DOCUMENT RESUME

ED 471 919 RC 023 774

AUTHOR	Bush, William S.
TITLE	Culture and Mathematics: An Overview of the Literature with a View to Rural Contexts. Working Paper.
INSTITUTION	Ohio Univ., Athens.
SPONS AGENCY	National Science Foundation, Arlington, VA.
REPORT NO	WP-2
PUB DATE	2002-10-00
NOTE	23p.; Produced by the Appalachian Collaborative Center for Learning, Assessment and Instruction in Mathematics.
CONTRACT	NSF-0119679
AVAILABLE FROM	For full text: http://kant.citl.ohiou.edu/ACCLAIM/rc/rc_sub/pub/3_wp/BB_WP1.pdf.
PUB TYPE	Information Analyses (070)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	Cognitive Style; Comparative Education; Cultural Context; *Cultural Differences; *Cultural Influences; Culturally Relevant Education; Elementary Secondary Education; Ethnic Groups; *Ethnomathematics; Mass Media Effects; *Mathematics Achievement; *Mathematics Education; Parent Attitudes; Parent Influence; Rural Education; Social Influences; Student Attitudes; Teacher Attitudes
IDENTIFIERS	Situated Learning

ABSTRACT

This paper summarizes the literature and research on the relationships between culture and mathematics. Ethnomathematics examines the ways that different cultural groups use mathematics. Various definitions of ethnomathematics are presented, along with a framework covering areas of mathematics and mathematics education included in the term. Summaries and sample writings are offered for each of these areas: the cultural nature of mathematics, mathematical thought in different cultures, cultural history of mathematics, politics of mathematics, mathematics learning in different cultures, situated cognition including language and bilingualism, societal effects of mathematics education, and relationships between ethnomathematics and mathematics education. In addition, research is cited on the effects of culture on mathematics achievement, focusing on the transmission of cultural influences via popular media, parents, teachers, and students' own beliefs and attitudes. Examples of cultural influences on mathematics achievement are offered for Asian American, African American, Native American, and Hispanic students, as well as students from some foreign cultures. A research agenda for culture and mathematics is outlined that is relevant to understanding how mathematics is situated in a rural setting. (Contains 119 references.) (SV)

Working Paper Series

Appalachian Collaborative Center for Learning, Assessment and Instruction in Mathematics

Culture and Mathematics: An Overview of the Literature with a View to Rural Contexts

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October 2002

ACCLAIM's mission is the cultivation of *indigenous leadership capacity* for the improvement of school mathematics in rural places. The project aims to (1) understand the rural context as it pertains to learning and teaching mathematics and (2) articulate in scholarly works, including empirical research, the meaning and utility of that learning and teaching among, for, and by rural people.

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Funded by the National Science Foundation as a Center for Learning and Teaching, ACCLAIM is a partnership of the University of Tennessee (Knoxville), University of Kentucky (Lexington), Kentucky Science and Technology Corporation (Lexington). Marshall University (Huntington, WV), University of Louisville, and Ohio University (Athens, OH).

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This material is based upon the work supported by the National Science Foundation Under Grant No. 0119679. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Culture and Mathematics: An Overview of the Literature with a View to Rural Contexts

Much has been written about relationships between culture and mathematics. The writings span a range of topics that include the cultural bases for mathematics, mathematics development in different cultures, the historical culture of mathematics, the effects of culture on mathematics learning and dispositions toward mathematics, and the political effects of mathematics and mathematics education on societies. This paper summarizes the literature and research by discussing major concepts, writers, and tenets; it concludes by offering a research framework for further study of mathematics and culture.

Ethnomathematics

Writings about culture and mathematics emerged in the early and late eighties around the concept of *ethnomathematics.* Ubiratan D'Ambrosio, a Brazilian mathematician, coined the term and offered one of its earliest definitions: "Ethnomathematics is the way different cultural groups mathematise (count, measure, relate, classify, and infer)" (D'Ambrosio, 1984). According to D'Ambrosio, the prefix *ethno* describes "all of the ingredients that make up the cultural identity of a group — language, codes, values, jargon, beliefs, food and dress, habits, and physical traits." The term *mathematics* describes "a broad view of mathematics which includes ciphering, arithmetic, classifying, ordering, inferring, and modeling" (pp. 2-3). Thus, *ethnomathematics* examines the ways different cultural groups use mathematics (D'Ambrosio, 1984).

