ETHNOMATHEMATICS IN THE MALDIVIAN CURRICULUM: Trialling An Implementation

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FOR MY FAMILY

ABSTRACT

Ethnomathematics is the study of the way people from a particular culture have common systems for dealing with quantitative, relational and spatial aspects of their lives. As such, it provides insights both into the social role of mathematics and into the nature of mathematical thinking. Ethnomathematicians argue that these perspectives on mathematics can be valuable components of school mathematics curricula.

There have been several descriptions of ethnomathematical initiatives in mathematics education, however research on implementing ethnomathematical principles in mathematics curricula and pedagogy are still in the very early stages. As a further contribution, this thesis develops an ethnomathematical curriculum model devised for Maldivian classrooms and investigates its implementation on a small scale. Following Lipka (1994), it is suggested that an ethnomathematical curriculum involves an integration of the mathematical concepts and practices originating in the learners' culture with those of conventional mathematics. This involves re-experiencing concepts and practices originating in the learners' culture from a mathematical point of view, and using these experiences to appreciate conventional mathematics, to understand its place in society, and to have a framework for its concepts. The understanding of conventional mathematics then feeds back into and contributes to a broader understanding of the culturally-based mathematical principles.

This study investigates the implementation of an ethnomathematical unit of work in Grade 5 in the Maldives. The research was conducted at two primary schools and involved teaching an ethnomathematical unit of work on measurement. The unit was designed in conjunction with the teachers. The implementation included students going out on field trips, bringing home experiences to classroom, and explicitly designed classroom activities relating the real-world activities to formal mathematics.

During the data collection, information was sought from teacher workshops, questionnaires, classroom observations, interviews, teacher resources, and a research journal. The data showed that despite the very traditional education of the Maldives, the ethnomathematical approach was appreciated and understood by teachers and students. Teachers and students were able to identify activities and experiences in the Maldivian culture exhibiting measurement systems, and were able to link this to the conventional mathematics that is part of the Grade 5 measurement syllabus. The data evidence showed that teachers and students were able to understand the idea behind the ethomathematical curriculum model. Teachers were motivated and had enthusiasm for professional development, but there is a need for ongoing leadership and guidance. The curriculum unit was clearly welcomed and appreciated by the school and the community. Therefore, it is concluded that in a culturally homogeneous context like the Maldives, the development of a more extensive ethnomathematical curriculum can be continued.

As a result of the study the model has been changed and further detail has been added. The model has been redrawn to include the motivational aspect that emerged prominently in the data, and is also strong in the literature. A further development of the model is its provision of more detail of the nature of mathematical thinking and reasoning in this context. This includes formalisation and generalisation of conventional mathematics, and re-viewing cultural practices via mathematical thinking.

The study points to the need for further research to investigate mathematical learning effects, assessment procedures, teacher professional development, and pedagogical procedures appropriate for a more comprehensive development of an ethnomathematical curriculum.

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1 BACKGROUND AND OVERVIEW

1.1 INTRODUCTION

The study of mathematics in any culture is important because, however it is practised, mathematics provides a means for understanding and interacting with the environment. Evidence from cross-cultural and anthropological studies has shown that every culture has its own mathematical knowledge and practices (Ascher, 1991; Barton, 1996a; D'Ambrosio, 1985). Furthermore, evidence from educational literature implies that meaningful mathematical learning can be built on students' experiences (e.g., Zaslavsky, 1991). Within this context, several mathematics educators have argued that incorporating cultural elements into the mathematics curriculum can contribute to a more meaningful appreciation of mathematics (Barton, 1993; Bishop, 1988; Gerdes, 1994; Zaslavsky, 1994).

Ethnomathematics is the study of the way people from a particular culture have common systems for dealing with quantitative, relational, and spatial aspects of their lives (Barton, 1996a). As such, it provides insights into the social role of mathematics. Ethnomathematicians argue that the view of mathematics as Eurocentric and value free misrepresents the evolution of mathematics and its role in society. Some of these researchers argue for a more culturally sensitive view of mathematics to be incorporated into the school curriculum (Barton, 1993; Bishop, 1988; D'Ambrosio, 1985; Ezewu, 1982; Gerdes, 1994; Zaslavsky, 1991). However, very few studies have been conducted with the primary object of evaluating the efficacy of ethnomathematical approaches in raising student achievement and understanding of mathematics. It is now time that ethnomathematics 'walks into' the classroom to be tested, and this study is my attempt to begin to consider these issues.

The adoption of ethnomathematical principles in mathematics pedagogy in schools will depend on their effectiveness in raising student participation in, and understanding of, mathematics. Indeed, the long-term fruitfulness of the ethnomathematical research project in mathematics education will depend on its impact in the classroom. Otherwise, as Wineberg (1989, p.9) notes, it will "leave its marks on archival journals, but leave the world of the classroom virtually untouched".

There are many questions surrounding the implementation of ethnomathematical principles into a traditional educational environment. How do we decide which cultural mathematical ideas are to be included in such a curriculum? Why are some cultural ideas valued and not others? What are the links between an ethnomathematical approach and the indigenous language? What are the teacher reactions and affective outcomes of implementing an ethnomathematical curriculum unit? Is it possible for a teacher who has been schooled in conventional mathematics to work with ethnomathematical ideas? Does an ethnomathematical approach imply a specific teaching style? What new knowledge and techniques will teachers need? How are students' mathematical abilities and dispositions affected by ethnomathematical ideas? Do learners who share the same cultural environment have the same experiences and mathematical knowledge? What are the effects of such an approach on the quality of the conventional mathematics being learned? (Adam, 2002; Vithal & Skovmose, 1997).

This study in the Maldives is one step towards addressing these questions. An ethnomathematical unit of work, on measurement, was designed in conjunction with nine Grade 5 teachers and was implemented in their classrooms. My interest in pursuing a study of this nature, in incorporating ethnomathematical principles to the curriculum, began from the work that I did for my Masters thesis entitled: *Exploring Ethnomathematics in the Maldives* (Adam, 1999). In this thesis, I explored the nature of indigenous mathematics thinking in the Maldives, with respect to counting and measuring. The intention was to consider the inclusion of this material in future curriculum development. In addition to this, as a member of the mathematics education community of the Maldives, I believed that the low attainment in mathematics in the Maldives is partly due to the lack of correlation between school mathematics and life in the Maldivian society. My experiences as a teacher and my reading of the literature lead me to conjecture that a curriculum incorporating ethnomathematical principles would be likely to enhance mathematics education for all in the Maldives. Hence, this study is a first investigation of the implementation of ethnomathematical principles in mathematics curricula and pedagogy.

1.2 RATIONALE FOR THE STUDY

Increasing globalisation, with its imperative on a single language and culture for communication, is decimating the linguistic and cultural pluralism of the world (Barton, 1993; Bockarie, 1993). Therefore, as well as my belief that an ethnomathematical curriculum would improve students' attainment by being more culturally relevant, there is also a need to revalidate cultural skills and preserve the unique mathematical culture of places like the Maldives.

Many researchers have documented mathematical practices in their own cultures. These include: Bakalevu's (1998) investigation of the Fijian culture for mathematical ideas; Millroy's (1992) exploration of how mathematical knowledge may be used in an everyday activity such as carpentry; Amancio's (2002) research into the mathematical traditions of Kanhgag - the second largest indigenous population of Brazil; and Alangui's (2003) ethnomathematical study into the practice of rice-terracing in the Cordillera region of Philippines.

For the past two decades ethnomathematics researchers have written about the possible benefits of teaching mathematics using these ethnomathematical studies in some way. Most of this writing has been from a theoretical and philosophical point of view. On the other hand, critics contend that too much focus on culture will be a retrograde step and a return to 'tribalism' (Diamond, 1988), or that too much attention on the students' cultural background in an educational setting may further marginalise the minority group of students (Vithal & Skovmose, 1997), or that too much emphasis on ethnomathematics "downplays mathematics as a formal and academic discipline" (Rowlands & Carson, 2002, p.80).

There is some initial evidence in research that inclusion of cultural aspects in the curriculum can have long term benefits to mathematics learners; that is, it enhances their ability to make meaningful connections, deepens their understanding of mathematics, and enables them to recognise mathematics as part of everyday life (Bishop, 1988; Boaler, 1993; Bockarie, 1993; Zaslavsky, 1991). The work of Gravemeijer (1994) on 'developing realistic mathematics education' and Treffer's (1993) work on 'Wiskobas and Freudenthal realistic mathematics education', support this argument by demonstrating the need for realistic contexts in mathematics education. To further reinforce the need for an ethnomathematical influence in education, Cobb (1994) from a social constructivist perspective claims that mathematics derived from a student's own culture would be more acceptable and enjoyable to them. A study of this nature can test these hypotheses, and further the debate about how to achieve better learning.

The Maldives has a rich heritage of mathematics because of its close connections with the traditions of both Indians and Arabs. There are also mathematical practices in the building, fishing, commercial, and craft activities of the Maldivian people that have persisted through many generations and have been adapted to Maldivian society. However, in recent years, the dependence on British examinations and the consequent reliance on a Western mathematics tradition have displaced the indigenous mathematics skills.

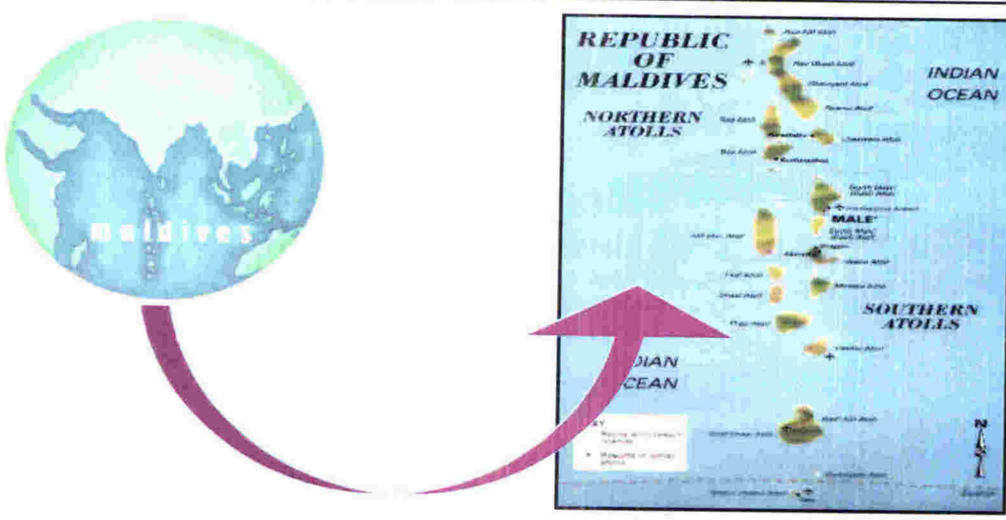
As all peoples, Maldivians reason mathematically; however, Maldivian mathematical ideas are not part of the mathematics curriculum (Adam, 1999). A belief in the universality of mathematics and a fear of change could be the reason that the Maldivian curriculum has depended on overseas practices. Maldivian Ministry of Education statistics show that the pass rate of students in mathematics in public examinations has been relatively low. It has been argued that for meaningful and relevant mathematical learning to occur, learning should be built on students' prior knowledge and experiences (von Glasersfeld, 1989). In this respect, the knowledge, thinking processes, and values students bring into the classroom are valid for their learning process (Begg, 2001a). However, the mathematical concepts of the school curriculum may not be related to students' cultural mathematical knowledge. It has been hypothesised that low attainment in mathematics, especially in the Third World countries, could be due to lack of cultural consonance in the curriculum (Bakalevu, 1998; Bishop, 1994; Ezewu, 1982). So it is timely to investigate whether culturally appropriate learning styles and mathematical ideas in the Maldivian society can be part of the curriculum.

In summary, then, the significance of the study derives from the idea that an ethnomathematical curriculum can enhance the existing curriculum and may help mathematics teachers and learners to make connections between the real world of the learners and school mathematics.

More specifically, the aim of this study is to investigate the implementation of an ethnomathematical unit in teaching and learning mathematics in a primary classroom in the Maldives. As such, the study examines the issues and problems in preparing an ethnomathematical unit of work, some of the initial outcomes of using an ethnomathematical unit of work, and the implications of introducing ethnomathematical ideas into the Maldivian curriculum.

1.3 SETTING OF THE STUDY

The research was conducted in my homeland – The Maldives. The Maldives is an island nation located in the Indian Ocean 275 miles Southwest of India, comprising about 1190 coral islands of which 200 are inhabited of which Male' is the capital (see Figures 1a and 1b). The islands are small, low lying, widely dispersed over an area of 90 000 square kilometres including land and sea, and have a population of approximately 270 000. The climate is hot and humid, determined by monsoons, with an average temperature of 28 degrees Celsius throughout the year. Tourism is the main occupation in the Maldives and fishing the second. Islam is the religion of the state and the national language is *Dhivehi* – a language unique to Maldivians.



- **No of islands:** 1190 of which 200 are inhabited
- **Population:** Approximately 270,000
- **Language:** Dhivehi
- **Religion:** Islam
- **Occupation:** Tourism, Fishing

Figure 1a: Maldives

Figure 1b: Male' – The Capital

(Ellis, 1997)

History of the Maldivian Society

It was believed that the first inhabitants of the Maldives were Aryan immigrants who came from Sri Lanka and Southern India before 500 BC. However, recent archaeological findings suggest that the islands were inhabited as early as 1500 BC. Maldivians believe that an ancient race of sun-worshipping people called the *Redin* were the first settlers who left a heritage of beliefs and customs including beliefs about evil spirits, which are still evident today. The *Redin* seemed to have left around 500 BC or to have been assimilated by Buddhists from Sri Lanka and Hindus from India. There is also evidence in these archaeological findings that the first settlers of the Maldives would have come from different cultures such as Arabia, Malaysia, Indonesia, and by arrangement rather than coincidence, from India and Sri Lanka. With the people from different nations came their cultures and beliefs (Ellis, 1997). Hence, today the Maldivian people are a mixed race.

The history of the Maldives is not very clear before the 12^{th} century. However, recorded contact with the outside world began in the 2^{nd} century when Arab travellers, en route to the Far East, visited the Maldives. The Maldives was known as 'The Money Isles' during that time when cowry shells were an international currency and the Maldives was a potential port for trade in pearls, spices, coconuts, dried fish, and abundant cowry shells. The news that these travellers must have taken home, about the exotic islands and rich natural resources, probably resulted in the arrival of more ships bearing traders and other travellers. Buddhism was practised in the Maldives until the embracing of Islam in 1153. The conversion to Islam was believed to have been instigated by a North African Arab traveller who stopped in the Maldives (Amin, Willets, & Marshall, 1992).

The outside world influenced the Maldivian life significantly, as legends and history reveal. After the 12^{th} century, the Arabs most influenced the course of the Maldivian history. Also, Portuguese (from Goa) ruled the Maldives briefly in the sixteenth century but guerrilla warfare tactics of six Maldivian heroes liberated the islands after 17 years. South Indian pirates and expeditions of Malabar opportunists tried to conquer the Maldives and 13 wars were fought in the 17^{th} century to preserve the islands' independence. A defence treaty with the French, who had a fort on the southern coast of India, helped the Maldives to repel further Malabar adventurers. However, this did not lead to a lasting French connection (Ellis, 1997). As Dutch and then British influence spread through the Indian Ocean in the 17th century, the Maldives came under their protection, but neither established a colonial administration. In the 1860s Borah merchants from Bombay set up warehouses and shops in Male', the capital, and quickly acquired an almost exclusive monopoly on foreign trade. The Sultan, dissatisfied with the Borahs' economic dominance, signed an agreement with the British in 1867, which guaranteed the islands' full independence. The Maldives subsequently became a British protectorate in 1887. An agreement was made whereby Britain agreed to protect the country against foreign enemies but to refrain from interfering in local affairs and administration. In return the British were allowed to have two military bases in the Maldives. The Maldives joined United Nations as a fully independent sovereign state on 26^{th} of July 1965 (Amin, Willets, & Marshall, 1992).

The freedom from the control of foreign powers in the country's history was a key determinant in the preservation of a culture and language that is unique to the Maldivians.

