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# MATHEMATICS, CULTURE AND CURRICULUM

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# ABSTRACT

This paper reviews the literature in a wide range of mathematics and schooling related areas that may provide insights into the difficulties experienced by Aboriginal children when attempting to learn Western mathematics in school. Thus, literature outlining research related to teaching/learning of mathematics in mainstream, bilingual, cross-cultural and Aboriginal contexts has been explored and findings that have curriculum implications for traditinally oriented Aboriginal children have been discussed.

The paper concludes that mathematics curriculum for these Aboritinal children must recognise their linguistic and cultural heritage; allow then more time to develop necessary concepts, and enable them to use their strong visuo-spatial orientation as an aid for learning how to talk their way into mathematical understandings.

In particular, the paper examines mathematics curriculum issues in the context of both the Aboriginal and pervasive mathematico - technological culture and points out that, while one provides links with the past and present, the other may be necessary to provide a secure place in the modern world.

## 1. INTRODUCTION

Aboriginal children from traditionally oriented communities in NT are failing to learn mathematics effectively in school. The degree of this failure has been documented by Bourke and Parkin (1977) and others. However, research findings based on testing procedures do not fully reveal the nature of the difficulty experienced by Aboriginal children when faced with the task of learning Western mathematics in the school environment. Nor do such findings reveal the degree to which present approaches to mathematics education result in Aboriginal children perceiving school mathematics more in terms of a meaningless ritual than as a purposeful pursuit (Christie, 1985, pp.48-49). The result is that after years of schooling many children have only learned the answers to 'sums' that have little relationship with the world as they know it. Much of this unusable mathematical knowledge is soon forgotten, both between periods of school attendance, and once school days are left behind. Even when some number facts are retained, many Aboriginal adults experience difficulty in knowing whether to add, subtract, multiply or divide when faced with the mathematical realities of the wider world that are inevitably encoded in the language of life rather than in the language of the classroom (Graham 1982, 1984).

If this situation is to be remedied, Aboriginal people and educators must together negotiate about the what, how and why of mathematics education for traditionally oriented Aboriginal children. Such negotiations, to be meaningful, need to be based on an in-depth understanding of the issues involved. This paper aims to explore current research in the areas of mainstream, cross-cultural and Aboriginal mathematics education and schooling and reflect on these findings in relation to the provision of more meaningful mathematics education for Aboriginal children.

## 2. MATHEMATICS FOR MINORITY GROUPS

Aboriginal children are not the only minority group who are failing to learn effectively in schools. Professor Jim Cummins of the Ontario Institute for Studies in Education has for many years been examining the way many minority language groups are disabled through educational programs that are provided for them by the dominant groups within various societies. He claims (1981, 1985) that, when schools ignore the linguistic as well as socio-cultural factors related to the education of minority students, academic failure results. Thus, any discussion related to providing mathematics education for traditionally oriented Aboriginal children must recognise the mathematical understandings (ethnomathematics) that Aboriginal children bring with them to school. These understandings are encoded into the language they speak and express a particular Aboriginal view of reality. However, Aboriginal children do not need to come to school just to learn ethnomathematics. Indeed, Aboriginal people have demonstrated, for many centuries, that they can learn the mathematical relationships inherent in their own culture quite effectively without schooling. Thus, before we look at what children know when they come to school and how such knowledge can be used to help children learn more effectively in that context, it is necessary to consider what it is Aboriginal children need to learn when involved in a school-based study of mathematics.

## 2.1 Learning the Mathematico - Technological Culture

In a discussion with teachers and others involved in mathematics education for Aboriginal children, Bishop (1985) pointed out that the body of knowledge that is referred to as school mathematics is in fact the technological component of a pervasive and almost world wide 'mathematico - technological' (MT) culture. This knowledge has been classified by the members of that culture into number, measurement and geometry (space) strands. In addition, the mathematical and logical meanings that encode these technological understandings and relationships are realized in the lexico-grammatical systems that operate within the languages of the societies that are part of the MT culture. Thus, mathematical meanings are readily available to children who speak such languages and may not be recognised, or will be difficult to construct in languages that are outside the MT culture (Bishop, 1985, p.2; Halliday, 1974).