At about the same time, other writers, including Paulus Gerdes of Mozambique, Marcia Ascher of the United States, and Alan Bishop of England, were conducting cultural research in mathematics and writing about ethnomathematics (Barton, 1996). Much of their work was published primarily in two international mathematics education journals, *For the Learning of Mathematics* and *Educational Studies in Mathematics*, with the latter publishing a monograph that Bishop edited. These writers laid important foundations for further writing about culture and mathematics and stimulated a variety of research studies.

A Problem with Definition

Since D'Ambrosio coined the term *ethnomathematics*, writers, including D'Ambrosio himself, have struggled with its meaning. A consensus was not evident in these early writings (Barton, 1996; Presmeg, 1998; Vital and Skovsmove, 1997). To illustrate, the following definitions of *ethnomathematics* were offered from 1984 to 1996:

> "The mathematics which is practiced among identifiable cultural groups such as national-tribal societies, labour groups, children of certain age brackets, and professional classes." (D'Ambrosio, 1985, p. 45)
>
> "The mathematics implicit in each practice." (Gerdes, 1986, p. 10)
>
> "The study of mathematical ideas of a non-literate culture." (Ascher and Ascher, 1986, cited in Barton, 1996, p. 209)
>
> "The codification which allows a cultural group to describe, manage, and understand reality." (D'Ambrosio, 1987, p. 3)
>
> "Mathematics ...is conceived as a cultural product which has developed as a result of various activities" (Bishop, 1988, p. 182).
>
> "The art of explaining, understanding and coping with the socio-cultural and natural environment... The dynamic of this interaction [between the individual and the environment], mediated by communication and the resulting codification and symbolisation, produces structured knowledge which eventually becomes disciplines" (D'Ambrosio, 1990, p. 22, cited in Barton, 1996, p. 208).
>
> "The study and presentation of mathematical ideas of traditional peoples" (Ascher, 1991, p. 188, cited in Presmeg, 1998, p. 328).
>
> "The arts or techniques developed by different cultures to explain, to understand, to cope with their environment" (p. 1184, D'Ambrosio, 1992).
>
> "Any form of cultural knowledge or social activity characteristic of a social group and/or cultural group, that can be recognized by other groups such as 'Western' anthropologists, but not necessarily by the group of origin, as mathematical knowledge or mathematical activity" (Pompeu, 1994, p. 3, cited in Presmeg, 1998, p. 328).
>
> "The mathematics of cultural practice." (Presmeg, 1996, p. 3, cited in Presmeg, 1998, p. 328).

As Barton (1996) noted earlier, these definitions pose contrasting views of *ethnomathematics* — from very specific views like those from Ascher, Pompeu, and early D'Ambrosio to very broad views like those of Bishop, Gerdes, and late D'Ambrosio. The definitions also show evolution over time, especially with D'Ambrosio, Gerdes, and Ascher (Barton, 1996). Vithal and Skovsmose (1997) and Barton (1996) both noted that the definitions of *ethnomathematics* offered by D'Ambrosio and Gerdes seemed to broaden over time.

Vithal and Skovsmose (1997), after an analysis of writings about *ethnomathematics*, offered a definition that attempts to capture the varied dimensions of the concept:

> "Ethnomathematics refers to a cluster of ideas concerning the history of mathematics, the cultural roots of mathematics, the implicit mathematics in everyday settings, and mathematics education" (p. 133).

Barton (1996), after reflective analyses of the writings of D'Ambrosio, Gerdes, Ascher, and others, noted that discussions about *ethnomathematics* were about either mathematics or mathematics education. Within each category, he identified four areas of writing.

Writings about Ethnomathematics	
Mathematics	Mathematics Education
Cultural Nature of Mathematics	Mathematics Learning in Other Cultures
Mathematics Thought in Other Cultures	Situated Cognition including Language and Bilingualism
Cultural History of Mathematics	Societal Effects of Mathematics Education
Politics of Mathematics	Relationships between Mathematics and Mathematics Education

Proceeding from this analysis, he offered an alternative definition of *ethnomathematics* that attempts to capture these categories and areas:

> "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).

According to Barton, this definition implies that "(a) ethnomathematics is not a mathematical study, it is more like anthropology or history; (b) the definition itself depends on who is stating it, and it is culturally specific; (c) the practice which it describes is also culturally specific; and (d) ethnomathematics implies some form of relativism for mathematics" (p. 215). Barton also provided a framework for research on culture and mathematics, which will be shared later in the paper.

Culture, Mathematics, and Mathematics Education

Using Barton's (1996) areas of *ethnomathematics* as a framework, we will offer a brief summary and sample writings within each area. Barton identified many of these writings; we have included other and more recent work.

