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ABSTRACT

Exploring ideas related to identifying what differences in mathematics instruction, if any, should be necessary for bicultural (Mexican American) students, this paper examines the nature of culture and the nature of mathematics and hypothesizes that a culture will predispose a person to learn mathematics in a particular way. It is noted that the Chicano, if he desires to compete in a technologically oriented society, needs to be appropriately prepared in mathematics. Teaching strategies, field-dependent (focus on student needs) and field-independent (focus on subject content), are presented with a view to adapting them according to individual learner characteristics. Following the implications of research toward inclusion of both the dependent and independent strategies within mathematics instruction, it is recommended that time and effort be spent in the reorganization of content so as to provide a variety of curricular experiences for all students in order to become accountable to each student. A list of 13 resources is included. (MJB)

MATHEMATICS FOR THE BICULTURAL STUDENT

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Many mathematics teachers have expressed a sincere and well-founded concern for the underachievement in mathematics of many of their students -- especially Mexican-American children whose lack of academic achievement has been described in other works (Hernandez, 1972). There exists today a number of views as to why Mexican-American children do not satisfactorily achieve academically. One view is that Mexican-Americans are intellectually inferior to their Anglo counterparts, but this view has been largely discredited on the basis that the instruments used for arriving at such a conclusion were invalid for this ethnically different group (Hernandez, 1972). The second view is that a culture of poverty, in which a great majority of Mexican-American children live, does not afford opportunities for children to develop the intellectual capacities that are needed in adult life. Frost, (1968) for example, claims that an environment of deprivation increases the possibilities that children develop language deficiencies which accumulate as the child fails to learn to read well, cannot conceptualize adequately, etc. At present this view prevails. The harmful effects of an impoverished environment on the growth and development of any person--regardless of race are well documented. A third view, emphasizes the culture as a variable in the lack of academic achievement of a learner. Some claim that a particular culture may predispose or inhibit certain kinds of learning. It is this last view that will be discussed in this paper.

The title supposes that certain unique kinds of mathematics should be provided for bicultural students. It is the purpose of this paper to explore a number of ideas that are related to identifying what differences in mathematics instruction, if any, should be necessary for bicultural students. The concepts to be considered in this regard are the nature of mathematics, the nature of culture and how these may be related to the learning of mathematics.

The Nature of Culture. The nature of culture as it is related to mathematics will be briefly discussed. The working definition of culture for this paper is taken from the Mexican philosopher, Samuel Ramos (1965). He defined culture as that which humanizes reality. Some cultures, for example, humanize the reality of having to eat by using knives and forks, others by using shells, and others by using chop sticks. Man lives within a cultural context. As a child, the culture he learns helps him represent a real, solid world. One may claim that this world teaches a child how to think, how to feel, and how to learn. This definition of culture suggests that mathematics is but another example of man's capacity to humanize reality, *e.g.*, by counting, measuring, expressing relationships, etc. Each culture has expressions of these mathematical concepts.

The Nature of Mathematics. There are a number of notions as to the nature of mathematics but only two divergent views will be presented here. In one case mathematics is considered as a purely abstract structure built by man and the supreme example of his intellectual powers. "...mathematics is the study of all structures whose form can be expressed in symbols, it is the grammar of all symbolic systems..." (Black, 1959). Concepts of number, space and form in such a system are all consequences of the structures so defined.

Kline (1953), however, describes mathematics differently. He declared that:

> mathematics is a creative or inventive process, deriving ideas and suggestions from real problems, idealizing and formulating the relevant concepts, posing questions, intuitively deriving a possible conclusion, and then, and only then, proving the hunch or intuitive argument deductively.

Here we have two differing points of view. On the one hand, we have mathematicians who believe that mathematics is the study of abstract systems, while the application of these systems to the problems of the physical world are not considered as mathematics. On the other hand, we have a different group who see the relationship between mathematics and physical reality as the energizer for growth and meaning of mathematics. Mathematics is important to this group because in it mathematics assists in understanding the environment. The former view appears to be one in which mathematics is a purely impersonal, abstract structure built by man. The second view suggests that mathematics comes about through the discovery of solutions to problems that men identify in physical reality.

It is probable that at various times during the history of man's civilization, different cultures have viewed mathematics from these two divergent perspectives. Each culture, however, views mathematics in its own unique way.

