational theorist, Ubiratan D'Ambrosio (1985, 1987, 1988, 1990, 2001). There are a range of intellectual positions that form views of ethnomathematics (Powell & Frankenstein, 1997). Of the many formulations of ethnomathematics, only some recognize a political stance that is intrinsic to its emergence and theoretical and research trajectories (For instance, Frankenstein, 1997; Gerdes, 1985, 1999; Knijnik, 1996, 1997, 1998, 1999, 2002; and Powell, 2002). In a recent book, Etnomatemática: Elo entre as tradições e a modernidade [Ethnomathematics: Link between tradition and modernity], D'Ambrosio (2001) articulates his viewpoint on the political nature of the nascent research program:

> Ethnomathematics is the mathematics practiced by cultural groups such as urban and rural communities, labor groups, professional classes, children of a certain age bracket, indigenous societies, and many other groups that identify themselves through objects and traditions common to the groups.[7]
> Beside this anthropological character, ethnomathematics has an indisputable political focus. Ethnomathematics is imbued with ethics, focused on the recuperation of cultural dignity of human beings.
> The dignity of the individual is violated by social exclusion that often causes one not to pass discriminatory barriers established by the dominate society, including and, principally, in schools (p. 9, my translation[8]).

[7] A conceptually fruitful consequence of defining ethnomathematics as specific mathematical practices constituted by cultural groups is the scope of such activities. One can theorize that in ethnomathematics, the prefix "ethno" not only refers to a specific ethnic, national, or racial group, gender, or even professional group but also to a cultural group defined by a philosophical and ideological perspective. The social and intellectual relations of individuals to nature or the world and to such mind-dependent, cultural objects as productive forces influence products of the mind that are labeled mathematical ideas. Dirk J. Struik (1948 reprinted in 1997), an eminent mathematician and historian of mathematics, indicates how a particular perspective—dialectical materialism—decisively influenced Marx's theoretical ideas on the foundation of the calculus. The calculus of Marx (1983) represents the ethnomathematical production of a specific cultural group. For a popular account of Marx's calculus, see Gerdes (1985).

[8] Etnomatemática é a matemática praticada por grupos culturais, tais como comunidades urbanas e rurais, grupos de trabalhadores, classes profissionais, crianças de uma certa faixa etária, sociedades indígenas, e tantos outros grupos que se identificam por objetivos e tradições comuns aos grupos.
Além desse carácter antropológico, a etnomatemática tem um indiscutível foco político. A etnomatemática é embebida de ética, focalizada na recuperação da dignidade cultural do ser humano.

By highlighting the damaging consequences of social exclusion, ethnomathematics represents a break with attributes of Enlightenment thinking. It departs from a binary mode of thought and a universal conception of mathematical knowledge that privileges European, male, heterosexual, racist, and capitalistic interests and values. D'Ambrosio (2001) puts it this way:

> Ethnomathematics encompasses in this reflection on decolonialization and in the search for real possibilities of access for the subaltern, for the marginalized and for the excluded. The most promising strategy for education, in societies that are in transition from subordination to autonomy, is to reestablish the dignity of its individuals, recognizing and respecting their roots. To recognize and respect the roots of an individual does not mean to ignore and reject the roots of the other, but, in a process of synthesis, to reinforce ones own roots (p. 42, my translation[9]).

As D'Ambrosio (2001) notes, this mathematics research program contains other dimensions including conceptual, historical, cognitive, epistemological, and educational. Furthermore, some researchers, for instance, Barton (1995) relate to philosophical dimensions of ethnomathematics, while some like Gerdes (1992, 1999) do profound and prolific work on uncovering hidden and frozen mathematics of material culture, and still others such as Knijnik (1996, 1997, 1998, 1999) and Frankenstein (1997) push the envelope of the political dimensions of ethnomathematics and so doing construct new theoretical paths.

RE-CONCEIVING MATHEMATICAL KNOWLEDGE: ETHNOMATHEMATICS AND FREIRE'S EPISTEMOLOGY

The work of Freire and other critical education theorists has important implications for ethnomathematics and its epistemological underpinnings. A key implication is that individuals and cultures are located in the act of knowing, in the act of creating mathematics. This position, naturally, counterstates prevailing methods of teaching which treat mathematics as a deductively discovered, pre-existing body of knowledge. Even more insidious, within these methods, mathematics educators present the discipline as a body of

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A dignidade do indivíduo é violentada pela exclusão social, que se dá muitas vezes por não passar pelas barreiras discriminatórias estabelecidas pela sociedade dominante, inclusive e, principalmente, no sistema escolar (p. 9).

[9] A etnomatemática se encaixa nessa reflexão sobre a descolonização e na procura de reais possibilidades de acesso para o subordinado, para a marginalizado e para o excluído. A estratégia mais promissora para a educação, nas sociedades que estão em transição da subordinação para a autonomia, é restaurar a dignidade de seus indivíduos, reconhecendo e respeitando suas raízes. Reconhecer e respeitar as raízes de um indivíduo não significa ignorar e rejeitar as raízes do outro, mas, num processo de síntese, reforçar suas próprias raízes. (p. 42)

knowledge that is decidedly European, a male domain, and practiced only by divinely anointed minds. Taken together, prevailing pedagogical practices have prevented and alienated many students, disproportionately people of color and women, from engaging in mathematics. As Freire has stated, "[a]ny situation in which some men [and women] prevent others from engaging in the process of inquiry is one of violence. The means used are not important; to alienate men [and women] from their own decision-making is to change them into objects" [as quoted in Gordon, 1978, p. 251].

Gordon (1978) argues that the experience of learning mathematics objectifies individuals to the extent that subjectivity and personal acts of choosing and valuing are denied. He and others[10] affirm that belief, commitment, and personal experiences are part of the act of knowing. Further, he writes that

> [t]he human acts of teaching and learning are shared acts of presenting and accepting oneself and others in coming to a particular way of knowing. As acts of control, they make us submerge our awareness of our existence. As acts of and toward understanding, they make us acutely aware of our human capacity and need for meaning and explanation of our experience. As liberating acts, they require honesty and, as honest acts, they require sensitivity to and recognition of subjectivity. To view the mathematics experience in both "repair and transcendence" is to understand that liberation requires the creation of personal meaning which, subsidiarily, tests the taken for granted (p. 252).