Culture and Mathematics

The cultural nature of mathematics. At the heart of the cultural nature of mathematics is the nature of mathematics itself. According to Dossey (1992), mathematicians do not agree on the nature of mathematics. One of the primary issues is whether mathematics is "external" or "internal" to the person. The debate can be traced back to the days of Plato, an externalist, and Aristotle, an internalist (Dossey, 1992). This argument is pertinent to the relationship of culture and mathematics in that internalists see connections between mathematics and culture while externalists see mathematics as culture free. Alan Bishop (1976, 1983, 1986, 1988), one of the early writers about culture and mathematics, believes that mathematics is "a cultural product which has developed as a result of various activities." This "cultural product" includes counting, locating, measuring, designing, playing, and explaining. Stigler and Baranes (1988) also view mathematics as "an assemblage of culturally constructed representations and procedures for manipulating these procedures" (p. 258). These viewpoints certainly suggest an internal view of the nature of mathematics because culture is inherent in persons. Critics of ethnomathematics, like Barrow (1992), Chevallard (1990), and Penrose (1989) tend to be externalists.

Mathematical thought in other cultures. This research includes extensive anthropological work on the mathematical thought of different peoples throughout the world. The focus here is on the intuitive mathematics thinking that has developed in largely undereducated cultures. According to Barton (1994), these studies include work by Harris (1991) with aborigines in Australia, by Gay and Cole (1967) with the indigenous people of Liberia, by Pixten (1987) and Ascher (1991) with Native Americans in North America, by Kyselka (1981) with Pacific Islanders, Carraher (1986) with Brazilian construction foremen, and by Zaslavsky (1973) and Gerdes (1991a, 1991b, 1991c) with tribes in Africa. Collectively, this work shows that mathematical thought is developed intuitively and in lieu of formal schooling.

Cultural history of mathematics. This work attempts to identify the historical mathematical contributions of different cultures across the world. These writers attempt to demonstrate a cultural evolution of mathematics within other cultures. They also address the common belief that most worthwhile mathematics known and used today was developed primarily in the Western world (Europe and North America). D'Ambrosio's (1980) review of the evolution of mathematics and his call for incorporating ethnomathematics into the history of mathematics (D'Ambrosio, 1985) provide excellent early examples of this work. Other examples include Anderson's (1990) concept of world mathematics and Frankenstein's and Powell's (1989) attempt to redefine mathematics. According to Barton (1996), major works also include Gerdes (1992), Fang and Takayama (1975), Kline (1953), Swetz (1987), and Restivo *et al* (1993).

Politics of mathematics. This work attempts to show how mathematics has affected non-academic areas of society. According to Barton (1996), primary works include Bishop's (1990) essay on the powerful influence of Western mathematics and D'Ambrosio's (1990) discussion of the role of mathematics in building democratic and just societies. Knijnik's (1993) research on the political and economic power of mathematics for Brazilian sugar cane farmers offers an interesting addition to this work. Finally, Osmond's (2000) analysis of employers' perceived value of mathematics contributes to this area.

Culture and Mathematics Education

Culture and mathematics education also have strong relationships. Cultural values affect teaching, learning and curriculum. Formal mathematics teaching, learning, and curriculum can provide a reflection of culture. Clearly, mathematics education can affect the political and social dynamics of a culture.

Mathematics Learning in Other Cultures. These writings focus on the importance of using a culturally specific context in teaching and learning mathematics. The literature might include (a) using relevant cultural examples from students' culture or (b) exposing students to a variety of cultural contexts (multiculturalism). Examples of the first category include Nelson-Barber and Estrin (1995) and Bradley (1984), who provide insights into revising mathematics teaching and curricula to capture the traditions and culture of Native Americans; Gerdes (1988b, 2001), who offers suggestions for using African art and games in elementary classrooms; Malloy (1997), who provides suggestions for improving mathematics instruction for African American students; and Flores (1997), who provides suggestions for instructional strategies and materials for Hispanic students. Examples of the second category include articles by Becker and Jacobs (1997), Thomas (1997) and Davidson and Kramer (1997) in the 1997 NCTM Yearbook (Trentacosta and Kenney, 1997). Other examples include Zaslavsky's (1991, 1998) suggestions for integrating ethnomathematics in middle school and elementary classrooms, Karp's (1994) use of multicultural children's literature for teaching mathematics, Dolinko's (1997) use of flags in instruction, and Yao's (1984) suggestions for multicultural teaching.

