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A Multicultural Matrix for Mathematics Education: Generic Ideas

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A major goal in mathematics education is to make learning more connected and meaningful for students. Supporting this goal is an emphasis on the integration of applications into curricula. These emphases provide many benefits. By connecting school learning with the world in which students live, we have the opportunity to pique student interest and motivate learning. We also provide the chance to deepen student understanding of the world around them. They may see that real learning is connected to many disciplines and also to many strands in mathematics.

One significant area of applications is the use of mathematics by the many peoples and cultures of the world both currently and in the past. Around the world, cultural groups, both native and immigrant, are concerned that youngsters recognize and value their cultural heritage. Often mathematics is embedded in cultural phenomena without members of the culture even aware of it. (Ascher, 1991). As families around the world become more mobile, it becomes more important for students to recognize the contributions to mathematics within their own heritage as well as that of others. Furthermore, there is a growing hope worldwide that through global understanding we may build peace. Thus, youngsters need to appreciate the diversity and insights of the many cultures that have and continue to contribute to human history. Indeed, for future progress it is vital for today's youth to see themselves connected to a continuum of human endeavor. Others throughout time have counted, measured, represented, located, reasoned, predicted, explored and used their minds to improve their existence ... so must we today. It is from these views that this project stems.

The matrix. To assist mathematics curriculum planners and teachers around the world in developing multicultural learning materials, this project offers a matrix to stir creativity. The two dimensions of the matrix are *cultural features* and *mathematics topics*. The entries in the cultural dimension have been adapted from various analyses of cultural attributes. The six categories are language, history and geography, economics and politics (including resources, technology, transportation, communication, and government), social features (including customs, beliefs, family, food, education, health, welfare), aesthetics (including art, music, drama, dance, pottery, textiles, architecture) and recreation (including sports, games, and entertainment). The entries in the mathematics dimension have been adapted from the *Curriculum and Evaluation Standards for School Mathematics* of the National Council of Teachers of Mathematics (1989). The eight categories are communication; reasoning; number and numeration; measurement; patterns, functions,

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and algebra; geometry; statistics and probability; and discrete mathematics. Problem solving permeates the entire matrix.

Following this essay are two versions of entries in the matrix. The first matrix identifies generic suggestions, ideas relating the mathematics topic to the cultural feature without specifying a culture. Indeed, several suggestions are intended to be cross-cultural. The second matrix offers specific suggestions, many of which are already in print, but not in a form for school children.

Methodology. The two dimensions of the matrix very naturally suggest two approaches to filling the cells: examining mathematical strands for cultural applications and examining cultural phenomena for mathematical aspects. Both of these strategies were used. Other curriculum developers should consider these two strategies as

ways to conceive even more possibilities. Broadening the list of categories on either dimension may also increase the inspiration of more ideas.

Limitations. There are many cautions in presenting a matrix such as this. First, the matrix has a limited scope: curriculum, not instruction or evaluation. Its major intent is to make suggestions for teaching materials in the form of topics, questions, activities, and avenues for student research. It does not address classroom climate, teaching strategies, or the structure of school programs. These factors, too, are culture-bound. Research suggests that altering these factors can make more mathematics more accessible to more students. A second limitation is the small number of categories on each dimension. Some reduction was needed to make the task manageable. This, however, reduces the possible number of ideas generated. Third, the categories themselves reflect the cultural perspective of the author. As Marcia Ascher points out (1991, p.3) "how people categorize things is one of the major differences between one culture and another."

Finally, by its nature, a two-dimensional matrix highlights relationships between pairs of factors, but overlooks other connections. This limitation has many ramifications. First, the categories are not entirely disjoint. For this reason, many items in the matrix could have been categorized in other locations. Next, by being two- and not three-dimensional, the connections made are limited to pairs and not triples or n-tuples. Also, the cellular structure tends to particularize ideas, rather then create networks of connected ideas. This masks important connections within both mathematics and cultures. Another approach might have been to begin with a cultural context and draw out as much of the possible mathematics from it as one could. This would produce a more thematic learning environment which has many educational benefits. This last limitation reveals the western influence of the matrix structure itself: it separates rather than integrates.