If one accepts the two divergent descriptions of the nature of mathematics and the definition of culture as suggested above, one can hypothesize that a culture will predispose a person to learn mathematics in a particular way especially if certain aspects of it are emphasized. If this is so, how is mathematics learning affected? Some ideas that could serve as tentative answers to this question are presented herein.

Mathematical Content

If one claims that bicultural students need mathematical content that is different from that taught to the majority, then one may assume either that the learning of a culture affects a person's subsequent learning capacities in mathematics, or that the purposes for learning the different mathematical concepts and skills, i.e., the application of these concepts, will be different, or both. (It is assumed that all ethnic groups have equal capacities to learn.)

Suppose that one assumes that learning of a culture predisposes a person to learn mathematics--either positively or negatively. If this is so, in what ways does it affect learning. One variable that is fairly obvious is that of motivation. A particular culture gives emphasis to mathematics according to its own system of values. For Pythagoras, mathematics was purely an intellectual pursuit. For others, like Kline, it assists man in understanding his environment. It is a fair guess that a culture which values mathematics for its own sake will produce a different kind of mathematics and mathematicians than a culture which values it only as a support for various enterprises such as scientific or business pursuits.

In examining our present culture as it affects mathematics and mathematics instruction, one finds that mathematics is valued for the support it gives our technology. Descartes' great invention--analytic geometry started us on our path to the moon. The great computers of today, programmed to solve problems which had not been formulated until a few years ago helped us arrive. We do value mathematics because it is the Queen of the Sciences. It is its Hand-Maiden.

But, we also value mathematics for the unique place it holds as one of the supreme examples of man's culture. We feel that although not all of us are, or can be, mathematicians, we should appreciate the nature of mathematics for its own sake.

And now, how does all of the above apply to the bicultural student, or the Chicano. Rodolfo "Corky" Gonzalez suggests a relationship.

> And now the trumpet sounds,
> The music of the people stirs the
> Revolution,
> Like a sleeping giant it slowly
> rears its head
> to the sound of
> Tramping feet
> Clamouring voices
> Mariachi strains
> Fiery tequila explosions
> The smell of chile verde and
> Soft brown eyes of expectation for a
> better life.
> And in all the fertile farm lands,
> the barren plains,
> the mountain villages,
> smoke smeared cities,
> We start to MOVE.

One interpretation of the poem is that the Chicano will begin to develop his own culture--to humanize his own reality. As yet he has not fully developed his system of values--it is emerging. Gonzalez continues:

I have come a long way to nowhere,
Unwillingly dragged by that
Monstrous, technical
industrial giant called
Progress
and Anglo success...

The Chicano is on the verge of choosing, of defining his system of values. In so doing, how will he value mathematics? The Chicano is coming to a realization of his potential and is desirous of harnessing the necessary energy to take the lead in an unfamiliar endeavor. He wants to humanize his own reality. He is at the cross-roads where he must make a choice.

When he makes this choice, he will make it on the basis of whether he wishes to compete in our present society. In order to compete, he must be prepared. Thus, the assumption must be made that the mathematics he must learn must be the same for him as for all other students, i.e., Chicano students must be in algebra, geometry and analysis classes in numbers much greater than they are today. The Chicano student must be helped to achieve in mathematics as well as in other subject matter areas. The educational attainment of Mexican-Americans as a whole is very low (Moore, 1970).

The Chicano now aspires to highly skilled professional and technical jobs. If the Chicano student has not achieved in the past and wishes to do so now, how can this be accomplished? The answer may lie not only in the area of content but also that of teaching strategies.

Teaching Strategies

Research by Lesser, Fifer, and Clark (1965) and Stodolsky and Lesser (1967) suggests that members of different ethnic groups exhibit different patterns of intellectual capacities. The results suggest that patterns in intellectual capacities exist within a cultural group and are consistent for children of low and middle socio-economic groups within the same culture. Moreover, the results indicate that the intellectual patterns could be attributed to culturally unique learning styles. It is possible that different ethnic groups value certain areas of intellectual achievement more than others and consequently reinforce one kind of intellectual activity more than others. Looking at another variable, incentive-motivational style, Kagan and Madsen (1971) studied the effects of cooperation and competition on task performance in Anglo, Mexican-American and Mexican children. The results indicated that Mexican children tended to be the most cooperative in achieving when the rewards were based on cooperation while the Anglo children were the least cooperative and the Mexican-American students scored in the middle. In contrast, the Anglo children tended to be the most competitive when rewards were based on competition and the Mexican children the least competitive. The Mexican-American scored in the middle. It appears, as suggested earlier, that learning and incentive-motivational styles are directed by the system of values inherent in an ethnic group or culture.