Hence, for children from traditional societies, acquiring a mathematical education involves learning a second language in which these mathematical meanings and relationships can be realised or adapting their mother tongue so such meanings can be conveyed. In addition, if the technological component is to be fully understood and mastered the ideological (beliefs etc.), sociological (institutions etc.) and sentimental (attitudes etc.) components of the MT culture which provide the 'context of situation' (Malinowski, 1923) for the technological component must be acknowledged, if not accepted, by the learner (Bishop, 1985, p.3). Bishop (1985) concluded that, when socio-cultural components of the MT culture are ignored by teachers, children from societies outside that culture, seem to find little or no sense in the curriculum offerings of the school.

Many teachers of Aboriginal children when faced with the continual failure of their students have suggested that only enough mathematics should be taught to enable children to function effectively in their home communities while the more demanding mathematical contacts with the outside world are managed by others. This solution has certain appeal in the face of the realities of teaching Western mathematics in remote traditionally oriented Aboriginal communities. However, such policies, while appearing to meet the particular needs of Aboriginal children, would, in Cummins' view (1985, p.4) continue to disempower them in any contact with the dominant non-Aboriginal society. For without knowledge of Western mathematics, Aboriginal children are denied access to further education and to the knowledge and power inherent in the social institutions which, even today, influence the way Aboriginal people live their lives. Thus, if Aboriginal parents want their children to achieve the kind of academic success that is perceived to be the normal outcome of a school education, teachers will have to find ways of making the socio-cultural as well as the technological components of the MT culture available to their students.

Many teachers and others see problems with this approach and express concern that if Aboriginal children are schooled in this way they will lose their Aboriginal identity. Teaching facts from the other culture is one thing, it seems, but teaching the value system quite another. However, as Bishop has pointed out the so-called facts make no sense without the other aspects of the MT culture that provide meaning for what is being learned.

Wolcott (1967, p.130) faced a similar situation when teaching Kwakiutl Indian children. He appreciated that these children needed to understand the values that gave meaning to school learning but believed that such values could be taught to minority children as skills. In that way they could be used when learning or working in the institutions of the dominant society but did not have to become values that dictated how children should live at home or in their community. Such a strategy, if used in schools, would enable Aboriginal children to establish domains, or separate areas, in their lives and so live confidently as bicultural people who are able to think, speak and act in a manner appropriate to the situation in which they find themselves. Without such a strategy, it would seem that Aboriginal children will continue to fail mathematics (and other subjects) in school and so be denied access to further education and in Cummins' (1985) view, patterns of disempowerment in relation to the dominant society, will remain the norm. Provision of programs that will empower Aboriginal students can thus be seen to be a complex matter that has implications for a wide range of curriculum related issues, some of which will now be explored.

## 3. REFLECTIONS ON MATHEMATICS IN MAINSTREAM SOCIETY

A brief examination of recent research into the teaching of mathematics in mainstream society reveals that while this subject has been taught in our schools for many years, few teachers fully comprehend the breadth and complexity of the subject matter involved. In addition, it would appear that we are only now beginning to appreciate just what children know when they come to school and how they learn and think about what they know. In particular, the role that language plays in helping children construct mathematical meanings has only recently, it seems, become a matter of concern. As Aboriginal children experience particular difficulties in working in the number strand we will begin by exploring some recent research in that area.