Situated cognition including language and bilingualism. Research in this area focuses on culture's influence in learning mathematics. In situated cognition, the mathematics that is learned is generally not the formalized, codified mathematics learned in school, but the intuitive mathematics needed for specific tasks. Barton (1996) offers several examples of this type of research: Saxe's (1988) study of Brazilian candy vendors, Carraher's

(1985, 1989) work with illiterate Brazilians, Lancy's (1983) work with the Kewa of Papua New Guinea, Schribner's (1984) work with dairy farmers in the United States, Lave's (1988) study of American shoppers, and Masingila's (1992) study of carpet layers provide a variety of examples of this research. The analysis of children's different written and oral uses of arithmetic by Reed and Lave (1981) also fits into this category.

Another area in this category is the effect of bilingualism on mathematics learning. Significant research and discussions can be found in Austin and Howson (1979), Clarkson and Galbreath (1992), Cuevas (1984), Cathcart (1980, 1982), and Khisty (1997). In related studies, Moore (1994) points to differences in the mathematical language of Native Americans and the English language of mathematics. The work of Geary et al (1996) examining the advantages of the Chinese language for learning early number concepts also fits in this category.

Societal effects of mathematics education. Barton (1996) uses Gerdes's analyses of the societal effects of the mathematics education reformation in Mozambique (Gerdes, 1981, 1985) as examples in this category. Vithal and Skovsmose (1997) provide a similar analysis of the role of mathematics education in social changes within South Africa. Frankenstein (1997) suggests a *critical mathematics* pedagogy and curriculum, based on the critical education theory of Frerior (1978), to help students understand how mathematics can serve as a mechanism to create and reveal power and oppression. The Mathematics and Society curriculum that includes the social institution of mathematics offered by Abraham and Bibby (1988) provides an excellent example of the writing in this area. Stanic's (1989) call for the elimination of cultural discontinuity and social inequality in classrooms also addresses this issue directly.

Relationships between mathematics and mathematics education. According to Barton (1996), Borba's (1990), D'Ambrosio's (1999), and Vithal's (1992) theoretical discussions about ethnomathematics and curriculum fit this category. Presmeg's (1998) strategy for bringing ethnomathematics into teacher preparation programs clearly fits into this category. Walker's and McCoy's (1997) study of the relationships between African Americans' perception of mathematics and their motivation to learn mathematics is a recent example of this work.

Effects of Culture on Mathematics Achievement

Over the past twenty years, researchers in mathematics education have sought to understand how cultural differences affect students' performance in mathematics and their dispositions toward the subject. The research methodologies for these studies have been generally comparative; researchers attempted to identify cultural factors that might explain differences in mathematics achievement and attitudes. These studies investigated cultural differences across three general groups: (a) students from different countries (usually Asian nations and the United States); (b) students from different racial or ethnic groups (Asian American, African Americans, Native Americans, Hispanic American, and Caucasian Americans); and (c) males and females. This body of research has revealed four general cultural factors that seem to affect mathematics performance and dispositions: (a) parent attitudes, values, and beliefs; (b) teacher attitudes, values, and beliefs; (c) student perceptions and beliefs; and (d) language. These factors will serve as the organizing structure to review the research in the area.

Influence of the Popular Media

Leder (1992) suggests that societal influences on beliefs about gender differences in mathematics can be assessed through an analysis of media. She comments, "The important role played by the media in shaping ideas and attitudes, as well as reflecting and reinforcing popular beliefs, is widely recognized" (p. 612). She reports that Jacobs and Eccles (1985) found parents' beliefs about gender differences in mathematics could be shaped by the media. In an analysis of media reports, she found that the media promoted a stereotypical view of male roles in mathematical careers and tasks (Leder, 1984, 1986). Similarly, Malloy (1997) suggested that the media's emphasis on achievement gaps leads to stereotyping among African American parents, teachers, and students about students' ability to do mathematics.

Influence of Parents

Across all types of comparative studies — international, race/ethnic, and gender — parent expectations have strong effects on student performance and attitudes. As Leder (1992) has reported, Armstrong and Price (1982) and Lantz and Smith (1981) found that students' attitudes and aspirations toward mathematics were linked to their parents' educational goals with regard to school mathematics. In comparing Chinese and American parents, Stevenson (1987) noted that Asian parents generally believed that any child is capable of learning, but American parents placed more emphasis on innate ability. He also noted that American parents believed reading to be more important than mathematics, while Asian parents believe that mathematics and reading were equally important. In addition, a large body of research indicated that Asian parents emphasized effort as the key to success in school more than parents from other ethnic or racial groups (Holloway, 1988; Mizokawa & Ryckman, 1990; Hess, Chang, and McDevitt (1987); Lee, Ichikawa and Stevenson, 1987; Tuss, Zimmer, and Ho, 1995).