In its favor, the matrix is a starting point, from which more interrelationships may be generated. The intent of the matrix is to seed creativity, not restrict it. It is a beginning, a point of departure. It succeeds to the extent that it inspires. Its value will be measured by the extent to which it assists teachers and curriuclum planners in identifying, creating, and integrating multi-cultural experiences for youngsters to make mathematics learning more global, humane, and meaningful.

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A Multicultural Matrix for Mathematics Education Generic Ideas

	Language	History & Geography	Economics & Politics	Social Features	Aesthetics	Recreation
Commun-ication			Coding or graphing economic information, transportation schedules, communication systems.		Coding systems used for dance, music, architecture, crafts, etc.	Coding systems used for games.
Reasoning	Proofs without words to share among students with different languages. Logic puzzles re distribution of languages in a multi-lingual classroom.	Proofs of famous theorems from different cultures, e.g. Chinese proofs of Pythagorean Theorem.	Reasoning within a country's legal system.	Implications applied to costumes and traditions.	Analysis of designs.	Strategies for winning games.
Number & Numeration	Numeration systems. Calculation devices. Gestures for numbers, measures, estimates.		Strengths or limitations on economic system caused by the numeration system used (e.g. limitations of Roman numerals).	Using proportions to resize recipes. Beliefs about numbers (values, superstitions).	Making scale drawings of artifacts.	Counting or scoring systems used in games, e.g. scoring in tennis, bowling. Magic squares in different cultures.
Measure-ment	Units and tools for measurement. Translating a table of measures by using the numbers as clues, e.g., 24 __ = 1 __.	Historical time lines. Historical development of measurement within a culture. Estimation of areas of lakes, etc. from maps.	Systems of measures. Unification of countries via creation of standard measures, e.g. Napoleon in France and Qin in China.	Calendars. Concepts of time.	Sizes of tools & materials needed for crafts.	Sizes of sports fields, game equipment.
Patterns, Algebra, & Functions	Interpretation of graphs in other languages where data and photos provide clues for context.	Use of coordinates for maps, locations. Climatic conditions as a function of latitude.	Categorization of economic phenomena as linear, exponential, polynomial. Simulation models for economic phenomena.	Groups to model family relation structures.	Transformations (reflection, scale change, rotation) applied to native designs.	Models for international sports records.
Geometry	Translation from another language of a glossary of geometric terms by use of diagrams. Interpretion of a geometry problem and solution presented in another language.	Comparisons of different systems of navigation using local or global parameters.	Geometric properties of trademarks (Metz, 1981).	Beliefs about shape, space. Home designs. Symmetry as a value.	Architectural design features, e.g., arches. Design of musical instruments. Shapes used in jewelry, pottery, etc.	Design of game materials and sports equipment
Statistics & Probability	Distribution of languages over the globe or by continent.	Analysis of data on land use, demographics, etc.	Analysis of data on resources, technology, commerce, production. Expected values for economic phenomena.	Analysis of data on health, education, religious preferences.	Differentiation of cultures based on analysis of design features e.g. frequency or absence of certain frieze patterns.	Probabilities related to games and lotteries. Design of fair games.
Discrete Math'cs	Analysis of grammars.		Network analyses of political structures, transportation and communication networks. Markov chains for analysis of economic phenomena.	Network analysis of use of space e.g. in homes and public buildings. Sociograms.	Network analysis of weaving designs.	Networks and recursion in recreational drawings and design of algorithms to reproduce them.