The Maldivian Language – Dhivehi

The roots of the unique *Dhivehi* language reflect the complex origins of the Maldivian people. Modern scholars consider *Dhivehi* to belong to the Indo-Iranian language group, closest to ancient *Sinhala*, with links to *Sanskrit* and other ancient tongues from Northwest India. *Dhivehi* displays much resemblance to several other languages from Sri Lanka, South East Asia, and North India. It contains many Arabic, Hindi and English words (Amin, Willets, & Marshall, 1992). It is possible that the Islanders deliberately adapted words they borrowed from other languages to form a language incomprehensible to others (Ellis, 1997).

There are three known scripts of *Dhivehi*: '*EveylaaAkuru*' found in three copper plates dating from 1195 to 1238; '*Dhives Akuru*' written from left to right which is very close to *Elu* the Singhalese script of 12th century; and the present day script '*Thaana*' which was introduced in the mid fifteenth century (Amin, Willets, & Marshall, 1992). '*Thaana*' is written like Arabic and Persian from right to left. There are twenty-four letters in the alphabet, nine of which are derived from Arabic numerals. Vowels are represented simply by marks below or above a letter. Figure 1c gives a sample of the Thaana script.

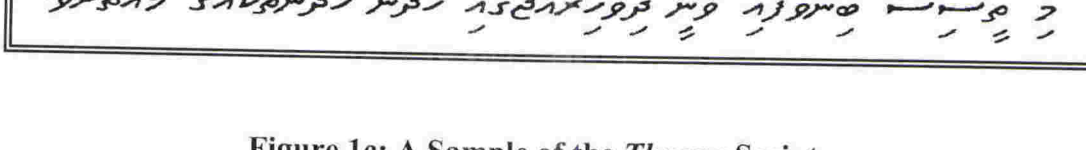


Figure 1c: A Sample of the *Thaana* Script

All Maldivians speak *Dhivehi*, which is also the official language of the Maldives, and is used in the administration of the country. Until the 1960s *Dhivehi* was also the medium of teaching at all schools. Since the 1960s English has been the medium of instruction in most secondary schools and now at all secondary schools. Therefore, all Maldivians who have gone through the formal education system can read, write and speak in English. There are also a number of people who have not gone through the formal education system who can speak fluently, and read and write in English. Additionally, all Maldivians can read and write in Arabic and those who have studied at the two Arabic medium schools in the Maldives, and in Arabic medium universities overseas, can speak fluently in Arabic.

Mathematical Traditions In The Maldives

Mathematical traditions in the Maldives, particularly with respect to counting and measuring, and the influences of other cultures such as the Indian, Sri Lankan, Arabs, and the British, were the focus of my Masters thesis (Adam, 1999). Hence, only a short summary will be given here.

The mathematical traditions of the Maldives have been influenced by the Indian culture since before the 12th century (Maloney, 1980), and the Arab culture since at least the 13th century (Neville, 1995). For example, the Indian influence is evident in the calendar system used by Maldivians to navigate, and the geometric designs of the Friday mosque in Male' are evidence of the Arabic influence (Adam, 1999).

From at least the medieval Christian era, Maldivians used base twelve to count (Maloney, 1980; Gibb, 1994), and even today there are many older people who do so. When Maldivians started counting or developed a base twelve counting system is not known. It is believed to have been transmitted by Arab traders, as counting by base twelve is not known in the neighbouring countries, India or Sri Lanka (Adam, 1999; Maloney, 1980). However, it is interesting to note that the *Dhivehi* words used in the duodecimal system are related to some of the Indo-Aryan words used in the decimal system (Maloney, 1980).

The decimal system is used throughout the Maldives at present. This use is reinforced by the influence of Indo-Aryan languages in South Asia, the Arabs, and then the British who came to Maldives. Though the decimal system is commonly used in the Maldives, many

Maldivians tend not to think in terms of decimals, but rather in terms of fractions. For example, in *Dhivehi*, three-fourths will be read as from four parts, three parts are taken.

Maldivians developed strategies for measuring length, volume, weight, measurement, distance, and area. Body parts are mainly used for linear measure while containers made from coconuts are used for dry and liquid measures.

Five calendar systems are used in the Maldives. They are the Gregorian (English) calendar, Hijri (Islamic) calendar, an Indian solar calendar, an Arabic solar calendar, and a *naksatra* calendar. The Gregorian and Hijri calendar are the official calendars of the Maldives. The Gregorian calendar is used as a link with the international world whereas the Hijri calendar is used as a link with the Islamic world and as a basis to mark Islamic festivals. Indian solar and Arabic solar calendars are rarely used now. However, the *naksatra* calendar is commonly used in navigation. The *Dhivehi* names given for different *nakaiy* (the divisions in the *naksatra* calendar) in this calendar are closely related to Sanskrit and it is evident that this system came to Maldives from India. The *naksatra* calendar or the *nakaiy* system is important for Maldivians as it is correlated with weather, with travelling back and forth between islands, and with fishing, agriculture, and other activities. For example, trading boats avoid stormy *nakaiy*, and there are certain *nakaiys* which are good for fishing, planting, and kite flying (Adam, 1999).

Mathematical traditions are evident in everyday activities of Maldivians such as fishing, boat building, building and construction, agriculture, mat weaving, rope making, toddy collecting, vase making, navigation and astronomy, money, and housework. For instance, precision is important for fishermen in sharing fish of different sizes and getting market prices; and in boatbuilding, the boats need to be symmetrical so exact techniques are needed to achieve this. Boat builders use a lot of estimation, as no plans at all are drawn in boat building (Adam, 1999). Figures 1d and 1e (Amin, Willets, & Marshall, 1992) show pictures of a fish market, and a *Dhoni*, in the process of being built, respectively.

Figure 1d: Fish Market

Figure 1e: A *Dhoni*, In the Process of being Built

Historical Overview Of Education In Maldives

Traditionally, education has been directed towards religion. From the age of three, or as soon as the child starts to speak, parents often begin to teach their children to read and write. They are taught to perform and pronounce the Arabic letters so they can learn the *Quran* (Koran) as early as possible. In addition to learning to read the *Quran*, all the daily prayers with the *Salawat* (benedictions) have to be learnt by heart. Children are also taught the *Dhivehi* script (*Thaana*) and some rudiments of arithmetic. Traditionally, children learned to write both *Thaana* and Arabic on boards, which are smeared with liquid lime and allowed to dry. On this surface the letters are written with a bamboo pen with the ink being made from burnt powdered coconut shell (Amin, Willets, & Marshall, 1992; Bell, 1930, 1940; Maloney, 1980).

The traditional system of education has evolved since the 12th century and is still practised today. It is composed of three types of institutions: *Kiyavaage*, *Makthab,* and *Madhrasaa* (see Figure 1g). The *Kiyavaage* is a gathering of children in a private house with the objective of teaching the pupils how to read the *Quran*, how to read and write *Dhivehi,* and to teach some basic principles of arithmetic. The *Makthab* provides further instruction for older children in the same subjects as well as Islam and is usually housed in a separate building. In the *Madharusaa* the curriculum is somewhat expanded to include additional subjects. In addition to regular religious instruction schools, there were schools for young adults for navigation, languages (Arabic, *Urudu*, and English), and for Muslim theology. Although educational attainment in the traditional system is low in terms of performance in formal examinations, the system has contributed towards achieving many educational objectives - the most important of which is the relatively high rate of literacy, about 98% in the *Dhivehi* language; and the preservation of national culture and tradition (Maloney, 1980; Ministry of Education, 1995, 1996; UNESCO, 1986; Williams, 1988). Figure 1f (Amin, Willets, & Marshall, 1992) gives an overview of a '*kiyavaage*'.

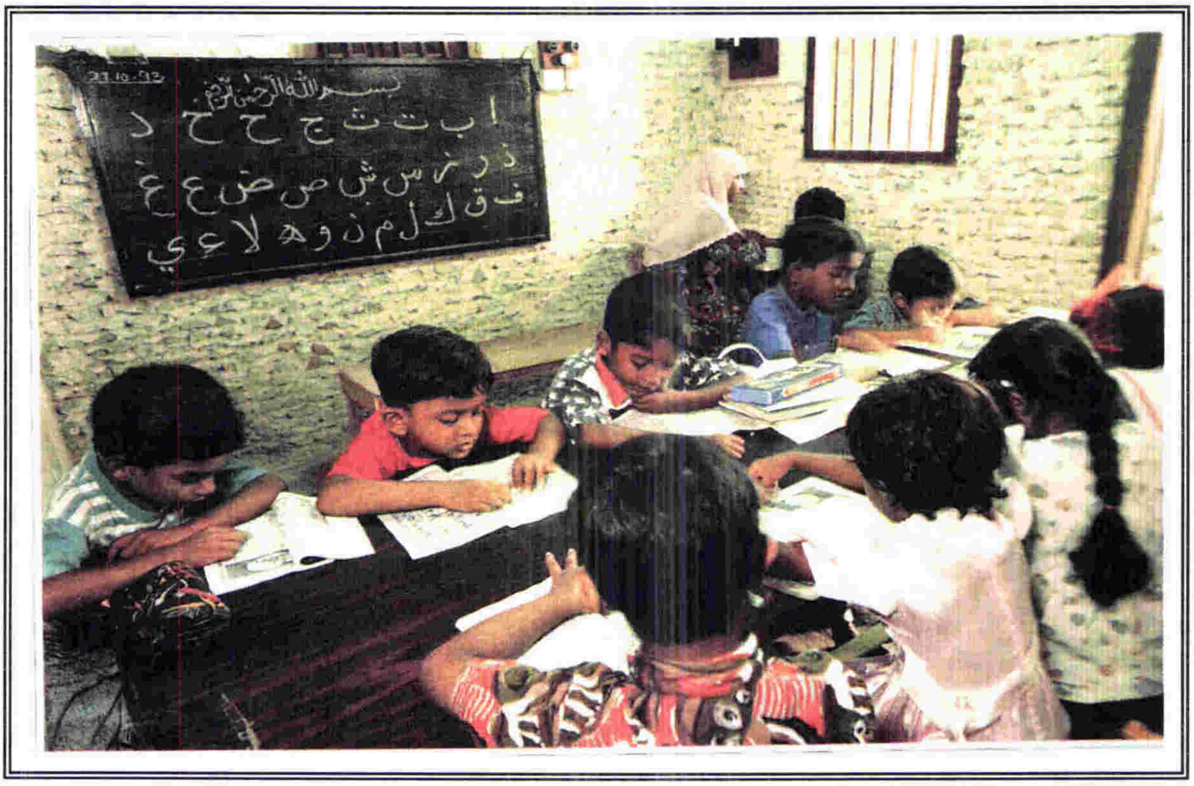


Figure 1f: ***Kiyavaage***

Education was originally conducted through private tutoring and by informal direct face-to-face learning. The first state-financed and state-administered traditional school was the covered gateway of the Friday mosque in Male', which began in the late 17th century. Basic religious knowledge and the recitation of the *Quran* were taught here. In 1927, the first government school was established in Male'. Originally it was for boys, but in 1944 a section was opened for girls as well. Instruction in this school covered *Dhivehi* language, Islam, Arabic and Arithmetic. Under the leadership of the nation's First Republic, in the 1940s and early 1950s educational development took place. By 1945 each inhabited island had a traditional school providing instruction at the lower primary level. In the 1950s the education system was remodelled to meet the requirements for trained people in growing economy. In 1960, education in Male' changed again with the introduction of two English-based schools. The primary purpose of the new English-based education system in Male' was to produce secondary school graduates with London GCE (General Certificate of Education) Ordinary-level qualifications for the betterment of the country in a globalised world. This resulted in two education systems existing side by side in Male' - the traditional education system and the English-based education system. However, until recently, the traditional education system was the only type of education provided for those living in the atolls (Didi, 1964; UNESCO, 1986).

Education Today

The two types of schooling have coexisted since the early 1960s. The traditional serves to preserve the cultural identity of the people, and the English-based schooling serves to provide the type of education required to help the country enter the modern world. This English system has emerged on a national scale in the last twenty years and now accommodates much of the traditional characteristics in that *Dhivehi* and religion are now taught in the English-based schools. This co-emergence followed the decision in 1978 to move to a unified national system of education and to promote an equitable distribution of facilities and resources. The policy was focused on providing Universal Basic Education for All. A unified curriculum for Grades 1-7 was formulated together with improvements in teacher training and the establishment and upgrading of new schools in the atolls. The primary education system is a 5-year cycle which students are expected to begin at age 6. This is followed by the 6th and 7th year of Education, which is referred to as the 'middle school' or 'extended primary'. In Male', the primary-middle school cycle is preceded by a 2 year cycle of pre-primary education (lower and upper kindergarten years). In the other atolls this form of pre-primary education is now becoming more common, especially on highly populated islands. Thus, the formal grade cycle 1-5 (Primary Level) and 6-7 (Middle School Level) together make up what the Ministry of Education (MOE) calls the 'Basic Education Cycle'. Secondary Education of the Maldives consists of Grades 8-10 (Lower Secondary) and 11-12 (Upper Secondary) (Ministry of Education, 1995). The medium of instruction in both the primary and secondary schools of Male', is English. In the other islands the medium of instruction in the primary school is *Dhivehi* and they learn English as a subject. In addition to the English-medium schools in Male', there are two schools – one primary and one secondary school where the medium of instruction is Arabic and English is taught as a subject. Students who go to these Arabic-medium schools are those who want to go into Islamic philosophy related subjects or do tertiary studies in an Arabic-medium university. In the past, children from the atolls completed their primary education at the Atoll school, and more than fifty percent of these children then came to the capital, Male', to get higher education. This created a burden on the capital city - an increase in population and some adverse social problems (Ministry of Education, 1996). Now there is at least one secondary school in each atoll offering London GCE Ordinary Level qualifications and in 2001 two atoll secondary schools have started offering London GCE Advanced Level qualifications. From this year – 2004, more schools from different atolls will start offering Advanced Level qualifications.

Until recently, there were no institutes for higher learning, such as colleges and universities. The GCE Advanced Level was the highest qualification available in Male'. Only a few first-year university courses were available through distance learning. After Ordinary Levels or Advanced Levels, most students usually went abroad for tertiary study. In 1998, The Maldives College of Higher Education was established. The College offers certificates, diplomas, and undergraduate degrees in disciplines such as education, management, accounting, computing, engineering, health sciences, tourism, law, and maritime studies. In addition, the College is affiliated with a number of Western universities to offer a variety of certificates, diplomas, and some under-graduate and post-graduate degrees. Figure 1g gives an overview of the current educational structure of the Maldives.