We agree with Gordon that, to make mathematics education a liberatory act, educators need to attend to subjectivity. Moreover, we contend that an ethnomathematical, Freirean perspective recognizes and is sensitive to the impacts of various cultural conventions and inclinations—from daily activities and linguistic practice to one's social and ideological context—for doing and learning mathematics. That is, besides personal meaning, liberatory education attends to ideological, linguistic, and other cultural meanings produced in the praxis of our everyday lives. Indeed, educational acts, and no less those of mathematics education, are powerful engines to maintain and reproduce and to critique and transform personal, social, economic, and political structures and other cultural patterns.

With its attention to culture, Freire's epistemology informs a theory that accounts for how inserting ethnomathematics into mathematics education can

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[10] See, for example, Belenky, Clinchy, Goldberger, and Tarule (1986), pp. 214-229; Fasheh (1982); and Buerk (1985). Weissglass (1990) also argues that the emotional aspects of knowing and acting must be attended to in order to bring about educational change and that "[t]he educational community's failure to help teachers, administrators and parents work through their feelings about education and change is a major obstacle to achieving fundamental educational reform (p. 352).

shift education away from maintenance and reproduction toward critique and transformation. Freire insists that knowledge is not static and this notion underlies the ethnomathematical project to re-conceive the nature of mathematical knowledge. He attends to the dialectical connections between objectivity and subjectivity, and between reflection and action, and this attention directs ethnomathematical educators to consider culture and context—daily practice, language, and ideology—as inseparable from the praxis of mathematics learning. Further, Freire focuses on the non-neutrality of all knowledge and thus forces us to interrogate the consequences of considering mathematical knowledge as neutral, and to re-search an undistorted world history of mathematical ideas, a history that includes the contributions of all peoples to the development of mathematics.

However, just as Gordon over-attends to personal meaning, Freire over-attends to culture in his discussion of critical consciousness leading to radical change. His work is particularly vulnerable to that critique: By ignoring "the political economy of revolution in favor of an emphasis on its cultural dimension…[His] talk of revolution tends to become utopian and idealized" (Mackie, 1981, p. 106, also see Youngman, 1986, pp. 150-196). Although Freire's later writings focus more attention on the role of institutional structures in and on education (Youngman, 1986) and his later comments[11] recognize the limitations of education to bring about liberatory social change, this aspect of his work remains under-theorized. However, the implications of the connections between ethnomathematical knowledge and Freire's epistemology do result in a clear critique of most current conceptions of mathematics and of related pedagogical practices.

In this section, we examine those implications and argue that reconsidering what educators value as mathematical knowledge, considering the effect of culture on mathematical knowledge, and uncovering the distorted and hidden history of mathematical knowledge are the significant contributions of a Freirean, ethnomathematical perspective in re-conceiving the discipline of mathematics and its pedagogical practice.[12] As we indicate in our final section, less clear are the implications of a Freirean, ethnomathematical program for societal transformation.

Reconsidering what counts as mathematical knowledge

In a French mathematics education study, a 7-year-old was asked the following question: "You have 10 red pencils in your left pocket and 10 blue

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[11] For instance, "in meetings like this we cannot change the world, but we can discover and we may become committed" (1982).

[12] See Powell & Frankenstein (in press), for a discussion and examples of the curricular applications of ethnomathematics.

pencils in your right pocket. How old are you?" When he answered: "20 years old," it was not because he didn't know that he was *really* 7, or because he did not understand anything about numbers. Rather it was, as Pulchalska and Semadeni (1987) conclude, because the unwritten "social contract" between mathematics students and teachers stipulates that "when you solve a mathematical problem... you use the numbers given in the story... Perhaps the most important single reason why students give illogical answers to problems with irrelevant questions or irrelevant data is that those students believe mathematics does not make any sense" (p. 15).

As the situation Pulchalska and Semadeni reveals, we can observe the split between "everyday" mathematical knowledge and "school" mathematics in many different contexts. Earlier, we noted that D'Ambrosio (1985) traces the historical development of this split to the social stratifications of Egyptian and Greek societies. In a contemporary context, Frankenstein (1989) finds that her working-class, adult students in the United States are often surprised to learn that the decimal point is the same as the point used to write amounts of money. Similarly, Spradbery (1976) worked with 16 year old students in England who

> had failed consistently to master anything but the most elementary aspects of school Mathematics...They had received, and remained unhelped by, considerable 'remedial' teaching and, finally, they left school 'hating everyfink what goes on in maffs.' Yet in their spare time some of these same young people kept and raced pigeons...Weighing, measuring, timing, using map scales, buying, selling, interpreting timetables, devising schedules, calculating probabilities and averages...were a natural part of their stock of commonsense knowledge (p. 237).

Besides social and class divisions, Harris (1987) shows that sexism also undergirds the dichotomy between "school" mathematics and one's stock of commonsense knowledge and perverts what counts as mathematical knowledge. For example, a problem about preventing the lagging in a right-angled cylindrical pipe from inappropriately bunching up and stretching out, is labeled engineering and considered to be "mathematics," whereas the identical domestic problem of designing the heel of a sock is called "knitting" and not considered to have mathematical content. We, instead, call this domestic problem an example of ethnomathematics.

The mathematical knowledge embedded in the activity of adults handling money, students racing pigeons, and women knitting socks is Freirean in the sense that it is not fragmented from the knowledge of each of these activities; rather, it is created and re-created in praxis. However, the academically enforced disjuncture between "practical" and "abstract" mathematical knowledge contribute to students feeling that they do not understand or know any mathematics. Further, Joseph (1987) considers that this disjuncture fuels the intellectual elitism that regards mathematical discovery as following only "from a rigorous application of a form of deductive axiomatic logic." Moreover, this elitism, combined with racism, considers non-intuitive, non-empirical logic a unique product of European, Greek mathematics. This Eurocentric view dismisses Egyptian and Mesopotamian mathematics as merely the "application of certain rules or procedures... [not] 'proofs' of results which have universal application" (pp. 22-23). Joseph disputes this biased definition of proof, arguing that

> the word 'proof' has different meanings, depending on its context and the state of development of the subject…To suggest that because existing documentary evidence does not exhibit the deductive axiomatic logical inference characteristic of much of modern mathematics, these cultures did not have a concept of proof, would be misleading. Generalizations about the area of a circle and the volume of a truncated pyramid are found in Egyptian mathematics…As Gillings [1972, pp. 145-6] has argued, Egyptian 'proofs are rigorous without being symbolic, so that typical values of a variable are used and generalization to any other value is immediate' (pp. 23-24).