### 3.1 Becoming a Counting Person

Gelman and Gallistel (1978), in an extensive series of studies, endeavoured to discover the mathematical understandings related to number acquired by children from mainstream society before they began formal schooling. They found that children as young as two and a half years used how-to-count principles. That is:

> When confronted with small sets of objects they tend to use as many tags as there are items to tag; they tend to assign unique tags; they tend to use a stably ordered list of tags and they often indicate that the last tag assigned to a given enumeration represents the cardinal number of the set of objects.
> (Gelman & Gallistel, 1978, p.203)

Such children, while certainly not counting with the skill and accuracy of adults, are on the way to becoming counting people.

Gelman and Gallistel also found that children used perceptual strategies - or subitizing - to name the total group only after they came to be sure of the counting procedure and not the reverse as had previously been hypothesized. The researchers noted that those children who had developed their own set of tag words and so 'counted', appeared to do better than those children who were learning to 'count' and learning to apply the correct sequence of number words at the same time.

As a result of their findings in relation to children's counting abilities, and following Chomsky with his notion of a 'language acquisition device' (in Gelman & Gallistel, 1948, p.209), Gelman and Gallistel came to regard an ability to count as natural or universal. To further support their view, they referred to research that reveals that counting behaviour in traditional societies has not always been recognised because, for example, gestures rather than words may have been used (Gelman & Gallistel, 1978, pp.73-78, also Harris, J., 1982 in relation to counting systems among Aboriginal groups).

In contrast, Berger and Luckman (1966) and Halliday (1974) would see that all such knowledge is socially constructed rather than universal and is thus a reflection of the knowledge that is inherent in the system in which the child is nurtured. Therefore, children who grow up in societies where counting is an integral part of the everyday life of the group, are able to construct such mathematical meanings for themselves at an early age. Likewise, very young Aboriginal children who grow up in Central Australia are able to indicate cardinal directions as they move about the community (Laughren, 1978).

But just as naming directions is not a 'natural ability' of children reared in mainstream society, even though adults possess that knowledge, so counting is not necessarily a 'natural ability' in communities where adults may at times indicate quantity but are not, what may be called, 'a counting people'. Hence, while Aboriginal people traditionally made use of some number words, in Sayer's (1982, p.187) experience they place little value on precise counting and in traditional communities have little understanding of the concepts involved. Thus, while Aboriginal children may recognize and name groups to three when they come to school - a skill that is possibly reinforced by the need to recognize both dual (two) and plural (three or more) when using personal pronouns - they are usually not counting. Hence, counting is something that has to be learned rather than refined in school. Therefore, if Aboriginal children are to be able to establish a foundation on which future mathematical understandings can be built, teachers must provide the experiences that convey the social meanings and allow time for children to gain the level of competence that is achieved by children from counting homes. The school-based research reported by Bubb (1985) indicated that, as had been suggested in Mathematics in Aboriginal Schools : Stage 1 (MAS), many Aboriginal children will require at least an extra year to master the content that is usually considered appropriate for the first year of formal schooling.

## 3.2 Learning in School

Children Learning Mathematics, (Dickson et al, 1984) provides an invaluable guide for teachers on recent research in all areas of mathematics. The collection highlights the diversity of mathematical experiences now contained in school programs, indicates areas in which children are likely to experience failure, and provides a resume of testing procedures, many of which could be adapted as teaching/learning strategies. Some examples of research findings have been selected from the 300 available to demonstrate how such a document could indicate reasons for failure and/or more appropriate curriculum strategies in the Aboriginal context.

### Example 1 : Number

A study by Starkey and Gelman (in Dickson et al, 1984, p.189) demonstrated that preschool children were able to solve addition and subtraction problems well ahead of the time they could conserve and they appeared to be using counting strategies to achieve this goal. Subsequent research by others have confirmed these findings. Hughes (in Dickson et al, 1984, p.190) demonstrated that while fifty-seven out of sixty preschoolers could correctly find the solution to 3-2 when concrete materials were used, they had difficulty in doing so when the problem was presented in a more abstract form (e.g., a 'hypothetical box' resulted in twenty-three correct responses while the formal oral 'sum' resulted in only three correct replies). Such findings stress the importance of counting knowledge and the use of concrete materials in learning mathematics. In the Aboriginal context there are also implications for curriculum decisions for too often mainstream curriculum documents which have been based on the assumption that children will bring mathematical knowledge, of that order, into the classroom with them are transposed without adaptation into Aboriginal schools.