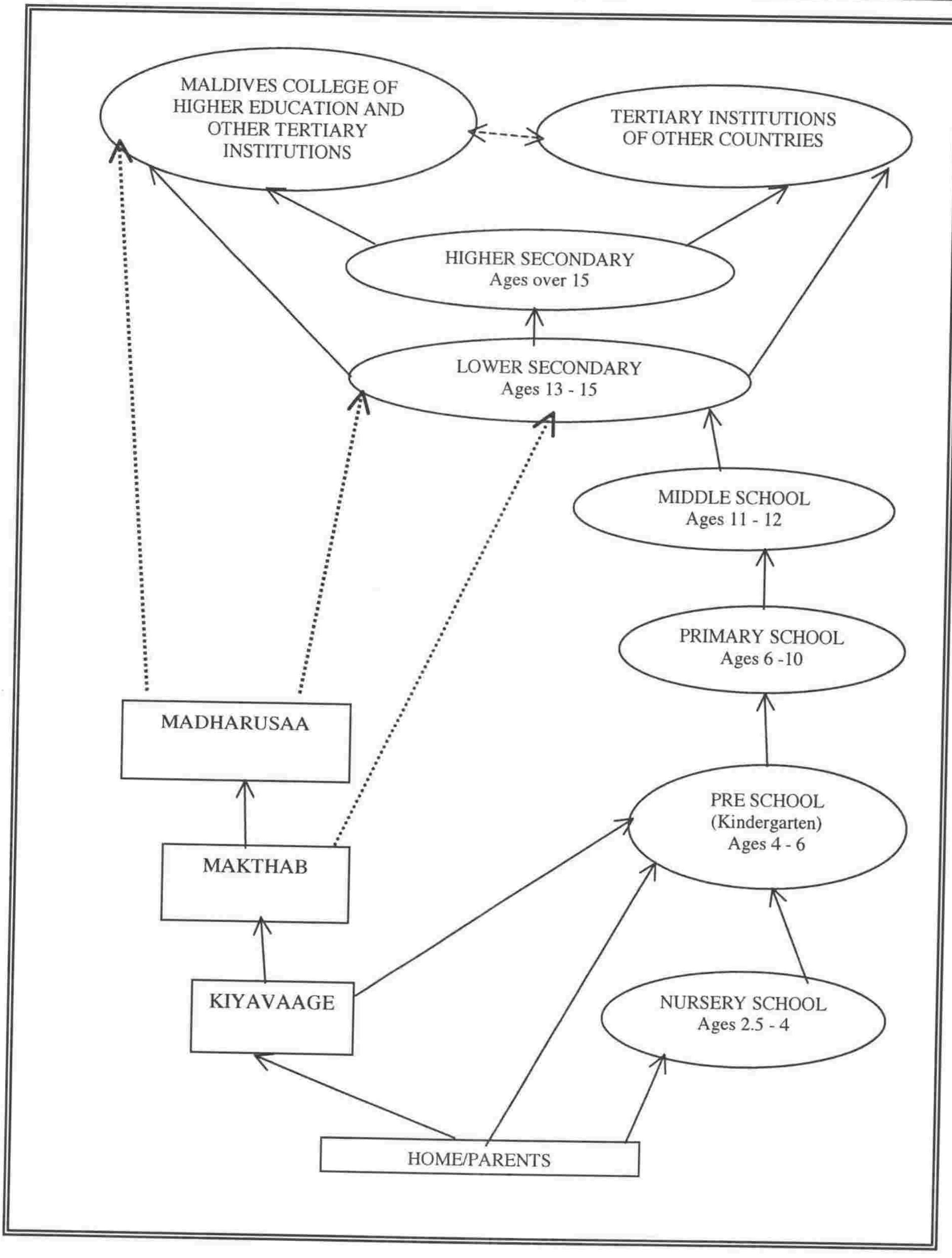


Figure 1g: The Current Educational Structure

The Curriculum And Assessment System

The National Primary Curriculum is designed and developed by the Educational Development Centre of the Ministry of Education, Maldives. It outlines a seven-year programme, starting from grade one through grade seven and acts as a 'feeder' curriculum for the secondary curriculum. As the current primary mathematics curriculum is a feeder curriculum for the overseas curriculum it is geared towards 'English'/Western mathematics, reinforcing the same ideas and similar concepts. Hence, cultural aspects are not emphasised.

The secondary curriculum is designed and developed by the University of London Assessment and Examinations Council, the secondary textbooks are produced overseas, and Maldivian students sit for the London Ordinary Level and Advanced level examinations when they finish grade ten and grade twelve respectively. A strong emphasis is put on examinations in the Maldivian education system. Students need to pass the end of year examination to go to the next grade in the secondary school. If they fail they need to repeat their year in the same grade, and if they fail consecutively for two years then they finish their schooling. Automatic promotion occurs in the primary school. Mathematics, English Language, *Dhivehi*, and Islam are compulsory subjects from grade one to grade ten. Students need to have at least five passes with a grade 'C' or above including either Mathematics or English at the GCE Ordinary Level and 'C' or above in Islam and *Dhivehi* at the local examinations to get entrance to the Advanced Level school. Students sit for Secondary School Certificate (SSC) Examination and Higher Secondary Certificate (HSC) Examination at the end of grades ten and twelve respectively in Islam, *Dhivehi* and/or Arabic. These two examinations are local and set by the Department of Public Examinations of the Ministry of Education, Maldives. The local examinations are also needed to ensure good employment and scholarship opportunities.

The Tertiary curriculum is designed and developed by the Maldives College of Higher Education, and accredited from the Maldives Accreditation Board (formed in 2001) of the

Ministry of Education. Although Maldivians develop these curricula, they are based on Western ideas. This means that there are no Maldivian contexts or attributes in it whatsoever, and the recommended textbooks for these curricula come from overseas.

1.4 OVERVIEW OF THE THESIS

This chapter has focussed on the background to this study. Looking ahead, the next three sections of the study relate to relevant literature, the theoretical framework and research design, and an account and discussion of the research.

Chapters Two, Three, Four, and Five are reviews of literature. Specifically, Chapter Two looks at the cultural context of mathematics education with respect to culture, cultural context of mathematics, and cultural context of mathematics education. Chapter Three gives an overview of the definition of ethnomathematics and critiques of ethnomathematics. The possibilities for an ethnomathematical curriculum and the issues and questions that need to be considered in implementing such a curriculum are discussed in Chapter Four. Chapter Five reviews the literature on curriculum implementation by considering the changing view of curriculum, the role of teacher, and the challenges of implementing curriculum innovation.

Chapter Six presents theoretical frameworks for the study in terms of models or framework for an ethnomathematical curriculum. Chapter Seven gives an overview of the research methodology and considers methods of data collection and analyses.

Research results are presented, analysed, and discussed in Chapters Eight, Nine, Ten, and Eleven. Chapter Eight looks at the issues, considerations, and problems in preparing an ethnomathematical curriculum unit, while Chapter Nine discusses the issues of implementing an ethnomathematical curriculum unit. Chapter Ten reports on the outcomes of using an ethnomathematical curriculum unit, and the curriculum implications of introducing ethnomathematical ideas into the curriculum are discussed in Chapter Eleven. Chapter Twelve summarises the main findings of the research, draws conclusions about these, outlines implications of using an ethnomathematical curriculum in Maldivian primary classrooms, and points to possible new directions for incorporating ethnomathematical ideas into mathematics education. It also suggests further research needs and possibilities.

2 CULTURAL CONTEXT OF MATHEMATICS EDUCATION

2.1 INTRODUCTION

Over the years, many philosophers and mathematicians have attempted to define mathematics (Hart, 1996). While there is considerable agreement as to what conventional mathematics encompasses, it is practically impossible to define mathematics, just as it is hard to define one particular philosophy (Halmos, 1981; Joseph, 1991). Traditionally, the predominant understanding has been that mathematics is culture free, rigid, fixed, ahistorical knowledge independent of human minds (Ernest, 1996; Kline, 1953; Shan & Bailey, 1991).

However, in recent years researchers have been increasingly working towards an understanding of the relationship between culture and mathematics. Challenging the belief that mathematics is found only in the form of Western rationalist thought, they are identifying mathematics expressed in ways unique to particular cultures. In this respect, Bishop (1988) and Wilder (1981) state that mathematical ideas are social in character. D'Ambrosio (1991) builds on this notion by stating that mathematical ideas are not only linked to our everyday life but that they have developed out of human needs situated in cultures and societies to explain or understand different phenomena.

If mathematics is a social construction, then the cultural environment of the student will shape the way mathematics is taught and learned. It is generally accepted that mathematical awareness develops differently in different sociocultural settings, and therefore, learning and teaching mathematics should be acts of making sense of the real world (Boaler, 1993; Masingila, 1993). Yet, there is still a mismatch between mathematics taught at school and the culture, or 'real world', of students. There is growing concern among educators that students who learn mathematics throughout their schooling are not able to use the school learned mathematics in the work place or situations outside the school context (Boaler, 1993, 1998). Several research studies have shown that this inconsistency is due to the non-inclusion of students' own real world contexts or cultural values in the mathematics classroom (Bakalevu, 1998; Bishop, 1988; Boaler, 1993).

This chapter very briefly considers cultural context from the mathematics education literature in a general sense before considering the more specific issues of ethnomathematics and ethnomathematical curricula. More specifically, this chapter gives a brief overview of culture, the cultural context of mathematics, and the cultural context of mathematics education.

2.2 CULTURE

Like mathematics, the concept of culture is difficult to define, and has been variously described in mathematics education literature. It conveys different meanings when perceived by different groups of people in different 'contexts' (Bakalevu, 1998). According to Porter and Samovar (1994), the characteristics of a culture are that: it is learned or experienced; it is vigorous; it is communicable; it is particular; it is complementary; and it is ethnocentric. Hence, culture may be defined as the customs, civilisations, lifestyles, common experiences, understandings, schemata, artefacts, behaviours, accomplishment, and achievements of a particular group of people (Ascher, 1991; Begg, 1995; Bishop, 1988). It is an organised system of beliefs and values that is transmitted to and inherited by individuals of that particular culture, both consciously and unconsciously (Bishop, 2001; Rogoff, 1990). Culture becomes evident through the jargons, codes, myths, symbols, stories, values, beliefs, and ways of reasoning, explaining, inferring that a group of people shares, experiences, engages, and accepts (D'Ambrosio, 1986). These experiences include mathematical practices such as the way people count, measure, design, locate, explain, and play (Bishop, 1988). These practices reflect the culture of the people and thus cultures do not share the same mathematical practices, values, conceptions, and beliefs (Bishop, 2001).

Cultural context involves the cultural history, language and communication, thinking patterns and styles, values and attitudes, religion, cultural traditions, customs, and methods used for finding solutions to problems people encounter in their day-to-day lives (Schillinger, 1998; Thomas, 1997).

2.3 CULTURAL CONTEXT OF MATHEMATICS

What is mathematics about? Are there mathematical truths in the external world to be discovered by human beings, or are they created by human beings whenever the need arises? These questions have attracted philosophical attention since the time of Plato and Aristotle and are being increasingly debated (Barton, 1996a; White, 1960; Wilder, 1968, 1972).

Plato described mathematics as an abstract body of infallible and objective truth and hence our knowledge of mathematics must also be independent of our experiences of this world (Honderich, 1995). According to this view, mathematical knowledge is not related to human beings and their sociocultural environment. However, recent attempts to examine the nature of mathematics have shifted from this traditional objective view of mathematics to mathematics as a social or cultural system (Bishop, 1988; Wilder, 1981).

One of the first challenges to the infallible view of mathematics from a social perspective was that of Spengler (1956, 1961). He argued that the origin of mathematics independent of human minds is a myth, that mathematics replicates a culture, and that mathematics (p. 63)

> … is a science of the most rigorous kind, like logic but more comprehensive and very much fuller; it is a true art, along with music and sculpture, as needing the guidance of inspiration and as developing under great conventions of form.

He focussed on the concept of *number,* which he believed to be the fundamental of mathematics, as the mathematics of present-day culture. However, he argued that (Bakalevu, 1998, p. 53), even though "number is the primary element on which all mathematics rest, mathematics itself is broader than the narrower theory of numbers, and that the numerical vision of a culture is not necessarily a measure of its mathematics". He contends that the concepts of number are used by human beings as a means to acquire control. Therefore, for Spengler, mathematics is an art that does not exist in isolation from a culture.

Wilder furthered the debate on the nature of mathematics. He did an elementary study (1968) on the evolution of mathematical concepts, a further study on the nature of mathematical concepts (1972), and, in his book (1981) *Mathematics as a Cultural System*, he described the nature of mathematics and its relation to culture and society from an anthropological point of view. He argued (1981, p. 154) that mathematics is an evolving cultural system, and as

> … mathematics evolves the individual mathematician caught in the culture stream, not only borrows his ideas therefrom, but is affected by the forces inherent therein as conveyed to him by his fellow mathematicians.

He also challenged the belief that mathematical concepts are evolved intuitively "from the minds of individual mathematicians", by stating that the "individual intuition is itself a result of the culture's effect upon the individual's mind" (p. 66). Additionally, he also proposed ten 'Laws governing the evolution of mathematical concepts' (1968, p. 207) which was an attempt to study mathematics as a cultural product.

As opposed to Wilder's statement of laws, Crowe (1975) gives "his own ten laws, based on the growing historiography of mathematics" which led into what is called the Crowe–

Daubin debate (Barton, 1996a, p. 44). In his statement of laws, Crowe (1975, 1992) claims that revolutions never occur in mathematics and that developments in new mathematical theories do not lead to older theories being rejected. He challenged the paradigms and theoretical constructs used by historians of mathematics, especially that of Kuhn's analysis of scientific revolutions (Barton, 1996a). In response to this, Daubin (1984) agrees that older theories need not be necessarily discarded in a mathematical revolution. However, he argues (1984, 1992) that new discoveries result in new modes of thought and hence, when a "true revolution" takes place, "a significant part of the 'older' mathematics will come to be replaced or dramatically augmented by concepts and techniques that visibly change the vocabulary and grammar of mathematics" (1992, p. 80).

Increasingly the fields of anthropology, sociology, and history are being added to philosophical debate in discussions about mathematics (e.g., Bloor, 1994; Jurdak, 1999; Restivo, 1992; Winslow, 2000), and as a result, the human role in mathematical development is now widely acknowledged.

2.4 CULTURAL CONTEXT OF MATHEMATICS EDUCATION

In recent years, attempts to examine the state and nature of mathematical understanding, and the decline in school mathematics performance have brought more attention to cultural factors in mathematics education (D'Ambrosio, 2001).

Mathematics curricula in most countries are strongly directed towards techniques, skills, rules, algorithms and theories geared towards drill and practice, and are examination focussed (Bishop, 1988). The relevance of mathematics to real life or culture is absent from content and instruction. This means that the mathematics taught in the classroom has little to do with the world that the children are experiencing. D'Ambrosio (2001) argues that this does not help students learn the necessary skills and information to function successfully in their day-to-day lives. Boaler (1993) notes that this results in most students believing that there is no connection between mathematics and the real world, and students failing to utilise school learned mathematics in life outside school. However, as expressed by Rosa (2000), all students need to extend their understanding to include how mathematics connects to other disciplines, to problems in society and to the environment, and how it is used by diverse people around the world.

This section looks at some of the prominent ways cultural context have been used in mathematics education literature. These include: context in classroom mathematics, situated cognition, Bishop's cultural conflict, and indigenous education.

Context In Classroom Mathematics

The use of contexts in mathematics classrooms has been advocated to make mathematics more meaningful to its learners, and so that students will be more motivated when they can see the connection between the real world and mathematics (Boaler, 1993, 1999; Gravemeijer, 1994; Masingila, 2002). The use of contexts in mathematics classrooms is strongly supported by the Freudenthal Institute of The Netherlands where they have introduced the programme 'realistic mathematics education'. In realistic mathematics education the emphasis is on the use of context, which may be physical but could also exist in the imagination of the students (de Lange, 1992). Students are given problems set in carefully constructed realistic contexts and are asked to explore, and investigate these problems from which they encounter mathematical formulae and theorems (Gravemeijer, 1994). The assumption is that students can use their knowledge of these contexts to formulate mathematical ideas in meaningful ways, and then to formalise them as mathematics.

The question is how real is real? There have been criticisms of the use of context in the classroom (e.g., Boaler, 1993; Masingila, 1993). One such criticism is the extent to which the students can identify with the context selected from the real world (Boaler, 1998). For example, when teaching a topic like probability in a Maldivian classroom, it would be more meaningful to the students if they were asked to investigate the chances of a boat catching different variety of fish than asking them to investigate a certain horse winning a horse race. This is because fishing is something related to their culture where as most of the students would not have seen a horse race or even a horse (Adam, 1999).

Situated Cognition

Situated cognition refers to the way people think differently in different situations. Studies on situated cognition focus on how people use mathematical knowledge in everyday activities, how this is different from school mathematics, and whether and how this knowledge can be integrated into mathematics learning. The theory of situated cognition stresses that all learning and knowledge are situated in the context and culture in which it is developed (Lave & Wenger, 1991). Researchers in this field who have explored the transfer of school-learned mathematical knowledge to mathematical practices outside school include Lave, Carraher (Nunes), and Millroy.

Lave's (1988, 1991) 'Adult Math Project', in United States, evaluated adults' use of arithmetic in the supermarket and in a classroom or test context. She observed that the same people differ in the way they approach arithmetic problems depending on the context. Hence, she concluded that the use of a real life context at school does not have much effect upon the use of school learned mathematics in real life contexts and vice versa. This was challenged by Boaler (1993) by arguing that even though learning is situation specific, transfer can be enhanced by contextual factors of the learning environment.

Carraher (Nunes) and her colleagues did extensive research in Brazil that explored the relationship between learning environments and the form of mathematical knowledge learned (Carraher, Carraher, and Schliemann, 1985, 1987; Nunes, Carraher and Schliemann, 1993; Nunes and Bryant, 1998). They were puzzled by the fact that working class children who fail in school mathematics were actually quite successful as vendors. They found that these children used different problem solving approaches when mathematical problems were set in different contexts. For example, they used mental methods to calculate problems set in the street market context whereas they tended to use written algorithms for problems set in a school context.