Castaneda, Ramirez, and Herold (1975) have attempted to subsume the results of the studies on learning and incentive-motivational styles by the use of Witkin's concept of field dependence-independence. A person who is described as field dependent is one who performs best on tasks of verbal expression, has facility in recalling human faces, and in learning material containing human content; is influenced more by opinions of others and in particular by indications of approval and disapproval from authority figures. People described as field independent, on the other hand, do better on tasks requiring the arrangement of pieces to make a whole and extricating parts from a whole, do better on problem-solving tasks requiring the use of common objects, do better at learning impersonal, abstract material, and are influenced less in making decisions by others and in particular authority figures.

Results of research done by Castaneda, Ramirez and Herold in Texas and California indicate that Mexican-American children tend to score in a more field dependent direction than their Anglo counterparts. The schools, however, are oriented in a direction which favors persons who are more field-dependent. The result is widespread frustration leading to depressed achievement. The institution does not provide for differences in learning nor incentive-motivational styles. Flexibility in at least these two variables should be provided. Although Anglo children tend in general to score higher in the direction of field-independence, there are nevertheless some who can be described as field dependent, e.g., Anglo girls in particular, (Castaneda, et. al. 1972). Thus, teachers who can use two strategies can be more effective with more children, i.e., an attempt at teaching in a style to match a given learning or incentive-motivational style may prove more effective than assuming that all persons learn in a like manner.

Castaneda, Ramirez and Herold describe two strategies which are designed with field dependent and field independent persons in mind. A summary of the two descriptions is given below.

Field-Dependent Teaching Strategy

1. The focus is on the needs, feelings and interests of the members of the class (the teacher identifies as a member of the class).
2. The teacher's role is to serve as a model and to be imitated.
3. The interaction between teacher and students is informal and induces open discussion.
4. The reward system is based on the use of personalized rewards, e.g., embracing a child, nodding, smiling, etc.
5. The class structure encourages group achievement and team work.
6. The teaching of concepts is by narration and associates human characteristics with the essential attributes of a concept.

Field-Independent Teaching Strategy

1. The focus of the class is on content.
2. The role of the teacher is that of consultant or supervisor.
3. The interaction is formal with emphasis on teacher lectures emphasizing facts and principles.

4. The reward system is based on impersonal rewards such as stars, grades, etc.
5. The class structure encourages individual achievement.
6. The teacher is emotionally detached.

The two strategies described above involve more than merely modifying teacher behavior and the structure of the class. The mode in which the content is presented is also important. The field-dependent strategy humanizes the content by the use of human faces and characteristics. The content is personalized, and characterized by fantasy and humor, and reflects the students' ethnic background and experiences in their homes and neighborhoods. The abstract portions of the content are presented in a descriptive mode, since only the global characteristics have meaning to these learners.

The treatment of content in the field-independent strategy suggests an orientation to reality devoid of personal references. Since field-independent learners are apt at putting pieces together to make a whole or extracting pieces from a whole, this strategy emphasizes induction. The content is abstract and involves interaction with materials rather than people.

Implications of Research

The implications that can be made about mathematics education in relation to the results of the research cited above are two-fold. The first is in relation to strategies and the second to the organization and choice of content. At least two viable instructional alternatives associated with cultural differences have been identified -- inductive and deductive approaches. Much has been written about inductive approaches; e.g., the discovery method and the Taba strategies (1966). Deductive or directive methods such as the lecture have come into disfavor in some circles as the laurels of the inductive method are sung. The research cited above, however, suggests that deductive methods with certain modification may be more effective for some students than inductive methods.

One deductive method that has never really established itself but seems especially suited to the field-dependent approach in mathematics is the advance organizer technique proposed by Ausubel (1963). This technique requires that the global, overarching ideas of a topic be presented first in an abstract, highly generalized manner and that progressive differentiation, and congruence and integration be made among the ideas as the lessons proceed. The sequence is determined by the inclusiveness of the ideas with the less inclusive ones following the more global ones.