Studies comparing Asian American students with Caucasian American students identified similar parental effects, although enculturation in the United States seemed to have lessened the cultural effects slightly. Chen and Stevenson (1995) found that parents of Asian American students held higher standards of achievement, believed effort was critical to success, and had more positive attitudes about achievement and studying diligently than their Caucasian American counterparts. Sue and Okazaki (1990) found that Asian American parents were more likely to insist on unquestioned obedience. Kao (1995) found that Asian American parents invested more in educational resources than their American counterparts. Hutsinger and Jose (1995) explored relationships among mothers, fathers, and daughters in Chinese American and Caucasian American families as they solved spatial tasks together. They also found that Chinese Americans were more respectful, more serious, and more orderly, and Caucasian Americans were more sociable, more talkative, and used more humor in solving the tasks. Furthermore, Chinese American parents talked less to themselves and more to their daughters, whereas Caucasian American parents talked more to each other.

In comparing parents of African American, Caucasian American, Hispanic American, and Asian American students, researchers have noted that mothers in all groups had equally high expectations for their children (Alexander and Entwisle, 1988; Stevenson, Chen, & Uttal, 1990; Galper, Wigfield, & Seefeldt, 1997). African American parents, however, reflected ambivalent and often contradictory values about education to their children (Alsalam, 1991). Hispanic American parents were less confident that their children would get a good education or job after formal schooling (Galper et al., 1997).

As noted by Nelson-Barber and Estrin (1995), the parenting practices of Native American students tended to contradict traditional schooling practices. Traditional tribal learning emphasizes "watch-then do" or "listen-then do" rather than "trial and error," which is often emphasized in schools (Swisher and Deyhle, 1989). Brod (1976) also noted the high mobility of Native American families and their limited access to schools as factors in poor mathematics performance.

Influence of Teachers

Higher expectations of student performance is clearly reflected in the differences between middle school mathematics curricula in China and in the United States (Zhonghong and Eggleton, 1995). Mathematics curricula in the United States revealed low expectations for performance, while Chinese mathematics curricula challenged its students. Stigler and Hiebert (1999) also found different teaching routines among Japanese, German, and American teachers. They noted that Japanese teachers challenged students more, introduced more advanced content, and spent more time analyzing and preparing lessons than their German and American counterparts. For Hispanic students, Valverde (1984) noted that school curricula did not reflect the intrinsic, cultural learning of Hispanic students and that teachers were not prepared to address the cultural differences of Hispanic Americans. Bradley (1984) observed that many Native American students had extensive knowledge of mathematics deeply rooted in their culture and traditions; however, few teachers tapped into this reservoir of traditional knowledge (Kawagley, 1990; Pomeroy, 1988).

Leder (1992), in an analysis of research on teacher interactions with male and female students in mathematics classrooms, noted some subtle differences in the interactions. She noted that, in general, males received more criticism and praise, were monitored more frequently, and had more contacts with teachers. She also noted studies that suggested teachers generally supported the notion that mathematics is a male domain (Fennema, 1990; Leder, 1986). In general, she concluded that the cumulative effects of these interactions and beliefs could have substantial impact on the ways females view their potential in mathematics.

Influence of Students' Own Beliefs and Attitudes

Students' beliefs and attitudes can be viewed as a product of their cultural heritage and, to a large extent, an extension of parental beliefs and attitudes. It is not surprising, then, that research reveals similar differences across types of students. Despite poorer performance on most measures of mathematics achievement, American children were more optimistic about their performance and future in mathematics (Stevenson, 1987) and Hispanic students had high aspirations for rewarding careers than Asian students (Anderson and Johnson, 1971; Espinoza, Fernandez, and Dornbusch, 1977; Juarez and Kuvlesky, 1968). Ramirez and Castaneda (1974) found that Hispanic American students tend to be more field dependent than Caucasian American students. Similarly, Malloy (1997, p. 24) concluded, "African American students generally learn in ways characterized by social and affective emphases, harmony with the community, holistic perspectives, field dependence, expressive creativity, and non-verbal communication" (see also Stiff, 1990; Willis, 1992). Malloy (1997) also suggested that school knowledge and cultural knowledge of African Americans sometimes oppose each other. Therefore, African Americans often did not value school knowledge. Through interviews of African American high school students, Walker and McCoy (1997) found that students' perceptions of mathematics were related to familiar surroundings in home, school, and community and that their motivation to learn mathematics was diminished by a variety of factors, such as lack of teacher support and relevance, as well as increased involvement in extracurricular activities.