The Eurocentric bias that denies the rigor of Egyptian mathematics also considers to be "childlike" and "primitive" the mathematical knowledge of traditional, non-literate cultures. Ascher and Ascher (1986) argue that "there is not one instance of a study or restudy that upon close examination supports the myth of the childlike primitive" (p. 131). They provide examples that not only support this point but also reveal how false assumptions about the mathematical knowledge of others and lack of respect for the logic of others intersect with racism when one considers what counts as mathematical knowledge. For instance, they discuss a well-known anecdote about a trade between an African sheep herder and an explorer. The herder agrees to accept two sticks of tobacco for one sheep but becomes confused and upset when given four sticks of tobacco for two sheep. The story is supposed to show that the herder cannot comprehend that $2 + 2 = 4$. An alternate interpretation, respecting the herder's knowledge, "raises the issue of the difference between a mathematical concept and its application…Sheep are not standardized units." So it is logical that a second, different animal would not also be worth two sticks of tobacco. "[T]he applicability of even the simplest of mathematical models becomes a question of cultural categorization" (p. 128).

Another example shatters the notion of a dichotomy between concrete and abstract thought and demonstrates the subjective, culturally determined nature of "abstract" categories. Glick (as quoted in Rose 1988, p. 291) recounts the frustrations of researchers working with a group of people who "academic anthropologists" would label "primitive." The investigators had twenty objects, five each from four categories: food, clothing, tools and cooking utensils. When asked to sort the objects, most of the people produced ten groups of two, basing their sorting on practical connections among the objects (for example, "the knife goes with the orange because it cuts it").

> [the people] at times volunteered 'that a wise man would do things in the way this was done.' When an exasperated experimenter asked finally, 'How would a fool do it?' he was given back groupings of the type…initially expected—four neat piles with foods in one, tools in another.

Walkerdine (1990) cites an encounter which illuminates the creation of the categories "concrete" and "abstract." She describes two observations: a mother and her sons arguing about buying drinks that they could not afford; and, a father and her son making a game out of calculating change—"what if I bought…?" She contrasts the concrete material necessity in the conversation between the mother and sons with the imaginary constructions in the dialogue between the father and son. She asks intriguing questions about these exchanges:

> What is the effect of relative poverty and wealth on the way in which certain problems can be presented as 'abstract' versus 'concrete,' or, as I would prefer to put it, problems of practical and material necessity versus problems of 'symbolic control'? And what is the relationship between the classic concrete / abstract distinction and the one between a life in which it is materially necessary to calculate for survival and a life in which calculation can become a relatively theoretical exercise? Might calculation as a theoretical exercise have become the basis of a form of reasoning among imperial powers which depended for the accumulation of their capital on the exploitation of the newly discovered colonies? Do theoretical concepts come with wealth and what, if so, does this mean for economic and psychological theories of development and underdevelopment? (p. 52)

She goes on to argue that to describe the interaction between the father and son as "abstracted" from everyday practices is misleading because the imaginary calculation "exists as a discursive relation in a new set of practices, namely those of school mathematics, with its own modes of regulation and subjection" (p. 54). Rather than dichotomizing concrete versus abstract, Walkerdine speaks for viewing the different conversations as shifting from "one discursive practice to another."

Considering interactions between culture and mathematical knowledge

In his educational practice, Freire initiates the process by first considering who creates culture. This is done to clarify that all people, whether literate or illiterate, are cultural actors. Toward this end, he emphasizes an anthropological concept of culture. In the following quote he indicates signposts of a definition of culture:

> the distinction between the world of nature and the world of culture; the active role of men [and women] *in* and *with* their reality; the role of mediation which nature plays in relationships and communications among men [and women]; culture as the addition made by men [and women] to a world they did not make; culture as the result of men's [and women's] labor, of their efforts to create and re-create; the transcendental meaning of human relationships; the humanist dimension of culture; culture as systematic acquisition of human experience (but as creative assimilation, not as information-storing); the democratization of culture; the learning of reading and writing as the key to the world of written communication. In short, the role of man [and woman] as Subject[s] in the world and with the world (1973, p. 46).

The salient points for our discussion are that cultural products are the creation of people and that transformations of nature are made by all people. Mathematics is a cultural product and, therefore, is created by humans in the interconnected midst of culture. The interactions are dialectical: people's daily practice, language, and ideology effect and are effected by their mathematical knowledge. Bishop (1990), and other mathematics educators, reviewing anthropological studies and investigating mathematical activities in different cultures, view mathematics as a "pan-cultural phenomenon…a symbolic technology, developed through engaging in various [integrated] environmental activities" which can be classified as

> counting: the use of a systematic way to compare and order discrete objects…locating: exploring one's spatial environment, and conceptualising and symbolising that environment, with models, maps, drawings, and other devices…measuring: quantifying qualities like length and weight, for the purposes of comparing and ordering objects…designing: creating a shape or a design for an object or for any part of one's spatial environment…playing: devising, and engaging in, games and pastimes with more or less formalised rules that all players must abide by…explaining: finding ways to represent the relationships between phenomena (pp 59-60).

Further Gattegno (1970, 1988) argues that mental functionings, or structures, needed to learn to speak a language are akin to those used in doing mathematics. The implication that he draws is that anyone who succeeds in learning a language has already mathematized his or her linguistic domain and, therefore, capable of mathematizing other domains. Not only does he posit that mathematics is a birthright but also that mathematical structures are developed through a specific cultural activity: learning to speak a language.

Observers of less universal cultural contexts also narrate how people acquire "unschooled" knowledge of mathematics. Considerable research document that unschooled individuals, in their daily practice, develop accurate strategies for performing mental arithmetic. For example, the Dioula, an Islamic people of the Côte D'Ivore, have traditionally engaged in mercantile activities. Ginsburg, Posner, & Russell (1981) discovered that unschooled Dioula children develop similar competence in mental addition as those who attended school. These researchers hypothesize that this is a result, at least in part, of the daily experiences of children working in marketplaces. Further, studying Brazilian children who worked in their parents' markets, Carraher, Carraher & Schliemann (1985) conclude that "performance on mathematical problems embedded in real-life contexts was superior to that on school-type word problems and context-free computational problems involving the same numbers and operations" (p. 21). Through interview with the youngsters, these investigators learned that in the marketplace the children reasoned by mental calculations, whereas in the formal test they usually relied on paper and pencil, school-taught algorithms.