A Multicultural Matrix for Mathematics Education Specific Ideas

	Language	History & Geography	Economics & Politics	Social Features	Aesthetics	Recreation
Commun-ication			How do some nations code transportation schedules more effectively than others? (Tufte, 1990)		How can we encode dance movement? (Tufte, 1990) How do musical time signatures encode numerical information?	How are chess moves coded for a computer? What other games can be similarly coded?
Reasoning		Use a time line to identify intersections of important periods and disjoint periods whose intersection might have had important implications.		Reconstruct sacred symbols, e.g. yin-yang and 7-12 New Jerusalem design (Kappraff, 1991).		Analyze the *mu torere* game of Maori of New Zealand (Ascher, 1991).
Number & Numeration	How do different communities in Africa use gestures to communicate numbers? (Zaslavsky, 1973) How do Hindus compare strenghs to people, animals and gods to build powers of ten? (Schultz, 1982)	How did the system of Roman numerals hamper development of Roman civilization?	How did Incan quipus encode economic information?	How are numeration systems related to beliefs in a culture? E.g. the Babylonians used 20 and 60 as bases. Why?	Make scale drawings of symbols, icons, artifacts (Krause, 1983, p. 42). Indian chain making builds links in 3s, then 7s, then 15s. Why these numbers?	
Measurement		Qin in China (221 B.C.) and Napoleon in France (early 19th century) created standardized measures to assist unification. Why? Today Europeans are planning for a single monetary system. How will this work? What are its advantages?		The Mayans had two calendars, one of 260 days, and one of 365 days. How long a cycle did they need before they both began together? How did different cultures solve the problem of leap years?		Design a scale model of one of the Olympic stadia or athletic fields encompassing multiple sports.
Patterns, Algebra, & Functions		Find growth rates of different nations at different periods of time. Project world population. How have sizes of major cities changed over time? How is mean temperature for one season a function of altitude?		Show how group theory explains family relationships of Warlpiri of Northern Australia (Ascher, 1991).	Categorize Incan strip patterns into 7 transformation categories (Ascher, 1991) and 2D patterns into 17 categories (Crowe, 1987). Find symmetries in folk arts (Krause, 1987; Bradley, 1992; Zaslavsky, 1979, 1990). Model music with trig'c functions and log'c properties (Maor, 1979). Analyze musical transformations (Schultz, 1982).	How many steps are needed to solve the Tower of Hanoi most efficiently? Create models and predict winning times for Olympic events for the next games.
Geometry		What geometric properties are embedded in the wonders of the ancient world? modern wonders?		Compare visions of the line and the circle from western and Native American perspectives (Ascher, 1991); Why do some cultures build round houses? (Zaslavsky, 1989) How do Japanese design homes with tatami mats in 2:1 ratios? (Boles & Newman, 1987) Why does Taj Mahal have two mosques? (Schultz, 1982)	How do you put a hemi-spherical dome on a square building as in the Aya Sofia in Turkey? (Blackwell, 1984) How are different shaped arches built? (Heafford, 1959, pp. 128-129)	What patterns of dimples are used on golf balls? What properties must these patterns have? What tesselation does a soccer ball have?
Statistics & Probability	What nations are most multilingual? What continents? A cryptogram might be French or English. Use frequency distributions of letters in each language to decode the message.	Create and compare population pyramids for different nations or continents.		How are religions distributed over the globe? What continents or countries have the most diversity? the most homegeneity?	Make inferences about Bach and the acceptance of his music from a graph (Tufte, 1990) on the writing, publication, and debuts of his works.	Determine expected values for outcomes in Iroquoian dish game (Ascher, 1991) or Hopi game (Krause, 1973). Find correlations for home altitude of athletes and Olympic sports records.
Discrete Math'cs	Translate the labels, given these set relationships: duos: { 2, 6, 28, 104 {10, 40, 50, 70 pentos: {5, 35, 75, 95	How do matrices and distance measures help classify lost Mayan groups and the Anasazi of Chaco Canyon? (Meiring, 1992; Crowe , 1987).	Analyze transportation networks (Zaslavsky, 1981).		Analyze, using recursion, the pattern of the roof tiles in the Sydney (Australia) Opera House.	Design algorithms to reproduce sand tracings of Malekula, Bushoong or Tshokwe (Ascher, 1991). How many dominoes must there be? Why? Suppose dominoes were numbered to 12, how many pieces would there be? Write computer code for scorekeeping in bowling, tennis, etc.