Millroy (1992) investigated how geometry and/or other mathematical knowledge may be used and constructed in everyday activities. She worked with a group of carpenters, from diverse cultural and language backgrounds, in a carpentry workshop in Cape Town, South Africa. She concluded that people construct and create their own methods to solve problems in real-life situations regardless of the school-learned mathematics, and that they are unable to apply school-learned mathematics in real life situations probably because mathematical practices in everyday activities are not included in classroom teaching.

As evident from the above, there are differences between mathematics practices in and out of school. For example, a mathematical concept may be understood and used differently in everyday situations compared with the way it is taught in school (Masingila, 1993). Similarly, when cultural knowledge is taken from its context and brought into mathematics classroom, it might be transformed completely so that it might no longer be recognised as cultural knowledge (Lipka, 2002b). However, these differences can be narrowed so that, instead of being activities that are disjoint and do not influence each other, mathematics learning and practice in and out of school can be built on and be connected with each other. As Lipka (2002b) states, the challenge is to adapt the cultural knowledge to school mathematics without trivialising or stereotyping and vice versa.

Bishop's Cultural Conflict

The term 'cultural conflict' refers to the mismatch between the culture of students and the culture of school. According to Bishop (1988, 1991, 1993, 1994) every child undergoes cultural interaction during his/her formal mathematics education, and therefore, throughout this process every child experiences some level of cultural conflict. Cultural conflicts may arise due to exposure to different values, beliefs, language, logical reasoning, attitudes, goals, or cognitive preferences. Cultural conflicts with school mathematics are predominant among students in Third World communities and minority students as, although school mathematics is taught as culture-free knowledge isolated from the students' 'real-world' (Bishop, 1994), it is in fact embedded in an unfamiliar cultural context (i.e. a Western one) that is not acknowledged

To reduce cultural conflict, Bishop (1993, 1994) proposed a research agenda to recognise the degree of cultural conflict and its possible resolution. To this end, he argues (1988) that a mathematics curriculum should represent the mathematical culture of the students, be accessible to all students, and be relatively broad and elementary (p.98); mathematics should be taught with the use of activities, projects, and investigations; and mathematics should be learnt through an understanding of the social nature of mathematics, by reflecting about mathematical ideas, and by linking mathematics to the society.

Nevertheless, cultural conflict can also be used for its positive aspects as was done by Barton (2003) and his colleagues in the 'Mathematics Enhancement Project' which is aimed at enhancing the participation and achievement of senior secondary mathematics students. For example, in this project (Barton, 2003, p. 137), conflicts were recognised and described, and were adapted into mathematics learning opportunities.

Indigenous Education

These theoretical constructs of cultural context, situated cognition, and cultural conflict become highlighted in the education of particular identifiable cultural groups. An example gaining increasing attention is that of indigenous education. What cultural issues become important in mathematics education for an indigenous group – particularly when they are a minority in their society?

At present, the mathematics education system existing in many countries does not enable indigenous people to participate fully in the learning environment. In the formal education system, the community and culture of the indigenous peoples' lives are ignored and there is a mismatch between what is taught at school and what is practised outside school (Alangui, 1999). Therefore, it is important to question the kind of mathematics education that indigenous people need in order to enhance their full participation in mathematics learning. Following Alangui (1999) and Rovillos (1999), I argue that mathematics education should be made meaningful to indigenous students. How can this happen? In this regard, the field of ethnomathematics offers possibilities.

Barton (2002, p. 4) sees the role of ethnomathematics in indigenous education as "a manifestation of the adaptation and affirmation of cultural concepts in a modern world". The ongoing work in Brazil on ethnomathematics with indigenous people (Refer Chapter Three) affirms this. However, we should be aware of the complexities of the issues of indigenous education (McConaghy, 2000). As Barton (2002, p. 8) states,

> Indigenous peoples education is one of the sites of the critiques of cultural and development positions and the projects that emanate from them. Issues of power are central to current positions. The links between ethnomathematics and indigenous knowledge, make it important for us to be aware of, and act upon, the debates that are emerging.

2.5 SUMMARY

This was a very brief look at some of the writing in mathematics education with regard to culture and mathematics education. This provides a background for the more detailed examination of ethnomathematics and ethnomathematical curricula.

It is apparent from the literature on culture and mathematics that mathematics will be meaningful to students not just through presentation of real world contexts but through contexts students are familiar with, and related to the cultural environment.

Students' social and cultural values need to be encouraged and supported in the mathematics classroom, through the use of contexts. When students' cultural mathematics is given enhanced recognition in a social setting, it should enable connections to be made with school-learned mathematics. This will also help when students are faced with the demands of the real world (Boaler, 1993).

Thus it is argued, that for mathematics learning to be meaningful, mathematics needs to be put in the context of real life experiences of students' lives outside school.

3 WHAT IS ETHNOMATHEMATICS?

3.1 INTRODUCTION

Ethnomathematics is a relatively new field of interest, and as a field of research it has been defined as the study of the cultural anthropology of mathematics and mathematics education (Gerdes, 1997a). Prior to the 1980s not much research had been conducted on culture and mathematics, possibly because people believed in the totality of mathematics (D'Ambrosio, 1991). The common understanding was that mathematics was culture free and isolated knowledge independent of human minds (Ernest, 1996; Kline, 1953). The acceptance was that, whichever culture you lived, 'two plus two equals four'. However, this belief does not acknowledge where the idea of 'two plus two equals four' comes from. In other words, this belief does not concede that the idea has been created by human beings to explain a certain concept at a time and in a way when it was necessary (Adam, 1999).

After the early 1980s, research writings on the relationship between culture and mathematics increased steadily due to an increased awareness among mathematics educators of the cultural and social aspects of mathematics education, particularly the equity and social justice issues. Educators realised that mathematical ideas exist in all cultures and the way these ideas are expressed would vary from culture to culture (Ascher, 1991; Barton, 1990, 1995; Gerdes, 1994; Masingila, 1993). Further, the research conducted around this time showed evidence, in some cultures, of mathematical practices such as counting, measuring, and designing being done in ways that were different from the conventions of school mathematics (Barton, 1995; Bishop, 1988; D'Ambrosio, 1991). Hence, the field of ethnomathematics originated when people started thinking and "recognising that different ways of thinking may lead to different types of mathematics" (D'Ambrosio, 1985, p.44). It was D'Ambrosio, regarded as the father of ethnomathematics, who coined the term in its present sense at the 1984 International Congress on Mathematics Education. Since then, there have been many issues and debates within the field of ethnomathematics, and two International Congresses on ethnomathematics have been held, with more than 20 countries being represented at the second congress.

This chapter gives an overview of ethnomathematics with respect to the definition of ethnomathematics and to writings in ethnomathematics in different eras, and to issues in ethnomathematical research.

3.2 ETHNOMATHEMATICS

From an ethnomathematical perspective, mathematics is a human creation that emerges as people attempt to understand their world. That is, mathematics is an intellectual mechanism invented by humans to cope with the environment, to explain, and make sense of their real world (D'Ambrosio, 2002). In particular, mathematics consists of the systems people use to make sense of the quantitative, relational and spatial aspects of their environment (Barton, 1996a). Barton gives examples: quantitative aspects could be the way people from different cultures count, measure and express quantities; relational aspects of the environment include, for example, the way people talk about relations in the family, construct an argument ("if … then"), or categorise (e.g., animals, fish species); examples of spatial systems include the way symmetry and patterns are talked about, or the way shapes are idealised and categorised, and locating or specifying position in navigation.

Since humans live in particular cultural contexts, the ethnomathematical perspective also includes those parts of their lives that contribute to such systems of meaning - language, values, beliefs, stories, myths, and knowledge. So, the systems that are created to understand the mathematical parts of the experiences of different cultures are likely to be different for different groups of people. Ethnomathematics is the study of these different systems. In other words, ethnomathematics is the study of mathematics in the context of the culture in which it arises. Ethnomathematics is taken to mean this for this thesis.

D'Ambrosio (1985, 1991) described ethnomathematics in terms of mathematics as a human invention that comes from inside one's culture – where culture is understood as the customs, civilisations, and achievements that one shares with a particular group of people. Further, D'Ambrosio (1994a) describes ethnomathematics as the study of different forms of mathematics resulting from different modes of thought with regard to mathematical practices and concepts of people of varied cultures within different environments. With his etymological definition of ethnomathematics D'Ambrosio (1994a, p.232) refers to distinct modes of explaining, classifying and coping with reality in different cultural environments where

> ... *ethno* stands for culture or cultural roots, *mathema* is the Greek root for explaining, understanding, learning, dealing with reality, *tics* is a modified form of *techne*, which stands for art, techniques, or modes.

A lot of writing on ethnomathematics was published in the two decades following D'Ambrosio's original definition of ethnomathematics in 1984. During the first decade the writings on ethnomathematics were especially associated with education, and were quite isolated from conventional mathematics (Barton, 1996a). However, in the mid-nineties, Barton (1996a, 1996b) provided a basis for ethnomathematics from a philosophical and theoretical point of view, and Gerdes (1997a) proposed a summary of different types of 'mathematics' that have been proposed to contrast with school (or formal) mathematics, and which came under the common denominator of ethnomathematics. Since then, the depth and scope of ethnomathematical research has grown significantly. This is evident from the proceedings of the First International Congress on Ethnomathematics in Granada, Spain (Contreras, Morales, & Ramirez, 1998), and the Second Congress in Ouro Preto, Brazil (de Monteiro, 2002).

First Decade

Detailed reviews of ethnomathematical research, during this era, have been written by several ethnomathematical researchers (e.g., Barton, 1996a, 1996b; Gerdes, 1997a, 1997b). Only a short summary will therefore be given here.

The leading writers in this field during this period were D'Ambrosio from Brazil, Gerdes from Mozambique, Barton from New Zealand, Bishop from Cambridge, Ascher and Zaslavsky from United States of America, and Borba and Knijnik from Brazil.

D'Ambrosio (1985, 1991, 1992, 1994a, 1994b) used a theoretical approach to ethnomathematics and his writings were from a political perspective, in the sense that he investigated ways in which mathematical knowledge is colonised and how it rationalises inequity and discrimination within and among cultures. Gerdes's (1986, 1991, 1994) writings were more practical in nature and were about recognising and identifying mathematics (especially geometry) implicit in different cultural practices. He worked with teacher education in Africa and saw this as means of enhancing practice. Barton's (1990, 1993, 1995) approach to ethnomathematics was philosophical and emphasised developing ethnomathematics as a field of research. His main work at the time was with Maori mathematical language. Bishop's (1988, 1990, 1994) work was on the nature of the culture of mathematics and the way mathematics is practised and perceived in different cultures. He was interested in the issue of cultural conflict in the mathematics classroom (refer Chapter 2 pages 28-29). Ascher (1986, 1991) concentrated on studying cultural practices from a mathematical point of view and sought to modify mathematics education to incorporate these cultural ideas. Zaslavsky's (1987, 1991, 1994) approach to ethnomathematics was pedagogical in that it aimed to use ethnomathematics in the classroom as a way to relate mathematics to the real world of students. Borba's (1990) work is based on the relationships between ethnomathematics and academic mathematics and argued the effectiveness of ethnomathematics in enhancing the access to students learning formal mathematics. Knijnik (1993) used a political approach to ethnomathematics in her work with landless Brazilian workers. She looked at how an ethnomathematical approach in education can contribute to the process of social change.

In addition to these writers, others working in this field focussed on the philosophy, politics, and sociology of mathematics (e.g., Ernest, 1991; Lerman, 1992; Fasheh, 1991; Mellin-Olsen, 1987); the psychology and ethnomathematics (e.g., Abreu, 1993; Nunes, 1992); the ethnomathematics of different cultural practices (e.g., Millroy, 1992; Saxe, 1988); the role of culture in mathematics education as a means for social justice (e.g., Abraham and Bibby, 1988; Frankenstein and Powell, 1989; Joseph, 1992; Skovmose, 1994); and the implications of ethnomathematics for mathematics education (e.g., Mtetwa, 1991; Pompeu, 1992; Vithal, 1992).

Mid Nineties

As mentioned above, before the mid nineties writings on ethnomathematics were mainly inspired by educational imperatives. Barton (1996a, 1996b) focussed the attention of ethnomathematical researchers on the implications of ethnomathematics for mathematics, and provided a philosophical and theoretical background for ethnomathematics. He proposed in his work (1996a, p. 287) that it is

> … possible to acknowledge one's own mathematical orientation while regarding that of others. Such an orientation leads us to observe those things which we want to call mathematical, but which exist in contexts removed from the mathematics we routinely practice in our cultural milieu.

His aim was to provide a theoretical and philosophical foundation for the field of ethnomathematics; develop a discourse about culture and mathematics among mathematicians, philosophers, historians, sociologists and mathematics educators; and to illustrate the effectiveness of ethnomathematics in mathematics and mathematics education. In summary, his intention was to develop ethnomathematics as a new field of academic research.

Another writer continuing to work in this era was Gerdes (1997a, 1997b). He provided a broad analysis of the published research in ethnomathematics. The focus of his analysis was on what ethnomathematics is about, how and why ethnomathematics emerged, and trends in ethnomathematical research. He documented (1997a, p.337-338) different types of 'mathematics' that had been discussed by other authors, and could be considered as ethnomathematics. These include: indigenous mathematics; sociomathematics; informal mathematics that one learns outside the formal system of education; spontaneous mathematical methods that each cultural group develops; oral mathematics that are transmitted from one generation to the next; oppressed mathematics that are not recognised by the dominant ideology; non-standard mathematics that are distinct from established patterns of academic mathematics; hidden or frozen mathematics in old cultural practices; folk mathematics that develop in the working activity of the peoples; mathematics codified in know-how; and mathematics in the sociocultural environment. However, the distinctions between these different types of 'mathematics' were vague and he did not provide a theoretical basis of why and how these 'mathematics' can be construed as ethnomathematics, nor of the relations between them.

In addition to these two researchers, Knijnik (1997, 1998a) continued her work with Brazilian Landless People focussing on the political issues of ethnomathematics, and Powell and Frankenstein (1997) compiled a compendium of writings in their book titled: *Ethnomathematics: Challenging Eurocentrism in Mathematics Education*.

The Two International Conferences And Other Initiatives

Several approaches to ethnomathematical research, from different perspectives, are evident from the proceedings of the two International Conferences on Ethnomathematics. These include historical, political, philosophical, theoretical, indigenous, and pedagogical perspectives. Most studies incorporate more than one perspective. However they are categorised below according to the perspective that is most explicit.

Historical perspectives to ethnomathematical research include: Conti's (2002) study on 'the Cupola of the Cathedral of Santa Maria Del Fiore in Florence' from a mathematical point of view; Esmonde, McIntosh, and Saxe's (2002) work on 'counting and currency in Oksapmin in Papua New Guinea'; Garcia's (1998) study on the 'ancient number systems of North-West Africa', Canary Islands in particular; Lumpkin's (1998) study on 'ethnomathematics and the beginnings of mathematics' which discussed Africa as the 'cradle of mathematics' and how teachers can use this material to motivate students from different backgrounds; and Segarra's (1998) work on 'commerce, colonialism, and culture in 19th century Puerto Rican arithmetic word problems'.

Political perspectives to ethnomathematical research include: Frankenstein and Powell's (2002) work on 'Paulo Freire's contribution to an epistemology of ethnomathematics'; Gilmer's (1998) work on 'ethnomathematics as a promising approach for developing mathematical leadership among African American women'; Gilmer, Frankenstein, Knijnik, and Powell's (1998) proposal on 'social justice and mathematics education' that looked at the politics of mathematics education; and Knijnik's (1998a) study on 'ethnomathematics and the Brazilian landless peoples' movements pedagogical principles', which aimed to develop a knowledge system of a group of people that have been marginalised throughout the history.

Philosophical perspectives to ethnomathematical research include: Barton's (1998) proposal of 'the philosophical background to ethnomathematics' where he discussed how the challenges of ethnomathematical ideas might be met philosophically; Barton's (2002) work on the distinctions between 'ethnomathematics and indigenous knowledge'; and Dusek's (1998) presentation of 'a philosophical defense of implicit ethnomathematics'.