> Mistakes often occur as a result of confusing the algorithms. More over, there is no evidence, once the numbers are written down, that the children try to relate the obtained results to the problem at hand in order to assess the adequacy of their answers...The results [of this study] support the thesis...that thinking sustained by daily human sense can be—in the same subject—at a higher level than thinking out of context (p. 27).[13]

[13] We do not interpret this work as suggesting that these youngsters *cannot* do school mathematics. Carraher, Carraher & Schliemann conclude just that the school mathematics curriculum should *start* from the mathematical knowledge that the children already have (p. 28). Further, Ginsburg (1982) reflects on this issue cross-culturally:

> although culture clearly influences certain aspects of cognitive style (i.e., linguistic style), other cognitive systems seem to develop in a uniform and robust fashion, despite variation in environment or culture. Children in different social classes, both black and white, develop similar cognitive abilities, including basic aspects of mathematical thought (pp. 207-208).

In the same study, he also concludes that "upon entrance to school virtually all children possess many intellectual strengths on which education can build…Elementary education should therefore be organized in such a way as to build upon children's already existing cognitive strengths." He

Using these studies, and ethnographic data of adults in the United States engaged in supermarket and weight-watching activities, Lave (1988) argues against considering mathematical knowledge and context separately. Rather, she theorizes that "activity-in-setting [is] seamlessly stretched across persons-acting" and that the context often shapes the mathematical activity, becoming the calculating device, rather than merely the place in which the mathematical calculations are applied (p. 154). Scribner (1984) found that this occurs when dairy workers invent their own units (full and partial cases) to solve, on-the-job, problems of product assembly. In another example, Lave (1988) describes how a shopper who found, in a bin, a surprisingly high-priced package of cheese investigated for error by searching through the bin for a similar-sized package and checking to see whether there was a price discrepancy (p. 154). If instead, the problem were solved as a textbook problem rather than as a calculation shaped by the setting, the shopper would have divided weight into price and compared that quotient with the price per pound printed on the label. Lave uses, in both senses of the term, the phrase "dissolving problems" for discussing what happens in practice. Mathematics problems "disappear into solution with ongoing activity rather than 'being solved.' Such transformations pose a challenge to scholastic assumptions concerning the bounded character of math problem solving as an end in itself" (p. 120).

Lave then theorizes about the societal reasons why so many shoppers attend to arithmetic. School mathematics, she contends, is filled with shopping applications, so that money becomes a value-free, "natural" term, just a form of neutral school arithmetic. When adults go shopping their choices are first made qualitatively. That is, an item may be the best buy mathematically but is rejected because the package is too big to fit on their pantry shelf. However, they fall back on arithmetic calculations when there is no other criteria for choice. This provides a basis for believing that their decision is rational and objective. Thus, as Lave argues, "price arithmetic contributes more to constructing the incorrigibility of 'rationality' than to the instrumental elaboration of preference structures" (p. 158).[14,15]

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further argues that the reason why poor children do not do "well" in school "may include motivational factors linked to expectations of limited economic opportunities, inadequate educational practices, and bias on the part of teachers…[therefore] reform efforts must not be limited to the psychological remediation of the poor child. They must also focus on teaching practices, teachers, and the economic system" (pp. 208-209).

[14] Borba (1991), in a manuscript on the politics intrinsic to "academic" mathematics, argues that the use of mathematics in everyday life not only makes our choices seem more "rational," but serves to end the discussion. Once we use mathematics to justify a decision, no one can question that discussion ---after all, it is now "scientifically proved."

[15] Frankenstein (1987) also contends that the shopping applications of school arithmetic curricula contribute to the appearance of "naturalness" in the way our social and economic structures are

Focusing on the linguistic construction of this kind of mathematical rationality, Walkerdine (1988) argues that a key way in which this "mathematically precise," positivist rationality gets constructed is through the suppression of the multiple meanings of lexical terms in different practices. One set of meanings, one path to cognitive development is chosen as true, as "normal." By analyzing transcripts of children using and learning basic mathematical concepts such as size relations, she indicates how the meaning of these mathematical terms is shaped by social relations constituting the practice in which those words are used. Schools, she contends, ignore these multiple signification's and, therefore, make judgments about the conceptual development of children which produce a particular set of behaviors and which then are considered *the* rational path to intellectual development. For instance, in asking children questions that involve comparing the sizes of "daddy, mommy and baby bear," teachers tend to ignore how the power relations in their families add another signification to the terms "big, bigger, biggest." For instance, in the life of a child, daddy may be the biggest physically but mommy may be the biggest power figure. Children may answer the school mathematical question incorrectly because the "bear story" context is confused with the meanings of size in their family practices, not because they are "unready" to learn the size concepts of the curriculum. Formal academic mathematics is "built precisely on a bounded discourse in which the practice operates by means of suppression of all aspects of multiple signification. The forms are stripped of meaning, and the mathematical signifiers become empty" (p. 97). Walkerdine goes on to suggest that to learn school mathematics, children must learn to treat all applications, all practices as undifferentiated aspects of a value-free, neutral, and rational experience.

Because of this suppression of reference, the discourse of mathematics in schools supports an ideology of rational control, of reason over emotion, and of scientific over everyday knowledge. But even these "reference-free" mathematical concepts are shaped by specific philosophical and ideological orientations. For example, Martin (1988) cites Forman who analyzed how the intense antagonism to "rationality" which existed in the German Weimar Republic after World War I resulted in a particular interpretation of a mathematical construction.

> Forman suggests that this pressure led the quantum physicists to search for…a mathematical formalism which could be interpreted as non-causal. In crude terms, the acausal Copenhagen interpretation and its associated mathematical framework was adopted because they looked good publicly.…In the decades since the establishment of the orthodox or

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organized. Her adult students often find it ludicrous to think of restructuring society where food was free, for example, where eating was a civil right not a paid for commodity.

> Copenhagen interpretation, a number of alternative interpretations have been put forth. Some of these use the same mathematical formulations, but interpret their physical significance differently, while others use different mathematical formulations to achieve the same or different results....[So] the interpretation of the equations of quantum theory as supporting indeterminism was not *required* by the equations themselves. Furthermore, it seems possible that many of the achievements of the theory might have been accomplished using a somewhat different mathematical formulation which could well have been *difficult* to interpret inderterministically (pp. 210-211).