The advance organizer technique appears to meet the requirements of the field-dependent strategy in the organization of the content. The advance organizer, however, must be designed at a higher level of abstraction and generalization than the lesson material. This characteristic appears to be more in line with the field-independent strategy. The problem can be overcome if the advance organizer is designed in a descriptive mode and involves humor and fantasy.

The second inference which can be made from the research cited above is in the area of content. One must come to grips with the question of what to teach. If the learner elects to go the field-dependent route as a viable instructional alternative, he will choose to learn a relatively few, comprehensive, overarching ideas that will permit him to understand what mathematics is, its method, its language, its definition of knowledge, its development, its applicability, etc., and in general, an appreciation of its value, but not necessarily be skilled at arriving at specific solutions to problems, e.g., division of rational numbers by the end of the fifth grade or finding the solution to quadratic equations at the end of the ninth. The concepts of, say, relations, functions, and mappings would be learned--the opportunity to develop a high degree of skill in solving equations and systems, etc., would be offered as an alternative in order to develop depth in selected topics as the need arose.

The approach outlined above would provide a realistic choice for students instead of the conventional one in which students go either the "college" route, the "remedial" route, or the "business" route. The conventional approach discriminates intellectually; it, in reality, does not provide for a democratic choice since students are assigned to each route on the basis of "intelligence." The validity of the measures used to make such judgments is highly questionable thereby making the system of routing even more indefensible. If the content were organized in the manner suggested above, all students would have access to the important ideas of what mathematics is about in an intellectually honest way. They could learn about mathematics and learn to appreciate its method and not feel that they are doing mathematics because they have memorized an algorithm and can even quote some postulates which justify it. These same students however, cannot appreciate the beauty of its definition of knowledge, etc. The choice for the amount of differentiation, or specific skills attained, in specific topics and the level of skill in problem-solving would be made on the basis of the students' interest, capacity, future goals, etc., and not merely on a dubious rationale which maintains that two years of algebra and one year of geometry are necessary preparation for college entrance.

At present there is a vigorous effort being exerted to bring accountability to education by emphasizing student performance. In moving to the accomplishment of performance objectives as determinants of effectiveness, and by inference, of accountability, one may run the risk of emphasizing skills which are easily demonstrated but are neither necessary to the student's future vocational goals nor essential in assisting him develop an adequate conceptual framework for the subject matter under consideration. These skills involve the minutiae which are needed only at the application stage of the discipline. In other words, educators must come to grips with the questions of what content is of the most importance. Is it important that students learn to work at the application level of all disciplines? e.g., to solve systems of equations rather than learn what one claims is knowledge in mathematics, what the mathematical processes are, etc. Students could be given alternatives from which to choose rather than have one curriculum assigned to all. The terminal behaviors for some students could justifiably emphasize general knowledges and understandings and selected logical processes related to the development of conceptual capacities; for others, the objectives could emphasize analysis, synthesis and evaluation, with opportunity to develop a high degree of skill at problem-solving in mathematics available upon request.

It has been suggested that the institution be changed in order to allow for flexibility in a number of variables which affect achievement. I am suggesting that in mathematics we go one step further and change the curriculum -- not for the bicultural student alone, but for all students. We should provide a regular smorgasbord of mathematical topics taught in a variety of ways. Students could select from these topics, with competent guidance, according to their interests, future needs, capacities and stated goals. For example, the curriculum could be developed in a variety of ways which reflect the divergent views of what mathematics is. As mentioned previously, at least two views of mathematics could be utilized to develop the mathematical content via at least two teaching strategies.

A new revolution in mathematics education is needed. Not one which will define the content or bring us up to date in mathematical ideas--that has been done adequately. But the revolution is one which will humanize the content by developing strategies and methods for content organization which reveal all the different facets of the discipline called mathematics. Mathematics is so universal in its nature and has so many aspects that every culture and every person can appreciate it provided that there is flexibility in what one identifies as the curriculum. Just as millions of dollars were spent in identifying content with programs such as SMSG and methods such as with UICSM, time and effort should be spent in the reorganization of content so as to provide a true variety of experiences if we are to be accountable to each student.

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