Theoretical perspectives to ethnomathematical research include: Alangui and Barton's (2002) proposal of 'methodological questions for ethnomathematics as a research field', where they discussed four critical ideas, namely, the construct of culture, the concept of alterity, the philosophy of mathematics, and the relationship between ethnomathematics and anthropology; Ness's (1998) study 'toward a psychology of ethnomathematics', where he looked at the relationships between ethnomathematics and Vygotsky's socio-historical psychology; Schillinger's (1998) study where he 'challenges the development theory of mathematics' from an ethnomathematical perspective; and Skovmose's (2002) proposal on 'students' foreground and learning obstacles', where he discussed the importance of looking at not only the students' cultural background but also the foreground in understanding students' learning obstacles.

Indigenous perspectives to ethnomathematical research include: Amancio's (2002) research on the 'mathematical traditions of Kanhgag, Brazil'; Crossley and Lun's (1998) work on 'recovering indigenous mathematics', where they looked at the thought patterns in ancient Chinese mathematics; Mosimege's (2002) work on the 'mathematical traditions of Mpumalanga Province of South Africa'; and Vergani's (1998) work on 'symbolic thought in Dogon's culture in Brazil'. In addition to these, several indigenous researchers are working on ethnomathematics with their respective indigenous groups in Brazil and other South American countries. They presented their work at the Second International Conference on Ethnomathematics.

There have been several descriptions of ethnomathematical initiatives in mathematics education – both in teacher education and in the classroom. These include: Correa's (2002) study on 'mathematics education on the formation of indigenous teachers', in Amazonia, Brazil, where he looked at students' stimulation of learning the knowledge of diverse cultures; D'Ambrosio's (2002) proposal of 'ethnomathematics in education', where he discussed the importance of ethnomathematics in mathematics curricula and pedagogy, in order to enhance cultural dignity and for full participation in the society; Favilli's (1998) work on 'linguistic and cultural aspects of teaching geometry in Somalia'; Gore's (1998) work on the 'influences of music in teaching algebraic structures'; Gould and Craine's (2002) work on 'use of ethnomathematics topics in North American college programs'; Jama's work (1998, 2002) on 'role of ethnomathematics in mathematics education' and 'using ethnomathematics in teacher training', in Somalia; Oliveras, Duran and Fernandez's (2002) work on 'using ethnomathematics in multicultural classrooms' in Spain; Oliveras, Favilli, and Cesar's (2002) work on 'teacher training for intercultural education based on ethnomathematics', in Europe; Ortiz-Franco's (1998) study on 'application of ethnomathematics in the classroom', where he illustrated how the number systems of the

Aztecs of Mexico can be used in teaching properties of algebra; Shirley's (1998, 2002) work on the use of 'ethnomathematics in teacher education'; and Zaslavsky's (1998) study on 'integrating elementary mathematics education with cultural practice: a Yup'ik Eskimo example'.

Research on implementing ethnomathematical principles in mathematics curricula and pedagogy is still in the very early stages. However, there are few studies that have been done on implementation, and the only evaluative study is that of Lipka's (2002a) work on 'connecting Yupi'k Elders knowledge to school mathematics', in Alaska (Refer Chapter 6, pages 78-80). Other research includes: Purkey and Mosimege's (1998) work on 'using ethnomathematics material' in the new curriculum in South Africa; Powell and Temple's (2002) work on 'using the Ahmose Mathematical Papyrus of Egypt to solve complex algebraic equations' in mathematics classrooms of United States; and Wenger's (1998) work on 'teaching middle school mathematics from an ethnomathematical perspective' in United States.

In addition to the two International Conferences, there have been other initiatives in ethnomathematics in the last decade. The International Study Group on Ethnomathematics [ISGEm] that was formed in 1985 has gained international recognition and a newsletter is published bi-annually that provides current research and advances in ethnomathematics.

Another initiative is the Glendon Lean Ethnomathematics Centre at the University of Goroka, Papua New Guinea. This centre was set up in 2000 in recognition of the work done be Glendon Lean in Papua New Guinea and other countries of Oceania. He collated data on nearly 900 counting systems of Papua New Guinea and Oceania for nearly twenty years, and "made comparisons between older and new counting systems and compared neighbouring counting systems from both Austronesian and non-Austronesian languages" (Owens, 2001, p.47). The aim of the Glen Lean Ethnomathematics Centre is to encourage research in ethnomathematics. The Centre can be contacted on glec.uog@global.net.pg (Owens, 2001).

In the Pacific, under the Pacific Educator in Residence (PEIR) program, an Ethnomathematics Digital Library (EDL) has been established in Hawaii. The goal is to develop ethnomathematics curriculum material in order to enhance Pacific students' knowledge of mathematics by relating it to cultural activities. The website of EDL is www.ethnomath.org (PREL, 2003).

Brazil still plays the most dominant role within the field of ethnomathematics. D'Ambrosio, who is regarded as the father of ethnomathematics lives in Sao Paolo, and several ethnomathematical research studies have been, and are being, conducted in Brazil. It is the only country that has held a National Congress on Ethnomathematics at an international level. Their second National Congress on Ethnomathematics was held in April 2004. A particular feature of the Brazilian work is the research on ethnomathematics and mathematical modelling. This is motivated by a belief that relating ethnomathematics to mathematical modelling helps mathematics students, teachers, and educators to better understand the Brazilian culture and the application of mathematics in their culture (Rosa, 2000). Another example of widening interest in this field is the Saami ethnomathematics conference that was held in June 2003 in Jukkasjarvi as part of a Swedish national review of mathematics curriculum.

The early ethnomathematics researchers have continued researching and publishing: for example, Barton's work on mathematics and language - his latest publication being 'Mathematical Discourse in Different Languages: Implications for Mathematics Teachers' (Barton, In press); Gerdes' work on geometry with his latest publication *Awakening of Geometrical Thought* (Gerdes, 2003); and Knijnik, Frankenstein, and Powell's work on ethnomathematics and social justice.

An increasing number of masters and doctoral studies are being done on ethnomathematics: for example, Alangui's (2003) doctoral studies investigate the mathematical ideas associated with rice-terracing practice in his homeland - Philippines;

Bakalevu's (1998) doctoral studies on 'Fijian perspectives in mathematics education; Bisher's (2001) masters studies on 'the ethnomathematics of Bedouin society in North Sinai - Egypt'; Fantinato's (2003) doctoral studies on 'quantitative and spatial representations among young and adults in the Morro de Sao Carlos, Brazil'; and Rosa's (2000) masters studies on 'using ethnomathematical knowledge for mathematical modelling'.

3.3 ISSUES IN ETHNOMATHEMATICAL RESEARCH

How can we recognise and label indigenous knowledge as mathematics, if it is different from the way we view mathematics? How do we avoid the danger of perceiving culture-specific knowledge as inferior or primitive compared to sophisticated, highly developed mathematical knowledge? How can we make comparisons between indigenous knowledge and other knowledge systems without trivialising or decontextualising the indigenous knowledge and vice versa? How do we decide which cultural knowledge is to be included in a mathematical curriculum informed by ethnomathematics? These are some of the issues and challenges in ethnomathematical research. Some of these have been the subjects of published critiques, especially in relation to the role of ethnomathematics in mathematics education.

One of the first critics of ethnomathematics was Chevallard (1989) who questioned the significance of culture on mathematics education. He also called for an open scientific debate on this issue as he believed that "any social practice is subjective to the objective laws of Nature" (p.7).

Vithal and Skovmose composed a comprehensive critique of ethnomathematics in 1997. They argued that the concept of culture in mathematics education in the South African context is problematic as it reinforces the relation between power and culture, and, as a consequence, promotes 'apartheid' in education. In particular, they criticised the notion of ethnomathematics in relation to mathematics education. They reasoned that ethnomathematics in mathematics education is dogmatic as there are no descriptions of educational research in ethnomathematical literature.

Another criticism is that of Dowling (1998, 2001). According to him, one of the aims of ethnomathematics is to liberate a culture oppressed by Western cultural imperialism. He argues that while doing this, ethnomathematics actually denies cultural value and prevents a particular culture from having its own 'voice', as cultural practices are described in Western mathematical terms. On the same note, Rowlands and Carson (2002, p.91) warn that "in the long run it will defeat the preservation of cultural traditions if we end up blurring the distinction between those localised ways of knowing … and scientific culture". In response to this, Adam, Alangui, and Barton (2003) argued that ethnomathematics widens the scope of the field of mathematics by recognising the uniqueness of complex knowledge systems of different cultures in their own context, and shows that there are alternative ways of knowing and thinking about mathematics.

Ethnomathematics has also been criticised as trying to replace or displace conventional mathematics, and for downplaying Greek rationality within mathematics (Rowlands and Carson, 2002). They further assert that the value of mathematics intrinsic in cultures will be understood "only through the lens of formal academic mathematics sensitive to cultural differences" (p.79), and hence, mathematics should be taught in a situation where there is no relation to the real-world of students at all.

The counter argument (Adam, Alangui, & Barton, 2003) is that ethnomathematics is not trying to replace mathematics or downplay Greek rationality. Rather it compels us to be critical of our discipline by reflecting on our practices as mathematics educators, and offers a broader view of mathematics by adopting methods and practices related to diverse cultural environments. Further, there is some empirical evidence (e.g., Lipka, 2002a) that students who are taught using ethnomathematical approaches perform better on conventional mathematics tests.

The emphasis in the ethnomathematical literature on considering the cultural context especially the background of students when constituting meaningful mathematics education was criticised by Skovmose (2002). His main criticism is that a focus on the background of the students is a scheme to "eliminate the political nature of learning obstacles" (p.8). Further, Skovmose (2002) argues that mathematical meaningfulness has not only to do with the cultural background of the students, but their foreground as well. The foreground of a person is (Skovmose, 2002, p.8):

> ... the opportunities, which the social, political and cultural situation provides for this person ... not the opportunities as they might exist in any objective form, but the opportunities as perceived by a person

In other words, the foreground of students is the way the students see the opportunities afforded by what they are doing; otherwise meaningful participation of students in mathematics learning might not take place. For example, (Skovmose, 2002, p.10)

> ... as mathematics educators, arrive in a village far away ... we find that in this village there are chickens everywhere ... what a perfect situation for making sense of mathematical notions! We construct tasks that relate to counting and selling and buying and cooking chickens. The students will be familiar with it all. This is part of their background. Nevertheless, this need not make sense to students. The students may be more interested in, say, pilot's mathematics ... introducing that there are many different places to go

The criticisms of the role of ethnomathematics in education will be considered in more detail in Chapter Four.

3.4 SUMMARY

Not much research had been conducted on culture and mathematics prior to the term 'ethnomathematics' being coined by D'Ambrosio in 1984. Since then the depth and scope of debate on culture and mathematics have grown significantly.

Ethnomathematics may be defined as the study of mathematics in the context of the culture in which mathematics arises. From an ethnomathematical perspective mathematics is a human creation that emerges as people try to understand and make sense of their world.

Ethnomathematical research is being approached from different perspectives, including political, historical, theoretical, philosophical, and pedagogical. The field is growing internationally, both in the number of countries where significant work is being done, and in the amount of research being produced. In particular it remains at the forefront of writing on social justice, and is being included in the literature on indigenous knowledge.

4 WHAT IS AN ETHNOMATHEMATICAL CURRICULUM?

4.1 INTRODUCTION

Classrooms or learning environments cannot be isolated from the communities in which they are embedded. Classrooms constitute a part of the community, with defined cultural practices and social norms and values. When students come to school they bring with them values, norms and concepts that they have acquired as part of growing up. Some of these are mathematical (Bishop, Clarkson, FitzSimons, & Seah, 2000). However, the modernisation process in Third World countries often presents situations in which Western educational ideas are imported into significantly different socio-cultural environments. Hence, the mathematical concepts of the school curriculum may not be related to the students' cultural mathematics. The field of ethnomathematics presents some possibilities for educational initiatives which could help address this situation. It is therefore important to consider what such an ethnomathematical curriculum might be like, and whether it would be worthwhile.

An ethnomathematical curriculum involves some integration between the mathematical concepts and practices originating in the learners' culture and those of conventional mathematics which are more or less universal in classrooms around the world. Some of the aspects of an ethnomathematical curriculum suggested in the literature include:

- Valuing or recognising the learning styles and backgrounds of the students and the community in which the school is situated (Jaworski, 1993);

- Encouraging students to talk about the mathematics in their culture (Gerdes, 1994; Bockarie, 1993);
- Increasing the students' knowledge of mathematical practices and ideas of various cultural and ethnic groups including their own (Zaslavsky, 1991);
- Linking current curriculum material to historical and literary records of mathematics (Kim, 2000);
- Incorporating mathematical aspects of the local physical and cultural environment (Barton, 1993).

These and other ideas lead to different versions of an ethnomathematical curriculum. From the literature, there are at least five different possibilities for an ethnomathematical curriculum that can be conjectured. Many implemented programmes offer aspects of more than one of these. However, all characterisations are premised on the belief that an ethnomathematical curriculum is one in which the cultural aspects of the students' milieu are infused in the mathematics learning environment in a holistic manner. The infusion is manifest in the epistemology of mathematics, its content, the classroom culture, and the approach to mathematics learning (Adam, Alangui & Barton, 2003).

This chapter looks at five conjectured forms that an ethnomathematical curriculum could take, namely: as an approach to mathematics, as cultural content, as a stage in the development of mathematical thought, as mathematical enculturation, and as an approach to mathematics learning. It then looks at the possible consequences of each for mathematics education. In addition, certain issues and questions that need to be considered in implementing an ethnomathematical curriculum are discussed.

4.2 AN ETHNOMATHEMATICAL CURRICULUM AS… AN APPROACH TO MATHEMATICS

An ethnomathematical curriculum could be the approach to mathematics taken by the curriculum as whole. This approach could be labelled as 'mathematics in a meaningful context'. For example, the New Zealand Mathematics Curriculum (Ministry of Education, 1992, p.12) stipulates:

> ... It is important that students are given explicit opportunities to relate their new learning to knowledge and skills they have learnt in the past.
> ... It is particularly important that mathematical learning experiences of Maori students acknowledge the background experiences, which have led to the formation of ideas and skills, which those students already have

This vision of an ethnomathematical curriculum is epistemological in that mathematics is presented as a cultural response to human needs. Every culture is assumed to have such mathematical responses, and these responses are valid content for a mathematics classroom (Adam, Alangui & Barton, 2003). A classroom using this type of ethnomathematical curriculum would be full of examples that draw on the students' own experiences, or on experiences that are common in the cultural environment of the students. These examples would be vehicles for communicating mathematical ideas which themselves would be relatively unchanged.

The Realistic Mathematics Education programme in Netherlands suggests this type of approach to mathematics curriculum. In realistic mathematics education, mathematics is learned in a meaningful context using contextual problems (Gravemeijer & Doorman, 1999; Wubbels, Korthagen, & Broekman, 1997). "Context problems are defined as problems of which the problem situation is experientially real to the students" (Gravemeijer & Doorman, 1999, p. 111). Other examples that suggest this type of an approach to mathematics curriculum include: Alangui's (1999, 2003) suggestion of contextualising education for indigenous people in Philippines; Amancio's (2002) study in indigenous schools in Kanhgag, Brazil; Fasheh's (1989, 1991, 1997) work, where he advocates a mathematics pedagogy appropriate to the needs of the students by including relevant contextual examples from their culture; Lee-Chua's (2001) study on using research on mathematical practices of tribal Philippines in the classroom, where she found that students appreciated the relationship between mathematics and real-life; Mtetwa's (1991) work investigating Zimbabwean secondary school students' beliefs about mathematics and classroom contexts; Oliveras, Favilli, and Cesar's (2002) work with teacher trainees in Europe on intercultural education based on ethnomathematics where one of the objectives is to develop attitudes among teachers on the nature of mathematics; and Rosa's (1998) study on lower class immigrant students of Central America in the United States, using a contextualised curriculum.

In terms of student learning, this curriculum will affect how students think about mathematics rather than how or what they learn. In addition, in classrooms containing students from several cultures, it may be that such a curriculum will have most learning benefits for students from the highlighted culture, either because they are interested in their own culture, or because it empowers them as 'owners' of a particular mathematical approach. Likewise, they may experience pride and respect for their own cultural mathematics, which they would not do for a non-specific universal subject (Bishop, 1988; D'Ambrosio, 1985; Gerdes, 1994; Zaslavsky, 1991). Each of these reasons needs to be examined as hypothesised learning outcomes for such an approach to mathematics.