On other occasions, philosophy and ideology have prompted variant interpretations of fundamental mathematical concepts and techniques. For instance, the dialectics and historical materialism of Karl Marx, along with his project to elaborate the principles of political economy, between 1873 and 1881, lead him to study, criticize, and develop an alternative theoretical foundation for the differential calculus (Marx, 1983). His critique of prevailing methods for deriving the derivative of a function was twofold: (1) the derivative of a function was always present before the actual differentiation occurred and (2) none of the methods accounted for the dialectical nature of motion and change to which a function is subjected in the process of differentiation (Powell, 1986, p. 120). Out of touch with professional mathematicians and unaware of Cauchy's work on the calculus and limits, Marx overcame his critique of the theoretical foundations of the calculus by developing both a conceptual formulation and a technique for differentiation that captured symbolically the vexing problematic that was the impulse behind the method of Newton and Leibniz: motion and change. Indeed, his discoveries, stimulated and informed by his philosophical and ideological framework, represented rediscoveries and, in some instances, anticipated future conceptual and philosophical developments (Gerdes, 1985; Powell, 1986).

Though it was grounded in a praxis, the conceptual, mathematical description of dynamics, Marx attempted to undergird the calculus with a cultural construct—dialectics—which was part of the philosophical and ideological perspective of an identifiable cultural group. Mathematical knowledge seems unconnected to cultural context since, in isolation and at historical moments distant from their genius, particular mathematical ideas, such as the derivative, may appear detached from a specific cultural interpretation or application. Ideas, however, do not exist independent of social context. Moreover, as some critical theorists and realist philosophers remind us, our categories, concepts, and other ideas are essentially dependent on objective reality or nature. In a critique of anti-realist epistemology, Johnson (1991) rightly argues that

> …all these (social) things are materialized in, and dependent on, that which is essentially mind-independent, namely: the natural world. The very human activity of "cutting up" the world into [for example] hammers and chairs presupposes a world of naturally existing things (like trees and iron ore) capable of being fashioned into tools. In other words, the essential independence goes one way: *nature is essentially independent of mind, but mind (and all its products) is not essentially independent of nature* (1991, p. 25).

The social and intellectual relations of individuals to nature or the world and to such mind-dependent, cultural objects as productive forces influence products of the mind that are labeled mathematical ideas. Further, though there are recognized philosophical variants to the foundations of mathematics, the seemingly non-ideological character of mathematics is reinforced by a history which has labeled alternative conceptions as "non-mathematical" (Bloor, 1976, as cited in Martin, 1988, p. 210).

Uncovering distorted and hidden history of mathematical knowledge

For our struggle toward human liberation, a major obstacle to overcome, Freire (1970, 1973) insists, is the "culture of silence." Through its mechanisms, the oppressed participate in their own domination by internalizing the views of oppressors and by not speaking or otherwise acting against those oppressive views. In the United States, this culture of silence concerning mathematical knowledge is fueled by the ideology of "aptitudes"—the deep-seated belief that "a difference in essence among human beings…predetermines the diversity of psychic and mental phenomena" (Bisseret, 1979, p. 2). Particular individuals, and various communities believe, speak and act as if they do not have "mathematical minds." Key structural, emotional, and culturally-conditioned cognitive factors that lead women to believe men have more mathematical "aptitude" have been explored. Tobias (1978) and Dowling (1990) discuss research into the hidden messages about gender, race, and class in the content and images of mathematics textbooks; Beckwith (1978) summarizes studies of media influence on children's perception of alleged superior mathematics abilities of boys. Ernest et al. (1976) conclude that these beliefs are "the result of many subtle (and not so subtle) forces, restrictions, stereotypes, sex roles, parental-teacher-peer group attitudes, and other cultural and psychological constraints" (p. 11). We argue that another significant reason so many women and people of color are "mathematically silent" is because of the wide-spread myths presented in Western "his-stories" of mathematics.

The prevailing Eurocentric, and male-centric, myth, expressed in the writings of many Western mathematicians, such as Kline (1953), is that:

> [mathematics] finally secured a firm grip on life in the highly congenial soil of Greece and waxed strongly for a short period.…With the decline of Greek civilisation, the plant remained dormant for a thousand years.…When the plant was transported to Europe proper and once more imbedded in fertile soil (pp. 9-10).

This and other myths permeate the history of mathematics so deeply that even the images of mathematicians presented in textbooks, such as Euclid, who lived and studied in Alexandria, are "false portraits…which portray them as fair Greeks not even sunburned by the Egyptian sun." There are no actual pictures of Euclid and no evidence to suggest that he was not a black Egyptian (Lumpkin, 1983, pp. 104-105). Joseph (1987) discusses the cosmopolitan, racially diverse nature of Alexandrian society, "a meeting place for ideas and different traditions…[involving] continuing cross-fertilisation between different mathematical traditions, notably the algebraic and empirical traditions of Babylonia and Egypt interacting with the geometric and anti-empirical traditions of classical Greece" (p. 18). African, Egyptian, Alexandrian society created the environment in which some of its citizens (and probably their students)—for example, Euclid, Archimedes, Apollonius, Diophantus, Ptolemy, Heron, Theon, and his daughter Hypatia—contributed to the development of mathematics.

We gain further insight into why such myths were created and perpetuated, which deny a community and culture of its history, when we examine how racism and sexism have impacted academic research. For example, European scholars arbitrarily, yet purposefully, changed the date of the origination of the Egyptian calendar from 4241 to 2773 B.C., claiming that, "such precise mathematical and astronomical work cannot be seriously ascribed to a people slowly emerging from neolithic conditions" (Struik, 1967 pp. 24-25, quoted in Lumpkin, 1983, p. 100).[16] For another example, the name of a key researcher in the theory of the elasticity of metals—the research which made possible the construction of such remarkable engineering feats as the Eiffel Tower—was not listed among the seventy-two scientists whose names are inscribed on that structure. They are all men, and the contribution of Sophie Germain remains unrecognized (Mozans, quoted in Osen, 1974, p. 42). This is just a small piece of a much larger the historical picture that obliterated knowledge that, in spite of sexism, women did contribute to the mathematics sciences.

We gain additional insight into the complexity of the Eurocentric myth when we note that, although Euclid is adamantly described as "Greek," Ptolemy

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[16] Lumpkin goes on to report that new discoveries caused Struik to reconsider. In a personal communication to her, he states that "[a]s to mathematics, the Stonehenge discussions have made it necessary to rethink our ideas of what neolithic people knew. Gillings (1972) has shown the ancient Egyptians could work with their fractions in a most sophisticated way."