Influence of Language

Language also seems to affect mathematics performance. For example, Geary and colleagues (1997) found that the language structure of Asian number names assisted Chinese children in developing meaningful early number concepts. Valverde (1984) noted that differences in English and Spanish contributed to Hispanic Americans' poor performance and involvement in mathematics. Moore (1994) noted that Native American language did not align well with traditional mathematics vocabulary and terms, thereby causing learning problems for Native American students.

A Research Agenda for Culture and Mathematics

In keeping with his definition of *ethnomathematics* as a research program, Barton (1996) outlined a scheme for classifying, analyzing, designing, and reviewing research that focuses on relationships between culture and mathematics. Besides establishing a system for classifying studies of *ethnomathematics*, Barton's scheme also is extremely useful in our attempt to understand *how mathematics is situated in a rural setting*.

Barton classifies research in *ethnomathematics* in three dimensions: time, culture, and mathematics. "On the time dimension, *ethnomathematics* may be concerned with conceptions of an ancient or a contemporary cultural group" (p. 220). It also may be concerned with historical or contemporary practices of a cultural group. Examples might include research on how early Appalachian settlers used mathematics or on modern-day Appalachian entrepreneurs' use of mathematics. "The cultural dimension of the definition extends from a distinct ethnic group, to a purely social or vocational group" (p.20). Research on this dimension may focus on African Americans in Appalachia, male teens in Appalachia, or teachers in Appalachia. "The mathematical dimension of ethnomathematics is determined by the relationship of the mathematical ideas to mathematics itself, i.e., ethnomathematics is a study which may be internal to mathematics, or conceptually removed from existing mathematical conventions." (p. 220). Examples of this dimension might include the varied formal conceptions of mathematics held by Appalachian teachers or the mathematics used by craftsman in Appalachia. The graph in Figure 1 (taken from Barton) below describes how these three dimensions might interact.

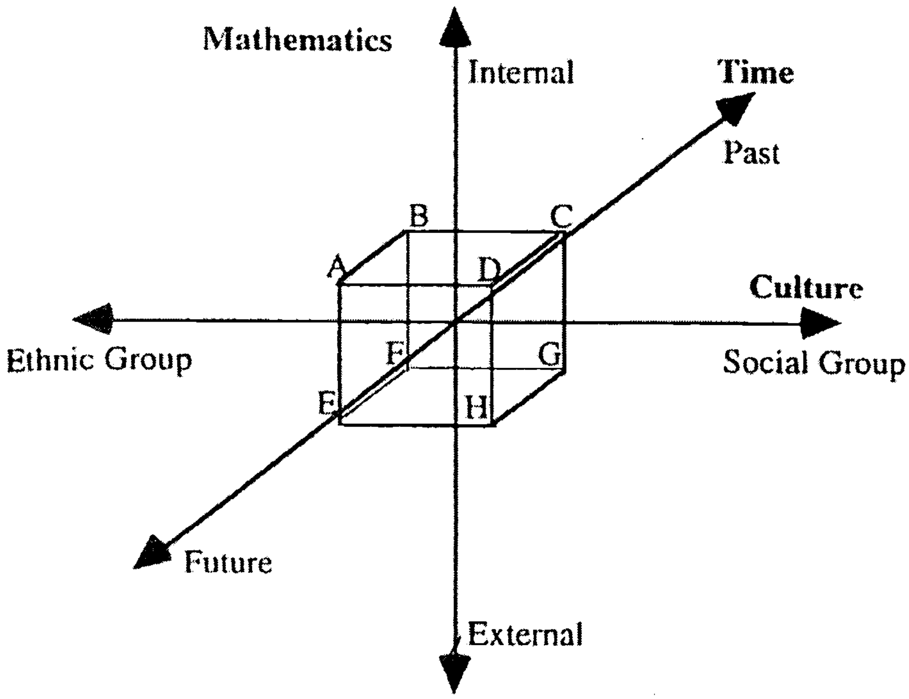

Fig. 4.

In shaping an agenda for research on culture and mathematics in Appalachia, one might consider this structure to define and delineate the parameters for our research.

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