Note that it has also been suggested that a reverse effect may be true (Barton, 1996a). For example, Vithal and Skovmose (1997) suggest that giving meaning to mathematics using contexts from students' cultural and social background is problematic. For instance, in the South African context, contextual reality might take on a different meaning of entrapment with race and apartheid. Further, they query the aspects of reality to be included in the mathematics curriculum with questions such as (p. 145): "Whose reality, adults' or children's? Which adult or child's reality? What about teachers who do not share the cultural background of their students?" This clearly has implications in the Maldivian context, where more than ninety percent of the mathematics teachers at the secondary level are expatriate teachers who do not share the same social and cultural background as their students.

4.3 AN ETHNOMATHEMATICAL CURRICULUM AS… CULTURAL CONTENT

In this approach, ethnomathematics is characterised as a particular content that is distinct from the universal mathematical concepts taught in most schools. Such content would include mathematical practices and concepts that belong to a particular social or cultural group. An example of this could be the work of Zaslavsky (1973), where she investigated the African culture from a mathematical point of view. She looked at the way Africans count, how they use numbers in daily life, mathematical recreations such as games, and geometric forms in architecture and geometric symmetries in African art. Other examples of mathematical concepts and practices of different cultural groups include: distinctive designs or decorative forms such as those exhibited in weaving (Ascher, 1991); idiosyncratic practices such as Lusona sand drawings (Gerdes, 1991); the geometry of Maori art (Knight, 1984a, 1984b); and mathematical concepts such as measurement or design found in engineering practices, like boat-building and water engineering (Cooke, 1990).

This ethnomathematical content could make up any part of the curriculum, from a small section to the major proportion of the total. The ethnomathematical content may be associated with a mathematical topic to which it is related, for example Powell and Temple's (2002) work on teaching algebraic equations using an Egyptian papyrus. This approach to curriculum seems to be implied by many of the American writers, for example by books with titles like *Multicultural Mathematics for the Classroom* (Mitchell & Salsbury, 1996). One aspect of this approach could be looking at the historical development of mathematics in different cultures. Another aspect could be integrating multicultural mathematics materials into the regular instructional program and using personalised activities that are related to different cultures.

Some examples from the literature that suggest this type of an approach to mathematics curriculum include: Bisher's (2001) study on the effects of using ethnomathematics in teaching primary mathematics in Egypt, where he looked at the achievement and behaviour of students; Cherinda's (2002) study of the exploration of a mat weaving technique in Mozambique; Gerdes' (1997a) work on geometrical thinking in Mozambique where he demonstrates how this ethnomathematical material can generate an 'empowering' curriculum for students; Jama's (1998) study on introducing mathematical notions in the classroom using examples such as trading in a livestock market and classical Somali fable; Mosimege's (2002) study in South Africa on incorporating cultural practices such as mural decorations, beadwork and indigenous games; Ortiz-Franco's (1998) suggestion of using the number system of the Aztecs of Mexico in teaching the commutative, associative, and distributive properties of algebra; Powell and Temple's (2002) work mentioned above; Kim's (2000) work on developing ethnomathematical materials in Korea; and Zaslavsky's (1987, 1994, 1996, 2001) work on integrating mathematics with the study of traditional cultures, where she advocates the multiculturalisation of the mathematics curriculum.

Many questions arise from this type of an approach to curriculum. For example, what might be the reasons for adopting this kind of curriculum? Will students learn this mathematical content more effectively? Will it be as useful (more useful, less useful) than the content in a conventional curriculum? Can ethnomathematical material be added to the curriculum without removing existing topics? If not, what topics should be replaced?

It has been hypothesised that a curriculum of this type will have benefits for student learning for motivational reasons (some of which are described in the previous section), and the same questions apply here. In addition, students will become aware of the particular mathematics found in their own society and may develop it further by preserving it at a time when the globalizing forces are making the world monocultural (Barton, 1993; D'Ambrosio, 1991; Thomas, 1997; Zaslavsky, 1991, 1996).

However, critics fear for the place of academic mathematics in such an ethnomathematical curriculum (Rowlands & Carson, 2002), and suggest that learning mathematical methods of other cultures hinders the development of mathematical thinking necessary for higher-level mathematics (Greene, 2000). However, whether or not learning of mathematics can be enhanced through cultural methods is "regarded as an open empirical question by most of those working in ethnomathematics" (Adam, Alangui, & Barton, 2003, p. 330). So far the evidence from ethnomathematical research is that using mathematical methods and practices of other cultures in the mathematics classroom, enhances students' appreciation and understanding of mathematics (e.g., Zaslavsky, 1991).

This type of approach to mathematics curriculum has implications in the Maldivian context, where the British syllabuses are followed at the secondary schools. It would mean that some of the mathematics lessons are given over to a study of Maldivian practices for their own sake, so that schools become the places where cultural knowledge is passed on. This could be problematic when many teachers are expatriates, and also when teachers are under pressure to complete the 'prescribed' syllabus on time.

4.4 AN ETHNOMATHEMATICAL CURRICULUM AS... A STAGE IN THE DEVELOPMENT OF MATHEMATICAL THOUGHT

In this notion, an ethnomathematical curriculum could be a stage in the progression of mathematical thinking that a child goes through during his/her mathematics education. In this approach it is assumed that mathematics learning starts from the mathematical world of the child, progressing through to the mathematical world of the child's culture, into the global mathematical world. The ethnomathematical curriculum is that part of the curriculum which focuses on the mathematical world of the child's culture. Figure 4a gives a framework for an ethnomathematical curriculum as a stage in the development of mathematical thought.

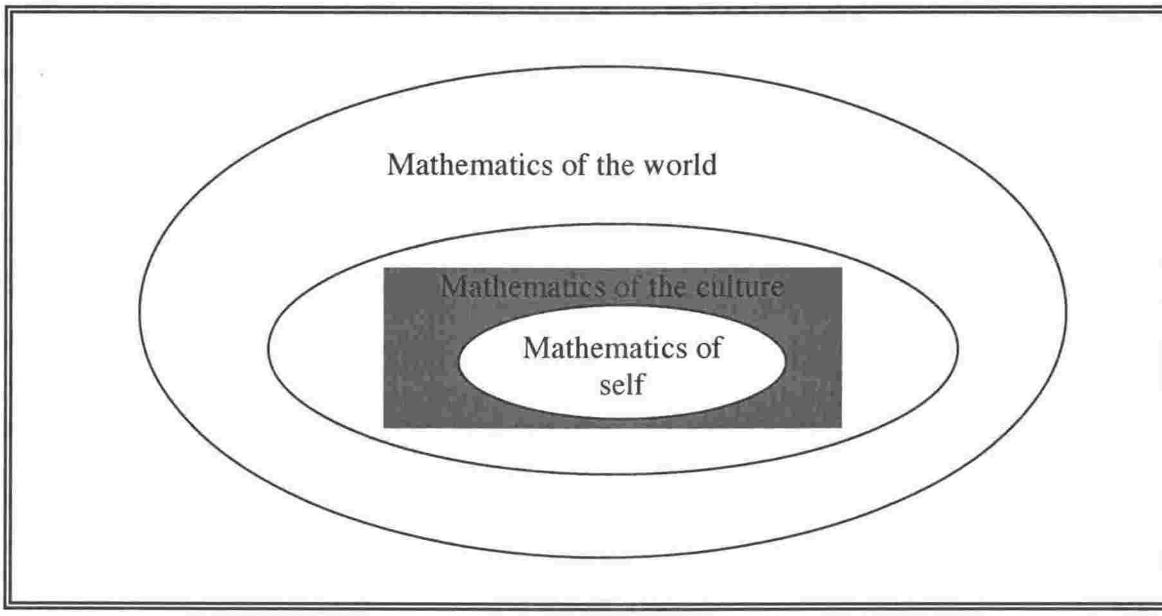


Figure 4a: Framework for an Ethnomathematical Curriculum as a Stage in the Development of Mathematical Thought.

This vision of an ethnomathematical curriculum is psychological in that it assumes that mathematical thinking develops concretely in practical situations, and "in order to succeed in studying a mathematical concept as an object, the subject must already have access to the concept as a tool" (Nunes, 1992, p. 571). A justification for this curriculum could be based on the notion that mathematics should start with where students are (Begg, 2001a, 2001b), and then make connections with mathematics in the culture, and then link it to the mathematics of the whole world. If this way of thinking about an ethnomathematics curriculum is adopted then it needs to be explained in any curriculum documents how the mathematics of the culture framework links with the other two parts and how an addition like this will affect the pedagogical model.

In a Maldivian classroom this type of curriculum could emerge in the early stages of primary school. All initial contacts with mathematical ideas would be seated in cultural experiences under the assumption that children can only work from what they know in a real and concrete manner. The mathematical ideas would then be abstracted from these (cultural) experiences and eventually be free of them altogether.

Some examples from the literature that suggest this type of an approach to mathematics curriculum include: Begg's (2001a) justification of the role of ethnomathematics in school mathematics from a constructivist perspective; Frankenstein and Powell's (2002) suggestion of connecting students mathematical understandings with history of mathematics and school mathematics to enable students to think mathematically; Matthews' (2003) study on incorporating culturally relevant teaching in mathematics to foster critical thinking; and Vergani's (1998) work on 'ethnomathematics, cognitive anthropology and psychology in mathematics education', in Portugal.

It has been presumed that this type of curriculum will have benefits for student learning in terms of students being aware of mathematics as a living and growing discipline and also of the mathematics found in their own culture. However, an apparent disadvantage of this type of curriculum is that it promotes the idea of 'better' or 'worse' mathematics and that cultural ideas will come off as 'worst' (Barton, 1993). A further critique of this model is that it relegates ethnomathematical ideas to being suitable for children at early stages of their education when ethnomathematics is valid and appropriate always for all members of the cultural community, and mathematics can never be free of cultural influences.

4.5 AN ETHNOMATHEMATICAL CURRICULUM AS… MATHEMATICAL ENCULTURATION

An ethnomathematical curriculum could be based on the idea that all classrooms are situated in a cultural context. This context involves values and beliefs about learning, aims of education, culturally specific learning theories and practices, and the classroom environment. The component of this cultural view of the classroom that is specific to mathematics could include, for example, whether learning mathematics is predominantly oral or written, what a mathematics classroom looks like, what sort of mathematical authority is required in a teacher, and what should be the format of assessment.

This type of an approach to curriculum is suggested by Bishop's (1988) work on 'mathematical enculturation'. He investigated the ways in which mathematics education infuses different values, beliefs, and ways of doing things. He argued (p. 98-99) that there are three components that are necessary for an "enculturation curriculum". They are: the symbolic component of mathematics that allows the explicit exploration of the values of "rationalism" and "objectivism"; the societal component that exemplifies how society uses mathematical explanations and as a result develop the values of "control" and "progress"; and the cultural component that illustrates "mathematics as a phenomenon existing in all cultures", and introduces the idea of mathematical culture, with values of "openness" and "mystery". He further argues (2001) that values are intrinsic in all levels of human relationships. Hence, in the classroom values can be intrinsic in the learners, between the learners and the teacher, and in the cultural context of the learning environment. Therefore, when these sets of values are not consonant with one another, cultural conflict arises (Bishop, 1993, 1994). An ethnomathematical curriculum of this kind aims to bring particular cultural and mathematical values closer together.

An example that suggests this type of an approach to mathematics curriculum is that of Meaney (2001). She studied the effects of involving indigenous parents in curriculum development, in New Zealand. She found out that several tensions emerged due to the uncertainty of parents' role in the curriculum development. Another example is that of Knijnik's (1997, 1998a, 1998b, 2002) work on ethnomathematics and pedagogical principles for the Brazilian Landless People.

If this way of thinking about an ethnomathematical curriculum is adopted, then it has to be decided whether a culturally specific classroom is good for students and whether or not students will experience other norms and values during their education. Furthermore, since conventional mathematics already has its own universally accepted values, when children are inducted into mathematics, these mathematical values may irrevocably clash with particular cultural values. This raises the question whether cultural values can be used to teach mathematics in line with the culture of students? And how about in a classroom where students are from several different cultural backgrounds? The complete transformation of mathematics consonant with the values of target culture may not even be possible.

These questions certainly apply to the Maldivian context where external curricula and examinations are followed. Hence, in that context, some of the disadvantages of this type of an ethnomathematical curriculum could be that:

- Maldivians who are used to the traditional methods of teaching and learning mathematics might not want to change their ways for the fear that it will not be useful in the globalized world; and
- Maldivians who believe that external examinations, especially those provided by the Western countries, have more 'value' might not like to adapt themselves to change.

In terms of learning, this curriculum will presumably help students to make connections between school and the real world and would develop their capacity to handle real life situations. Moreover, this type of curriculum would help students use mathematics to examine important aspects of their lives (Bishop, 1988; Boaler, 1993; Bockarie, 1993; Zaslavsky, 1991). However, as mentioned before (see 4.2), the reverse may occur.

4.6 AN ETHNOMATHEMATICAL CURRICULUM AS... AN APPROACH TO MATHEMATICS LEARNING

This approach assumes that relevant mathematics can be found in the pupil's environment that can demonstrate the characteristics of mathematical concepts. Using these mathematical ideas, an ethnomathematical curriculum can be devised that could be labelled as 'an approach to mathematics learning'. The ethnomathematical curriculum is the integration of the cultural mathematics of the learners and the 'academic' mathematics, without the addition or replacement of content or the topics outlined in the curriculum (Lipka, 1994).

If this way of thinking about an ethnomathematical curriculum is adopted, then the ethnomathematical curriculum becomes an investigative approach to mathematics learning through problem-solving, reasoning and communication. In this approach, the ethnomathematical curriculum takes the learner's world or culture and uses it explicitly to integrate outside experiences into the world of conventional mathematics. That is, the learners will be building on what they know or the experiences they have from the environment or culture. These are then used neither as motivation nor as an introduction, but as part of understanding how mathematical ideas develop, how they are built into systems, how they are formulated, and how they are then applied in various ways within the culture. This mathematical knowledge is related to conventional mathematics in such a way that the underlying mathematical ideas are fully understood, and the power and utility of conventional methods are appreciated. In addition, links are made to familiar practices and concepts by building on the mathematical ideas in one's culture and in other cultures, realising and understanding the need for such mathematical characteristics as accuracy and formal reasoning, in both mathematics and in real-life situations. The understanding of conventional mathematics then feeds back and contributes to a broader understanding of the culturally-based mathematical principles. Figure 4b (page 58) gives an overview of a framework for an ethnomathematical curriculum as an approach to mathematics learning.

The work of Lipka (1994, 2002a) in Alaska is an example of this type of an approach to curriculum innovation. Other examples that suggest this type of an approach to mathematics curriculum include: Domite's (2001) work on problematising and posing problems in teaching and learning of mathematics; Nossum's (1998) investigation of the impact of ethnomathematics on mathematics learning in Norway; Pompeu's (1992) study on 'bringing ethnomathematics into the school curriculum', where he investigated teachers' attitudes and pupil's learning; Rosa's (2000) proposition of using ethnomathematical knowledge in mathematical modelling; and Wenger's (1998) study on teaching middle school mathematics from an ethnomathematical perspective.