(*circa* 150 AD) whose work dominated astronomy until replaced by Copernicus's theory around 1543, is often described as "Egyptian." Ptolemy's more "practical," applied work could be contrasted to Euclid's more "theoretical" contributions (Lumpkin, 1983, p. 105). As we have discussed, Harris (1987) shows how this distinction continues to denigrate women's knowledge. Diop (1991) discusses a number of cases in which European scholars used this practical-theoretical hierarchy to deny the sophisticated mathematical knowledge of the ancient Egyptians. In the case of the Egyptian formula for the surface of a sphere ($s = 4pr^2$ demonstrated in problem 10 of the Papyrus of Moscow), Diop shows how Peet (1931) "lets his imagination run its course" in a "particularly whimsical effort" to avoid attribution of this mathematical feat to the Egyptians. Instead, Peet tries to demonstrate that problem 10 represents the formula for the surface of a half-cylinder, knowledge which is consistent with the less sophisticated mathematics he believed the Egyptians understood:

> The conception of the area of a curved surface does not necessarily argue a very high level of mathematical thought so long as that area is one which, like that of the cylinder, can be directly translated into a plane by rolling the object along the ground. (quoted in Gillings (1972), p.198)

To transform this information in the Papyrus, Peet, "who does not recoil from this difficulty," explains that only one datum[17] is given in problem 10 because the diameter and height of the cylinder were equal, so the one datum represents both values! In addition, Peet theorizes that the scribe in charge of recopying the Papyrus must have made a mistake and omitted a statement about the second missing datum (Diop, p.253)!! Further, Diop points out that even Gillings, who argued forcefully for the sophisticated mathematical knowledge of the ancient Egyptians, gets caught up in the practical-theoretical dichotomy. After accepting the interpretation of problem 10 as the formula for the curved surface of a hemisphere, 1500 years ahead of Archimedes work, Gillings speculates that:

> Whether the scribe stumbled upon a lucky close approximation or whether their methods were the results of considered estimations over centuries of practical applications, we cannot of course tell….[From murals and other art, one can conclude that] the art of the basket maker or weaver must have been one of some consequence in the Egyptian economic world. When one is weaving baskets which are roughly hemispherical one requires a quantity of material for the circular plane lid that is about half that

[17] Only one datum, the diameter, is needed in the formula for the surface of a sphere; both the diameter and height are needed in the formula for the surface of a cylinder.

> required for the basket itself. Since the calculation of the area of a circle was a common place operation to the scribes (problem 50 of the Rhind Mathematical Papyrus), over a period of years it could have come to be equally commonplace that the curved area of the hemispherical basket was double that of the circular lid (pp. 200-201).

Diop comments on how absurd it is to think that solely empirical observation, without any theoretical reasoning, could lead to such complex mathematical knowledge. Finally, Diop (1991) remarks on how curious it is that

> [i]f the ancient Egyptians were merely vulgar empiricists who were establishing the properties of figures only through measuring, if the Greeks were the founders of rigorous mathematical demonstration, from Thales onwards, by the systemization of 'empirical formulas' from the Egyptians they would not have failed to boast about such an accomplishment (p. 255).

The above discussion provides examples of the interaction and intersection of racism[18] and sexism with intellectual elitism, which, in part, is fueled by the different values attributed to practical and to theoretical work. Such hierarchical distinctions are antithetical to the epistemological position of Freire. For the dichotomy in work and value assigned to theory are what Anderson (1990) theorizes as key factors in the alienation that results from capitalist modes of production which "distances people from their creative source and their creativity…and allows capital to extract more surplus value from human labor and gain more control over our minds and socio-political activities" (p. 352). Instead, if we understand the creation and development of mathematics as inextricably linked to the material development of society, we can undistorted and uncover its hidden history.

In ancient agricultural societies, the needs for recording numerical information that demarcated the times to plant, gave rise to the development of calendars such as that found on the Ishango bone, dating between 9000 BC and 6500 B.C., found at a fishing site of Lake Edwards in Zaire (Zaslavsky, 1983, pp. 111-112; De Heinzelin, 1962, June). And, as African women, for the most part, were the first farmers, they were most probably the first people involved in the struggle to observe and understand nature, and therefore, to contribute to the development of mathematics (Anderson, 1990, p. 354). Then, as societies evolved, the more complex mathematical calculations that were needed to keep track of trade and commerce gave rise to the development of place-value

[18] For another example, this time of the denial of the knowledge that the ancient Egyptians used to construct the Pyramids, see Bernal (1987, pp. 272-280).

notation by Babylonians (*circa* 2000 B.C.) (Joseph, 1987, p. 27). And this continues to the present day when for example, military needs and funding drive the development of artificial intelligence (Weizenbaum, 1985)

CONCLUSION: IMPLICATIONS FOR FURTHER ETHNOMATHEMATICAL RESEARCH

As the field of ethnomathematics develops, we will need to continue re-interpreting conclusions others have drawn about various people's mathematical knowledge, and continue uncovering and disseminating the distorted / hidden history of mathematical knowledge. This research will expand and deepen the knowledge we create and re-create about our world; it will also lead us to re-examine how we generate knowledge. So, for example, we suggest co-investigation between students and teachers into discovering each others' ethnomathematical knowledge. This will improve our teaching, as we discuss below, and will also point the way to new research methodologies. Finally, in support of Freire's theory that the purpose of knowledge is for people to resolve the fundamental contradiction of our epoch between domination and liberation, we need to explore the connections between the cultural action involved in teaching and learning ethnomathematics and the economic and political action needed to create a liberatory society.

As ethnomathematical knowledge forces us to reconsider what counts as mathematical knowledge, it also forces us to reconsider all of our knowledge of the world. Henderson (1990) argues that although "formal, symbolic expressions are often excellent ways of capturing certain aspects of our experience" the erroneous view that "formal" mathematics is the ultimate, *real* mathematics "limits the understandings which we construct of our human experience…[and] damages the human spirit" (p. 5). Pinxten, van Doren, & Harvey (1983) argue that the mathematics education of Navajos start from a fully developed knowledge of their spatial system (a dynamic system which is in direct contrast to the static concepts of academic mathematics), not solely because this is the only way to avoid socio-cultural and psychological alienation of Navajos, but also because "[a]s long as science cannot pretend to have valid answers to all basic questions... it is foolish to exterminate all other, so-called primitive, prescientific, or otherwise foreign approaches to world questions" (p. 174). Adams (1983) reminds us that in Eastern societies such as India and Africa, "There are no distinct separations between science and religion, philosophy and psychology, history and mythology. All of these are viewed as one reality and are closely interwoven into the fabric of daily life" (p. 43).[19] He argues that

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[19] In this essay, Adams provides an incredible example of the exaggerated distortion of the knowledge of African peoples. To explain how the Dogon of Mali acquired their extensive astronomical knowledge some Western scientists went as far as hypothesizing that alien ships landed from outer space to tell the Dogon about the stars (1983, pp. 36-37).