### Example 2 : Measurement of Time

Kerslake (in Dickson et al, 1984, p.144) found that preoccupation with activities that aimed to teach children how to 'tell the

the time' (e.g., drawing time on clock faces, moving hands on 'pretend' clocks) is often detrimental to children's ability to develop concepts related to the measurement of time. As Aboriginal children need both to develop concepts about the measurement of time and to learn how to tell the time in school the approach adopted in MAS : Stage 1 of delaying the teaching of time telling while helping children acquire understandings related to the use of clocks and of the measurement of time is supported.

Example 3 : Shape

Fusan and Murray (in Dickson et al, 1984, p.19) replicated a study originally reported by Piaget. They found that children were able to identify circles first, then squares, followed by triangles and lastly diamonds; an order of focus that could be worth exploring with Aboriginal children. Of particular interest however, was the difficulty experienced by mainstream children in naming shapes that are only named in the classroom (e.g., only thirty per cent of secondary students could correctly name a rhombus or a trapezium). This finding would seem to indicate that many children experience difficulty in retaining some knowledge acquired only in the school setting. Clearly this has implications for the teaching/learning strategies that are used in classrooms.

## 3.3 Spatial Learning

Dickson introduces the section related to spatial studies with an interesting analysis of the way some children tend to use spatial representation rather than language for the development and communication of mathematical ideas. Those children who favour a spatial orientation tend to process visual information in wholes rather than parts. On the other hand, children who learn through language tend to process information sequentially. School mathematical programs, it seems, have tended to focus on approaches that make use of verbal, sequential learning to the disadvantage of those children with a strong spatial orientation (Dickson et al, 1984, pp.7-10).

As Kearins (1976) demonstrated, Aboriginal children from the Western desert, have strong visual spatial memories. Davidson (1979), who studied the way that Aboriginal children at Bamyili played cards also noted this ability. He found that card players did not use the numbers on the cards to identify them, nor did they add up to find total scores:

> Rather they used complex systems of pattern recognition and grouping in which all combinations of cards for all possible scores were already known before the game began.
>
> (Davidson and Klich, 1984, p.144)

As Davidson noted (1979, pp.277, 267-8), these children were using simultaneous or synchronous rather than successive or serial methods of synthesis of perceptual information. In Davidson's view such children are at a disadvantage in classrooms where language is the dominant medium of the teaching/learning process, and learning is based on successive or serial analyses and syntheses of ideas and facts typical of both literacy and Western scientific thinking.

Bishop (1986, in press) believes that the imbalance in our approach to teaching mathematics needs to be addressed: to enable children who experience difficulty in learning through language to have another avenue of attack; to allow children with a strong spatial orientation to make better use of it in school learning; to increase the spatial awareness of all children and help them to become aware of the way space can be mathematized (i.e., not just a label, 'circle' but an understanding of circularity); and to provide a basis for the learning of geometry which is an area of mathematical education that appears to be neglected.

To achieve these goals, Bishop (1986, in press) believes that children need to be encouraged to reflect on their particular spatial view of the world and through discussion be helped to focus on features of space that are of significance to mathematics. He also believes that children should be encouraged to represent their spatial understandings through modelling, drawing and language. In this way, spatial strengths can be used to provide a foundation for verbal learning. These insights are of particular importance if more effective mathematics programs are to be provided for Aboriginal children who have a strong spatial orientation and yet need to develop the language skills through which much school learning is mediated.

## 4. THINKING, TALKING and LEARNING

### 4.1 Thinking and Learning

It may be appropriate at this time to briefly reflect on some of the literature about cognition and about when and how children

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