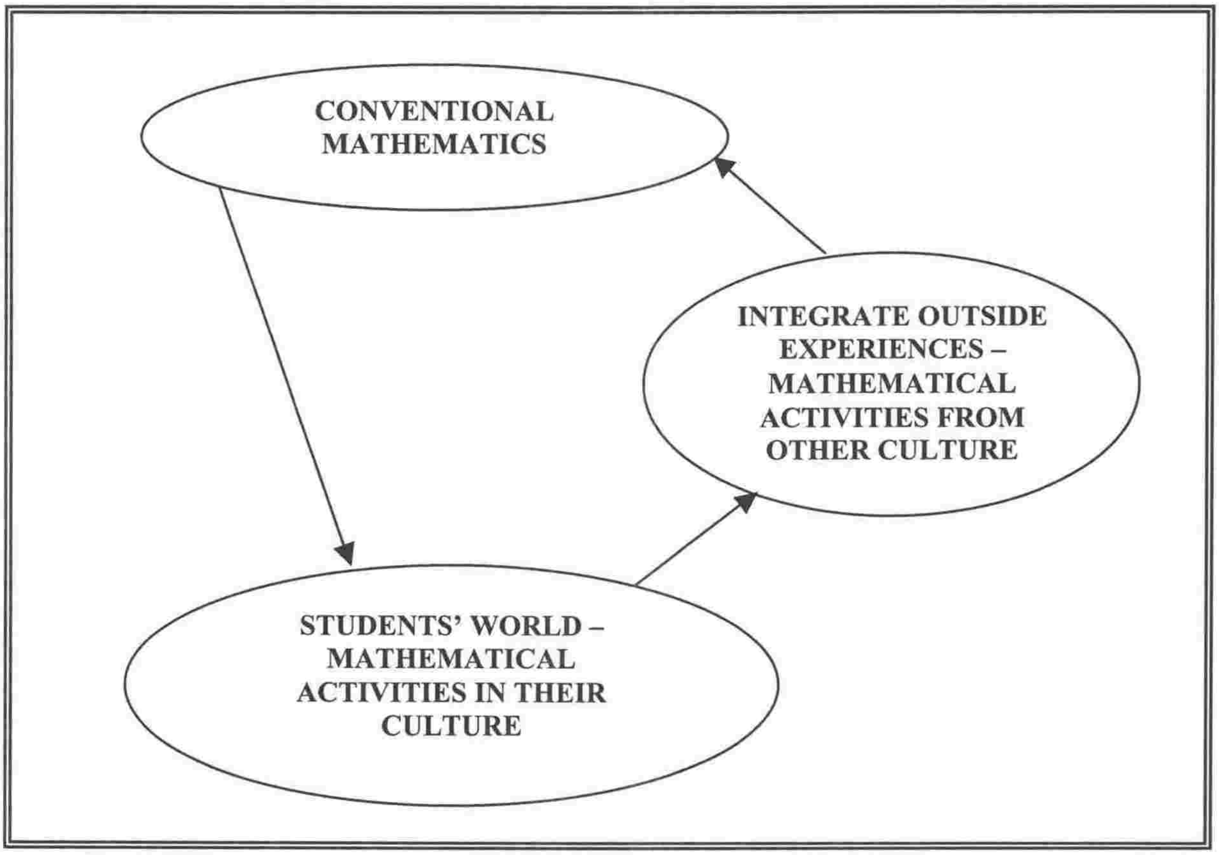


Figure 4b: Framework for an Ethnomathematical Curriculum as an Approach to Mathematics Learning

It is assumed that a curriculum of this type will motivate students to recognise mathematics as part of their everyday life, enhance students' ability to make meaningful mathematical connections and deepen their understanding of mathematics as an international field of study. Further, it is hoped that a curriculum of this type will help learners build up confidence in mathematical knowledge, be creative problem-solvers, and use real-life examples in problem solving (Adam 2002; Barton, 1996a; Boaler, 1993).

A potential difficulty of this approach is that not all characteristics of mathematics may be found in any specific cultural context. This may be able to be overcome by using other contexts. Similarly, starting from cultural practices may not be the quickest and most efficient way of learning mathematics, and may force other topics out of the curriculum through lack of space. Both these difficulties need to be investigated with the Maldivian curriculum in Maldivian classrooms. Can this type of curriculum be implemented without adding or replacing any content in the current curriculum? Could it be the way forward to make mathematics meaningful to its learners?

This study is aligned with this model of an ethnomathematical curriculum, and investigates these and other concerns. That is, an ethnomathematical curriculum is conceived as an approach to mathematics learning. The ethnomathematical curriculum framework used in this study will be developed in detail in Chapter Six.

4.7 ISSUES TO BE CONSIDERED IN IMPLEMENTING AN ETHNOMATHEMATICAL CURRICULUM

Before the implementation of an ethnomathematical curriculum, there are certain issues and questions that need to be considered. These include (Adam, 2002): the extent to which ethnomathematical assumptions are adopted, the impact of language, the quality of learning, and the teaching style.

The Extent Of An Ethnomathematical Approach In The Curriculum

Are there ethnomathematical systems in the culture that can usefully be used in every part of the conventional mathematics curriculum? If not, for which parts of the curriculum should we include ethnomathematical principles? (Vithal & Skovmose, 1997). How can it be decided?

The justification for an ethnomathematical curriculum to familiarise students with the study of conventional mathematics is a broad one. Once the student is thus familiarised, what is the point of continuing with the ethnomathematical work? Why not simply concentrate on conventional mathematics if that is the ultimate goal? Or does ethnomathematics have some intrinsic value itself?

Gerdes (2001, p. 321) supports the notion of continued ethnomathematical activity in the class by stating that:

> Mathematical activity is both a human and cultural activity. Mathematical ideas and methods vary from culture to culture, and our understanding of what constitutes mathematics grows as these ideas and methods enhance one another ... if the activities are effectively integrated into the curriculum, collectively they may empower all pupils, broaden their cultural and mathematical horizons, and deepen their understanding and learning.

Furthermore, as D'Ambrosio (2002) states, the purpose of education should not be just to prepare students for professional success. Education should develop 'cultural dignity' and prepare students for full participation in the society. Ethnomathematics is a step towards facilitating critical citizenship among mathematics learners. Hence, according to D'Ambrosio (2002, p. 10):

> The main reason to teach ethnomathematics has two main goals ... to demystify a form of knowledge (mathematics) as being final, permanent, obsolete, and unique ... and to illustrate intellectual achievements of various civilisations, cultures, peoples, professions, and gender.

In this study, one unit of work based on ethnomathematical principles was trialled, and the ethnomathematical aspects to be included in the unit were decided in conjunction with the teachers. In addition, since cultural values and culturally-specific knowledge are valued and respected in the Maldivian society, no resistance by the school or community with regard to including ethnomathematical aspects in the curriculum was anticipated before the implementation.

The Links Between An Ethnomathematical Approach And The Indigenous Language

Language shapes the way people of particular cultures construct their world. Mathematical concepts in particular are also developed through language and from peoples' experiences. As such, mathematical thinking is a function of language (Barton & Frank, 2001).

In the book *Indigenous Educational Models for Contemporary Practice* edited by Nee-Benham and Cooper (2000), indigenous people ask that all knowledge is taught in their indigenous language in a manner appropriate to the cultural methods and values. So why should the teaching of mathematical knowledge be any different? What difficulty arises due to some of the 'conventional' mathematics vocabulary not existing in the indigenous language and vice versa?

Several studies have indicated the difficulties that English as a second language students' face when they have to study Mathematics in English (e.g., Bakalevu, 1998; Barton & Neville-Barton, 2003). However, the question remains as to whether students who sit for examinations in a second language are able to cope better if they are taught mathematics in the indigenous language?

Therefore, should an ethnomathematical curriculum be taught in the indigenous language? What are the links between an ethnomathematical approach and the indigenous language? What effect will it have on the indigenous language? Barton, Fairhall and Trinick (1995, 1998) suggest that it may not all be positive. For instance, several linguistic and social issues arose during the development of a Maori mathematics vocabulary. These issues include (1995, p. 156): "How does a community reach agreement about language", and how quickly can new language develop and be learnt, and can it remain part of accepted conversational language?

Even though cultural practices are likely to be better expressed in the indigenous language, use of *Dhivehi* is likely to be problematic in the Maldivian society where most of our teachers, especially in the secondary schools, are non-Maldivian teachers. This would be an on-going problem in the Maldives. In addition, some of the 'conventional' mathematics vocabulary may not even exist in *Dhivehi*. Code-switching may provide a solution in some classrooms.

The Effects Of An Ethnomathematical Approach On The Quality Of Conventional Mathematics Learned

One of the main objectives of implementing ethnomathematical approaches to school curricula is to introduce conventional mathematics in such a way that it is more fully understood, that it links to familiar practices, and that concepts are made explicit (Lipka, 1994). However, by implementing this approach, does the quality of conventional mathematics learnt improve?

It is apparent that the learning of mathematics will change – but what could be the criteria for evaluating whether it is better or not? Mathematics education is conceived differently under an ethnomathematical curriculum, and therefore one of the difficulties is to make comparisons between a conventional curriculum and an ethnomathematical curriculum.

There is some empirical evidence of the 'success' of at least one ethnomathematical approach to curriculum. The findings of Lipka's (2002a) study in Alaska confirm that students who have been taught using an ethnomathematical approach to curriculum achieve better on conventional mathematics tests. There is a need for more empirical studies to investigate these effects. This study is not in this category.

Since this study is about investigating the effects of implementing an ethnomathematical curriculum, rather than investigating the outcomes, students did not undergo any extra tests or evaluations associated with this study. As such, achievement or test data was not explicitly used in this study.

The Teaching Style Implied By An Ethnomathematical Curriculum.

Does an ethnomathematical curriculum imply a specific teaching style that is different from the conventional styles? Why might an ethnomathematical curriculum imply a new teaching style? An ethnomathematical approach operates under a different philosophy and therefore there is a need for new resources and new professional development. And since curriculum implies all 'planned activity' (Begg, 1996), there should be an interrelationship between all parts of the curriculum. What are appropriate teaching styles, assessment procedures, student learning modes, and classroom discourses?

Ethnomathematical approaches insist that cultural practices are relevant to learning mathematics. When cultural practices are used in the classroom, sometimes some students (or more likely their parents) may have more knowledge about the object of classroom study than the teacher. This may require a change in teacher/student relationships – at least temporarily – and possibly teaching style.

In the Maldivian classrooms, when cultural practices are used, it is likely that students may have more knowledge of the cultural aspects than the teachers, especially the non-Maldivian teachers. This would require a change in teacher/student relationship from what is being practised in the Maldivian classrooms.

4.8 SUMMARY

There is a call for a shift in mathematics education from the belief that mathematics is a given to a vision of mathematics as culturally formed. The reasons put forward include enabling students to relate school experiences to the outside world, to be aware of mathematics as a living and growing discipline, to appreciate the fact that mathematical practices arose out of the real needs and desires of all cultures or societies, and to understand the true development of mathematics as not being the heritage of one culture or civilisation (Barton, 1996a; D'Ambrosio, 1985).

Such a shift may require a radical reconstruction of mathematics education, particularly in those countries where external examinations dominate the education system. At the very least it is necessary to restructure mathematics curricula in such a way that enable students to make connections between school mathematics and the outside world, most importantly to the world most important to the majority of people – their own cultural world. The way forward could be an ethnomathematical approach to school curriculum.

Five approaches to an ethnomathematical curriculum have been identified. These are: as an approach to mathematics; as cultural content; as a stage in development of mathematical thinking; as mathematical enculturation; and as an approach to mathematics learning. The argument for ethnomathematical approaches is that they will make mathematics more meaningful and relevant to learners. Even though ethnomathematical research opens up new possibilities, research has not yet confirmed or disproved the argument that an ethnomathematical curriculum is the best way to make mathematics more meaningful to learners. However, ethnomathematical curricula must be implemented before their effects can be evaluated. Such an implementation will highlight other important issues to be considered, and helps us to ask fundamental questions about the role of ethnomathematics in mathematics education.

5 CURRICULUM IMPLEMENTATION

5.1 INTRODUCTION

As argued in Chapter Four, ethnomathematics must become part of a curriculum approach – it is not just another pathway to school mathematics. Rather it is an approach to mathematics learning that affects all 'planned activities' in a mathematics class. The research reported in this thesis involves a trial implementation of a small section of work using a new ethnomathematical curriculum approach. Thus, without going into a comprehensive analysis of all features of curriculum development and its associated professional development, it is important to briefly trace the main trends and features in order to effectively analyse this particular implementation.

From the early nineteenth century, 'curriculum' has both a comprehensive history and a literature. The term is diversely defined and used in curriculum studies (Davis, 1996). For some, curriculum means a programme offered at school, whereas for others it means the learning experiences of the students whether at school or in their day-to-day lives (Begg, 1996; Singh, 1992).

Until the late 1980s, mathematics curricula in many countries have been dominated by the behaviourist traditions, where mathematics was divided into facts, figures, objectives, skills and techniques, without giving consideration to learners' prior knowledge or cultural background (Begg, 1995). This is true, even now, in most small states and Third World countries where resources are limited and external examinations shape the way curricula are written (Bray & Packer, 1993), and also in countries where assessment has played a major role. The use of 'chalk-and-talk' methods is the common method of behaviourist teaching, and there is often little experimentation with co-operative or collaborative learning environments where students are encouraged to use problem solving, mathematical modelling, reasoning, communicating, and making connections to the real world (Begg, 1991).

However, in recent years, there has been an increase in implementing innovations in mathematics curricula, as curriculum developers have realised that traditional views of curriculum do not necessarily make mathematics meaningful to its learners (Begg, 1995, 1996). While implementation is commonly associated with innovation and change, the focus of implementation activities is often on putting a given curriculum into place, where teachers are usually given prescribed material (Singh, 1992). Thus, even though teachers play a central role in implementing a curriculum, most teachers are not engaged in the development of that curriculum. Begg (2002) suggests that, for successful implementation, teacher involvement in the development of curriculum is desirable. In addition to this, other factors such as professional development of teachers through workshops, discussions, and teacher reflections, collegial support, and factors affecting teacher change need to be considered, evaluated, and action taken before any implementation (Clarke & Peter, 1993; Britt, Ellis, Irwin & Ritchie, 1993).

This chapter is a brief summary of the main features of curriculum development and implementation. The summary is based on Begg's (1991, 1994, 1996, 2002) work on curriculum development and related professional development of teachers. This chapter gives an overview of the three key issues that are important for this project: the changing view of the curriculum; the role of teacher in curriculum implementation; and the challenges of implementing curriculum innovation.

5.2 CURRICULUM

What is a curriculum? In the dictionary curriculum is defined as a specified course of study, syllabus, prescription, or course outline (Collins Gem Dictionary and Thesaurus, 2000). According to Goodson (1989, p.13),

> The word curriculum derives from the Latin word *currere*, which means to run, and refers to a course (or race-chariot). The implications of etymology are that curriculum is thereby defined as a course to be followed, or most significantly, presented.

The *Oxford English Dictionary* finds the first use of the word curriculum in 1633 in Glasgow (Goodson, 1989). However, the earliest writings about curriculum began in the early nineteenth century (Davis, 1996), and it has been variously defined and utilised.

In the 1910s, Bobbitt began from a conception of society and schooling as unchanging and therefore, for him, curriculum consisted of elements of scientific knowledge divided into teachable parts. He viewed education as a preparation for life rather than part of life (Davis, 1996). Schubert (1986) retains this static philosophy by defining curriculum as subject matter and as a programme of planned activities that includes what is valuable to know. He believed that once the knowledge is identified, the learning outcomes could be perceived independently of learner, teacher, classroom, culture, and the era.

Singh (1992), on the other hand, reinforces the idea that, since classroom is related to the wider socio-political context of the society, curriculum is something that addresses aspects of the socio-political issues in the society. Another dynamic view is given by Begg (1996, p.1), for whom curriculum is all 'planned activity' for a class, school, or a programme. He contemplates curriculum as

> ... process, as a continually changing plan for my class. It changes as I come to know the needs of the students and their interests, as I observe the responses to what I have already done, and as I note the applicability of current events. My curriculum is continually developing in response to theory, context, and practice. With this definition curriculum becomes interwoven with reflection and professional development.

Since, ethnomathematical approaches are intended to affect all planned activities in a mathematics classroom, and respond to cultural, social and political realities of the situation, an ethnomathematical perspective views curriculum in a similar way. As Bishop (1988, 1996) states, it is important that a mathematics curriculum represent the culture of the students, be accessible to all learners, be relatively broad and elementary, and acknowledge historical and everyday life experiences.

5.3 ROLE OF THE TEACHER

Teachers play an important role in the implementation and interpretation of any curriculum. They are the link with the students and have the responsibility for implementing the curriculum in accordance with any prescription (Hannif, 1996). This requires taking a number of decisions and actions when planning lessons and schemes of work, and during the actual delivery of the lesson. Hence, the success or failure of curriculum implementation is closely linked to the way curriculum is delivered, or to classroom pedagogy (Singh, 1992). As Begg (1996) states, teachers have an authority over, or indirect influence, on any curriculum.

It is common that the proposed curriculum is based on requirements perceived by the curriculum developers; however, it is the recognition by the teachers that the requirements are essential that will make a difference at the implementation level. A study done in Fiji by Singh (1992) agrees that teachers need to be assured of the need for curriculum changes in terms of merits, especially for student learning, before they initiate implementation. One way to obtain teachers' ownership of a new curriculum is for them to be involved in its development.