Western science would deepen its knowledge of the world by reconsidering the value of emotional, intuitive and spiritual knowledge. He quotes Einstein who claimed "there is no inductive method which could lead to the fundamental concepts of physics…there is no logical path to these laws; only intuition, resting on a sympathetic understanding of experience, can reach them" (p. 41). We feel much more research needs to be done to uncover how the logic of all peoples can interact with each other to help us all understand and act more effectively in the world.

One place for mathematics teachers to start this research is with our students' ethnomathematics. These explorations suggest the importance of developing methodologies that effectively and ethically probe our students' mathematical knowledge. Powell and López (1989) as well as Powell and Ramnauth (1992) use a participatory research model combined with journal and other writing activities to prompt students to reflect on both the cognitive and affective components of learning mathematics and to engage them in analyzing critically methodological dimensions of teaching and learning. As López observes he

> became interested in the study due to my poor math skills. I felt that if I took a more active role in the learning of mathematics I might be able to do better in the course. Throughout the semester I kept a journal detailing my observations of the class, course, and my learning of mathematics.…We met after classes and whenever our schedules allowed us to discuss what I felt that I had gained as a result of writing in a mathematics course. I was then asked to comment on the writing experience and the journals that I had kept, to see exactly how it was that I had gained a better understanding of the mathematics I was learning. I found many instances where certain ideas or concepts became clearer to me as a result of writing about them… (Powell & López, 1989, p. 172).

Extending the idea that writing is effective in learning mathematics and that teacher and student jointly can study this process, Powell, Jeffries, & Selby (1989) have inserted into the discussion the need to attend to the more general, human process of empowerment. Their concern is for the empowerment of all actors in various settings of mathematics education. Not only did students and instructors study students' journals, but students critiqued the instructors pedagogical approach. In analyzing the project, students went on to define research activities in pedagogy to be participatory and to have the potential to be empowering when they give authority to the voices of students. For students generally feel, and are often considered, to be without power in many instructional settings. To give authority to the voices of students and to incorporate their perspectives in transforming mathematics pedagogy, instructors must begin by listening to students and finding in-depth ways to incorporate students' perspectives into educational research.

On the other hand, we need to avoid what Youngman (1986) calls Freire's tendency toward an "uncritical faith in 'the people' [which] makes him ambivalent about saying outright that educators can have a theoretical understanding *superior* to that of the learners and which is, in fact, the indispensable condition of the development of critical consciousness" (p. 179). While we listen to students' themes, we organize them using our critical and theoretical frameworks, and we re-present them as problems challenging students' previous perceptions. We also suggest themes that may not occur to our students, themes we judge are important to shattering the commonly held myths about the structure of society and knowledge that interfere with the development of critical consciousness.

We need to do more research to find ways of helping our students learn about their ethnomathematical knowledge, contributing to our theoretical knowledge, without denying inequality of knowledge, but as much as possible "based on co-operative and democratic principles of equal power" (Youngman, 1986, p. 179). And we need to attend to Freire's concept of praxis—the inseparability of action and reflection—to break down the dichotomies between teaching and learning, between formulating research questions and finding answers. As Lave (1988) concludes about the Adult Math Project study of supermarket mathematics, "description and analysis have been part of the project as a whole in all its phases, rather than uniquely divided between methods (or disciplines)" (p. 121).[20]

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[20] Lave's work on the inseparability of cognition and context and an ethnomathematical perspective of the meaning of "logical thought," forces us to re-evaluate A. R. Luria's (1976) conclusions about reasoning and problem solving. His political project was progressive, stemming from a desire to show that with schooling peasants were intellectually equal to people in the other classes in Russian society. But his interpretations were limited by his static view of what "abstract" reasoning is. His cognitive psychological experiments in mathematics problem solving with unschooled people in remote Russian villages led him to theorize that these people could not abstract "the conditions of the problems from extraneous practical experience…and [derive] the appropriate answer from a system of reasoning determined by the logic of the problem rather than graphic practical experience" (p. 120). Luria felt that "the significance of schooling lies not just in the acquisition of new knowledge, but in the creation of new motives and formal modes of discursive verbal and logical thinking divorced from immediate practical experience" (p. 133). But, if as Lave recognizes, cognition occurs always inextricably seamlessly intertwined in practice then possibly Luria's experimental findings were the result of a cultural dissonance (affective, linguistic, ideological, and so on) between the experimenters and the experimented upon. And if, as a Freirean ethnomathematical view theorizes, we cannot and do not want to dichotomize the abstract and the practical, then we can conclude that school's attempts to do this are attempts to *obscure* knowledge in the interest of the status quo. We hope some people more versed in cognitive psychology than we are, will pursue these questions. Also, we think such a re-evaluation of Luria would be an important case study in how even the most progressive, critical projects occur in a

But the underlying question throughout all this work is how the cultural action involved in teaching and learning ethnomathematics can play a role in the economic and political action needed to create a liberatory society. Carby (1990) highlights this issue in her remarks on the changes in the literary canon at the universities, where African-American women have become subjects on the syllabus, but the material conditions of most African Americans are still ignored. She challenges us to think through the issues of real power: "Are the politics of difference effective in making visible women of color while rendering invisible the politics of exploitation?" (p. 85). Moreover, as Lange and Lange (1984) found, although mathematics education can be empowering in a more general way, it is not necessarily the best approach in working with people on specific empowerment issues. The piece-rate workers they were organizing in the textile industry in the southern United States were struggling with a pay system made intentionally obscure, and the Lange's felt it was more empowering to create a slide-rule distributed by the union that did the pay calculations for the workers, making the mathematics problem disappear, so that the workers could "focus on the social and economic relations underlying the way they are treated and paid" (p. 14).

On the other hand, the general empowerment through ethnomathematical knowledge is, we feel, a very important part of the struggle to overcome a colonized mentality, Samora Machel (1978) argues that

> colonialism is the greatest destroyer of culture that humanity has ever known. African society and its culture were crushed, and when they survived they were co-opted so that they could be more easily emptied of their content. This was done in two distinct ways. One was the utilization of institutions in order to support colonial exploitation…The other was the 'folklorising' of culture, its reduction to more or less picturesque habits and customs, to impose in their place the values of colonialism (p. 400).

As we have discussed above, the connections between educational action and liberatory social change are the most undeveloped aspects of Freire's theories. Our practice confirms that ethnomathematical knowledge increases student's self-confidence and opens up areas of critical insight in their understanding of the nature of knowledge. But there is no confirmation that this knowledge results in action against oppression and domination. In the current historical context of an advanced capitalist society, it may be that the most critical collective change that a pedagogy of the oppressed can bring about is a subtle shift in ideological climate that will encourage action for a just socialist

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historical context which limits their work. As Freire's epistemology says, *no* knowledge is static, all knowledge must be critically interrogated, re-examined, and re-created.

economic and political restructuring. This is not significant. Nteta (1987) argues that "revolutionary self-consciousness [is] an objective force within the process of liberation" (p. 55). He shows how the aim of Steve Biko's theories and the Black Consciousness Movement in South Africa was "to demystify power relations so that blacks would come to view their status as neither natural, inevitable nor part of the eternal social order…created conditions that have irreversibly transfigured South Africa's political landscape" (pp 60-61). We argue that as we more clearly understanding the limits of our educational practice, we will increase the radical possibilities of our educational action for liberatory change. Thus, we feel the most important area for ethnomathematical research to pursue is the dialectics between knowledge and action for change.[21] Fasheh (1982) points the way to the direction of investigation by hypothesizing that

> teaching math through cultural relevance and personal experiences helps the learners know more about reality, culture, society and themselves. That will, in turn, help them become more aware, more critical, more appreciative, and more self-confident. It will help them build new perspectives and syntheses, and seek new alternatives, and, hopefully will help them transform some existing structures and relations (p. 8).

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[21] To this end, John Volmink and the authors (1991) have organized a Criticalmathematics Educators Group. See the Appendix for our proposed definition of a 'criticalmathematics educator,' adapted from the first newsletter (1991, p. 5), indicating many of the philosophical and pedagogical underpinnings of the group.

Appendix

Criticalmathematics Educator:

A definition[22]

As mathematicians, criticalmathematics educators view the discipline:

* as one way of understanding and learning about the world; they do not view mathematics as a static, neutral, and determined body of knowledge; instead, they view it as knowledge that is constructed by humans;

* as one vehicle to eradicate the alienating, Eurocentric model of knowledge, widely taught in the schools, particularly this model's narrow view of what are considered mathematical ideas and who are capable of owning ideas, and this model's historiography which excluded and distorted, marginalized and trivialized the contributions of women and men from all the world's cultures to what is then considered "academic" mathematics;

* as an human enterprise in which understanding results from actions; in which process and product, theory and practice, description and analysis, and practical and abstract knowledge are "seamlessly" (Lave, 1988) interconnected; and in which mathematics and other disciplines interact, as does knowledge with the contexts of social, economic, political and cultural perspectives.

As teachers, criticalmathematics educators:

* listen well (as opposed to telling) and recognize and respect the intellectual activity of students, understanding that "the intellectual activity of those without power is always characterized as nonintellectual" (Freire and Macedo, 1987);

* maintain high expectations and demand a lot from their students, insisting that students take their own intellectual work seriously, and that they participate actively as "co-interrogators" (Powell, Jeffries, & Selby, 1989) in the learning process;

* are not merely "accidental presences" (Freire, 1982) in the classroom, but are active participants in the educational dialogue, participants capable of

[22] It is patterned after the "radicalteacher" definition, constructed by Pamela Annas, which appears on the back cover of every issue of *Radical Teacher*. After the first issue, this defintion has been debated in subsequent issues of the newsletter.

advancing the theoretical understanding of others as well as themselves, participants who can have a stronger understanding than their students (Youngman, 1986);

* assume that minds do not exist separate from bodies, and that the bodies or material conditions, in which the potential and will to learn reside, are female as well as male and in range of colors; that thought develops through interactions in the world, and that people come from a variety of ethnic, cultural, and economic background; that people have made different life choices, based on personal situations and institutional constraints, and that people teach and learn from a corresponding number of perspectives ;

* believe that "most cases of learning problems or low achievement in schools can be explained primarily on motivational grounds" (Ginsburg, 1986) and in relation to social, economic, political, and cultural context, as opposed to in terms of a "lack of aptitude" or "cognitive deficit;"

* recognize the reality of mathematics anxiety and avoidance, but deal with them in ways that do not blame the victims, and that recognize both psychological and broader societal causes;

As concerned and active citizens, criticalmathematics educators:

* have a relatively coherent set of commitments and assumptions from which they teach, including and awareness of the effects of, and interconnections among, racism, sexism, ageism, heterosexism, monopoly capitalism, imperialism and other aliening totalitarian institutional structures and attitudes;

* believe that good intentions are not enough to define a criticalmathematics educator; criticalmathematics educators are actively anti-racist, anti-sexist, anti-all the other alienating totalitarian institutional structures and attitudes, and they work with themselves, their mathematics classes and their colleagues to uncover, name, and change those conditions;

* view that a major objective of all education is to shatter the myths about societal structures, to develop commitment to rebuild alienating structures and attitudes, and to strive for the personal and collective empowerment needed to accomplish these tasks;

* are open to debate about which curricula and which investigations best achieve our goals; there are varieties of criticalmathematics educators; e.g. feminist criticalmathematics educators are not in every respect identical with socialist criticalmathematics educators;

* maintain that "dehumanization, although a concrete historical fact, is <u>not</u> a given destiny, but the result of an unjust order" (Freire, 1970);

* are militants in the Freirean sense of the term, committed to justice and liberation: "Militancy forces us to be more disciplined and to try harder to understand the reality that we, together with other militants, are trying to transform and re-create. We stand together alert against threats of all kinds" (Freire, 1978);

* understand that no definition is static or complete, all definitions are unfinished, since language grows and changes as the conditions of our social, economic, political, and cultural reality change;

* also have fun, laugh, and play…(CmEG Newsletter, 1991).

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Palavras-chave: ethnomathematics
Comentários:
Data de criação: 09/07/02 09:55
Número de alterações: 2
Última gravação: 09/07/02 09:55
Gravado por: User4
Tempo total de edição: 1 Minuto
Última impressão: 25/07/02 11:53
Como a última impressão
Número de páginas: 36
Número de palavras: 11.869 (aprox.)
Número de caracteres: 67.658 (aprox.)