This raises the question as to how teachers might have a role in the development of the curriculum. Biddulph, Taylor, Hawera and Bailey (2002) believe that teachers should play an important role in any development rather than being just implementers of a curriculum that someone else has assigned. Ways that teachers might be involved in curriculum development include: identifying the needs, writing the curriculum, teacher resources, and texts, as a professional development leader or advisor, and/or as a teacher collaborator.

However, whether or not they have participated in curriculum design, research shows that before the implementation of a mathematics curriculum, teachers need to be inducted into professional development programmes where they engage in activities that require self-reflection, collaboration, and development of mathematical understanding, and where they can develop a sense of ownership over the new curriculum and have collegial support (e.g., Begg, 1991, 1995, 1998).

Professional Development Of Teachers

A professional development programme provides an opportunity for teachers to gain support and guidance in order that they might improve the quality of their teaching and learning (Hannif, 1996). For a professional development programme to work, it must create a critical awareness in the teachers and be relevant to their current problems. Through critical self-reflection and collaboration teachers need to develop their mathematical understanding and classroom discourse. An environment has to be created that encourages teachers to question their existing beliefs, self-reflect, explore classroom activities, and work collaboratively with other teachers (Britt et al, 1993). Without the creation of such an environment, a professional development programme is likely to fail.

A teacher professional development programme that can help bring about an adaptive change will have a number of features such as (Begg, 1994; Britt et al, 1993; Clarke & Peter, 1993):

- Teachers being highly motivated to try out new strategies and willing to implement new approaches in the classroom;
- Teachers being open to self-reflection and self-learning;
- Exploring classroom activities for themselves;
- Documentation or reporting of experimentation strategies;

- Encouraging use of successful strategies among peers; and
- Having a supportive collegial environment.

Reflection seems to be the key to pedagogical development. It is a moderating process that translates classroom experience and experimentation into beliefs and attitudes that can sustain ongoing change. For teachers to commence a process of self-reflection, a number of requirements are highly desirable (Begg, 2002; Britt et al, 1993; Castle & Aichele, 1994; Clarke & Peter, 1993; Weissglass, 1994).

1. They need time to think.

Teachers in many education systems continue to struggle to do their teaching, with increasing administrative and pastoral demands on their time. However, teachers need time to think to be reflective on their classroom practices for change to occur in classroom environments. They need to have the time to review their own understanding and integrate new learning to their existing values and beliefs. Only then they will be able to participate actively in the professional development programmes.

2. They need assistance to acquire methods or tactics to promote reflection on their classroom experimentation.

Teachers need assistance to acquire methods to evaluate or reflect on their classroom practices. These processes are both complex and deliberate, and few teachers have had opportunities to develop these skills, or even find out about different possible techniques.

3. They need to collaborate with colleagues;

Teachers who are interested in implementing new ideas in the classroom need to collaborate with other experienced teachers, and they need to be initiated into a community of practice, which shares experience, is mutually supportive, and provides the teachers with meaningful choices and ideas.

4. They need to experience ownership of the professional development programme. Teachers need to contribute to, and have a say in their professional development programmes, they need to be able to communicate about the process, thereby giving them a greater opportunity for learning and evaluating new ideas.

These issues raises the question as to what sort of professional development or teacher involvement is necessary in order to implement a curriculum based on ethnomathematical principles, in the Maldivian context.

5.4 CHALLENGES OF IMPLEMENTING CURRICULUM INNOVATION

For a successful curriculum implementation, the following features are likely to be important:

- Explaining the format of the curriculum document and how it relates and links to other documents and teachers' existing beliefs and practices (Hannif, 1996).

- Enhancing teachers' understanding of the subject matter. Reluctance of teachers to implement curricular innovations have been expressed in Hannif's (1996) and Britt et al's (1993) studies due to limited background of the subject matter.

- Encouraging teachers to engage in the new mathematical ideas themselves. According to Wood, Cobb, and Yackel (1991), teachers learn the same way as students learn, and hence, when teachers explore classroom activities themselves, they are more confident to try these strategies in their classrooms (Britt et al, 1993).

- Introducing adequate resources and making them available. These may be access to advisors, background teaching materials, books, journals, and other instructional materials for practice of implementation of the change (Begg, 1992).

- Educating Principals, Supervisors, and Heads of Departments about the change process. Their support can have a very significant impact on any change process or implementation programme. Hence, it is important that they understand how the programme works, the impact of the process on teaching and learning, and their role in the change process (Britt et al, 1993; Singh, 1992).

These features clearly have implications for a professional development programme for Maldivian teachers developing and implementing an ethnomathematical curriculum in the Maldivian classrooms. For example, we have many non-Maldivian teachers who need to themselves see and understand the Maldivian mathematical practices before they can feel comfortable with an ethnomathematical curriculum. Maldivian teachers, who are trained formally, need to see the links between school mathematics and mathematical practices in the culture before they will accept an ethnomathematical approach to curriculum. It is also not normal for teachers in the Maldives to engage in mathematical explorations. So it is necessary that teachers try the new curricular approach themselves before they can feel comfortable implementing this approach in their classrooms. Adequate resources are also scarce, and since this approach is completely new, teachers need to create appropriate resources to enable them to successfully implement the new curricula.

An ethnomathematical curriculum involves a philosophical change that includes teachers' beliefs, values, and teaching style, hence, it is necessary that teachers get support from the higher levels before they can feel secure to take the new approach on board. Therefore, the schools invited to take part in this research were decided in conjunction with the Ministry of Education, Maldives. The Principals of the school were approached, and the research was conducted with their consent, and after the mathematics teachers volunteered to take part in this project.

Further, as Hannif (1996) states, successful implementation of a new curriculum is likely to be enhanced by teachers experimenting with the new innovations referred to in the curriculum and integrating them with their beliefs, values, and views on teaching and learning of mathematics. As Begg (1993) argues, the greatest barrier to implementation is lack of ownership. When teachers are not involved in the development they feel as if the changes are imposed on them. When changes are imposed, quite often the assumption is that the way they are teaching is not right and therefore something needs to be changed (Edwards, 2000). This can be disempowering.

Teachers play the key role in any implementation process. For successful implementation of a curriculum teachers need to be committed and mentally ready to change, visualise what changes could be made and determine to make a change within a given context, and reflect and compare classroom practices with the vision (Edwards, 2000). Hence, for successful change, teachers need to set goals, be reflective and patient, look for and provide support, and turn barriers into opportunities.

Other barriers or challenges to implementing curriculum innovations identified by Hannif's (1996) and Singh's (1992) studies include: lack of support from the government, school administrators, and colleagues; lack of time, guidance, and training to implement the new curriculum; lack of understanding of the subject matter, and the processes and approaches required by the curriculum document; lack of teacher motivation; teachers' personal qualities and beliefs; overload and routines expected of teachers by the school management, parents, and students.

In addition to the implementation challenges discussed above, states such as the Maldives face challenges due to the smallness of scale. As evident in Bray and Packer's (1993) report, one of the challenges that small states face is the limited professional, technical, and economic resources. As such, external consultants often prepare curriculum documents based on those from other countries. Furthermore, international examinations and textbooks shape the curriculum in most of the small states, as international validity and acceptance are seen as necessary (Bray & Packer, 1993). Due to this, curriculum documents may not be very meaningful to the locals.

For many years now, the Maldives has relied on external resources and ideas. At present, the mode of pedagogy in Maldivian classrooms relies heavily on the 'transmission of knowledge' model. As a result, Maldivian teachers might not have the confidence to initiate new ideas and put them into practice. Therefore, these teachers need ongoing support and guidance, and curriculum developers need to be committed over a long time period.

As a researcher I introduced the new curriculum approach for the teachers to explore and experiment with so that they would develop a sense of ownership. Workshops were conducted to induct the teachers in the research, and to work on the draft material. Then, an ethnomathematical unit was designed in conjunction with the teachers.

It was anticipated in this study, that challenges could arise during the research due to limited time as there are certain parts of the syllabus that have to be covered during a certain time frame. Another concern was that, as there are limited professionals, teachers might not get adequate support and guidance to continue implementing the new curriculum approach in their classrooms. However, no barriers to implementation due to lack of support from government and school administrators, or due to lack of teacher motivation were foreseen.

5.5 SUMMARY

This brief look at the features of curriculum development and its associated professional development, traced the main trends for successful curriculum development and implementation, and related them to the particular features of this study and its context in the Maldives.

It is evident from the literature that, for successful implementation of curriculum innovation, it is the responsibility of curriculum developers to involve teachers in curriculum development. This is because problems occur when changes are imposed on teachers, and when they do not feel a sense of ownership. Change is a difficult and slow process. However, with adequate support, professional development, and teacher motivation to change, the implementation process can be in itself worthwhile.

The teachers themselves are the agents for change and they need to create a school culture, through a process of reflection and collaboration, which enables them to implement and experiment with different strategies in their classroom. This implies a reconceptualisation of the curriculum to allow for experimentation (Kilpatrick, 1995).

Hence, implementing a curriculum is not a means to end, but it is a process of interaction, communication, and also maintenance of a culture of change for both the teachers and the students, at the same time a coping with beliefs, feelings and values.

Currently, a 'culture of change' does not exist in the Maldives. However, the conditions are ripe for it to develop, as the government and school administrators are calling for it and are supportive of all development efforts.

6

A FRAMEWORK FOR AN ETHNOMATHEMATICAL CURRICULUM

6.1 INTRODUCTION

An ethnomathematical curriculum may be conceived as one in which the cultural aspects of the students' milieu are infused into the mathematical learning environment in a holistic manner. This has been attempted in many different ways (see Chapter Four). For example cultural aspects have been used as motivation only, as new content, or as new methods for mathematics learning.

From the five conjectured possibilities for an ethnomathematical curriculum discussed in Chapter Four, the approach adopted in this study uses an ethnomathematical curriculum as an approach to mathematics learning. This approach involves an integration of the mathematical concepts and practices originating in the learners' culture with those of conventional mathematics (Lipka, 1994). Such an ethnomathematical curriculum involves learning by experiencing the mathematical concepts and practices originating in the learners' culture, and using these experiences to appreciate the power and utility of conventional mathematics, to understand its place in society, and to have a framework for its concepts (Lipka, 1994). The understanding of conventional mathematics then feeds back into and contributes to a broader understanding of the culturally-based mathematical principles.

The reasons for adopting this type of an approach to an ethnomathematical curriculum, and why it would be problematic to implement the other approaches in the Maldivian classrooms, were discussed in Chapter Four. In brief, most of the mathematics teachers in the Maldives are expatriates who do not share the same social and cultural background as their students. In addition, British syllabuses and examinations are followed in the Maldivian classrooms. Therefore, it would be difficult to implement an ethnomathematical curriculum as an approach to mathematics (see section 4.2) that uses examples from the socio-cultural environment of the students as a means to communicate mathematical ideas, as most teachers do not have the same social and cultural experiences as their students. Likewise, implementing an ethnomathematical curriculum as cultural content (see section 4.3) would be difficult, as in this case some of the mathematical lessons have to be given over to study Maldivian cultural practices and teachers might not be able to finish the 'prescribed' syllabus on time.

It is an argument of this thesis that ethnomathematics is always appropriate and valid, and that mathematics can never be free of social and cultural influences. However, implementing an ethnomathematical curriculum as a stage in the development of mathematical thinking, (see section 4.4) implies that mathematics classrooms will be free of cultural experiences eventually. Therefore, in the Maldivian classroom, this type of an approach is not appropriate for the rationale behind this thesis. On the same note, it would be problematic to implement an ethnomathematical curriculum as mathematical enculturation (see section 4.5). This is because Maldivians, who value external examinations provided by Western countries, are not likely to change too far from an international model for fear that their education, will not be accepted in the globalised world.

Therefore, it is argued that the most appropriate and feasible approach for the Maldivian classrooms is an ethnomathematical curriculum as an approach to mathematics learning (see section 4.6). This approach allows revalidation of cultural skills; helps preservation of the mathematical culture of the Maldives; helps mathematics teachers and students to become aware of mathematical practices in their culture and use this awareness to learn about formal mathematics; and hence, helps teachers and students to make connections between real world and school mathematics. In addition, this approach could be implemented in the Maldivian classrooms without the addition or deletion of topics in the current syllabus. Moreover, it requires acceptable levels and modes of professional development. The teachers need to explore, experience, and be inducted into the curriculum before they implement this in their classrooms. Such activities are exactly those that are indicated in professional development literature.

This chapter details the framework for the ethnomathematical curriculum model, and then presents the research questions that this study seeks to answer.

6.2 AN ETHNOMATHEMATICAL CURRICULUM MODEL

From the early 1990s, Lipka and colleagues have worked collaboratively in Alaska with Yup'ik Eskimo Elders and teachers to create a supplementary elementary school mathematics curriculum by incorporating local knowledge into mathematics classrooms. The basis for this work is that (Lipka, 1994, p. 20),

> ... the Yup'ik language, culture, and worldview, particularly subsistence activities, contain mathematical concepts ... This has direct applications to school math. However, just as important, the project participants are increasingly realizing the potential of using their culture and language as a means to change the culture of schooling.

For example, Lipka (1998) suggests that a possible way of bridging the context between school and culture is to "use some of the concrete and more experientially connected Yup'ik conceptions of math and science as a means of teaching in school" (p. 141). Their work involves (Lipka, 2002a, p.3):

- Documentation of elders' stories and related cultural practices.
- Observing mathematics in nature and society, such as the movement of stars, the building of fish racks, or making models of various cultural artefacts.
- Constructing educational or curricula practices that connect the elders' knowledge to schooling jointly with Elders, Yup'ik teachers, and University researchers.

Their work also highlights four distinct ways of basing instruction on Yupi'k culture. They are (Lipka, 1998, p. 191):

- A literacy-based model that uses oral Yup'ik tales in a number of traditional and creative modalities.
- A mathematics approach that uses Yup'ik patterns and symbols as a basis for teaching mathematics.
- The use of modern games in which oral literacy, symbolic manipulations, mathematics, and science are integrated.
- A scientific approach that uses Elders as leaders and 'field experiences'.

According to Lipka (1994, p.25), the pressure behind developing a Yup'ik mathematics is three-fold:

- To show students that mathematics is socially constructed.
- To engage students in a process of constructing a system of mathematics based on their cultural knowledge.
- To connect students' knowledge of 'their mathematics' through comparisons and bridges to other aboriginal and Western systems.

In other words, Lipka and his team promote the idea that access to the formal or school mathematics should come through the world-view in which it is expressed.

The 'culturally-based' curriculum developed by Lipka and his colleagues has been trialled since 1999 in both urban and rural areas of Alaska. In this research, a treatment group (those who used the project's curriculum), and a control group were used. The results of the research show that the treatment groups performed statistically significantly higher than the control groups from both the urban and rural areas (Lipka, 2002a). This suggests that including students' socio-cultural context in mathematics teaching can enhance the learning of mathematics. However, as Lipka (2002b) states, the research process must not only determine the academic performance of students, but should also explore how the cultural experiences influence the teaching and learning of mathematics and vice versa. Yet, a further question is, what is the extent of these influences? How do we know? Of course there are other factors involved – the Hawthorne effect suggests that any new innovation will be successful simply because it is new.

In addition, two conflicting and/or competing issues arise in this process of developing curriculum. They are, ensuring cultural knowledge is not trivialised or decontextualised, and meeting the requirements of the school mathematics curriculum (Lipka, Wildfeuer, Wahlberg, George, & Ezran, 2001). Besides, as 'outside' researchers are doing the research, there is always the danger of mistransformation and misinterpretation of the local knowledge. Therefore, for successful development and implementation of a culturally-based curriculum, schools, teachers, community, and the researchers need to work collaboratively by taking initiatives, and seeking "opportunities for its culture, language, experience, and future within the school" (Lipka, 1998, p. 195).

An ethnomathematical curriculum was devised for Maldivian classrooms using Lipka (1994) as a basis. However, it is important to note that Lipka's curriculum model is for an indigenous group, which is not the dominant culture and is marginalised, whereas in the Maldives, the indigenous group is the dominant culture. In addition, there are some gaps in Lipka's model. For instance, he does not detail an appropriate basis on which comparisons can be made, nor does he specify what a 'bridge' between systems involves. Making comparisons between cultural practices and mathematics as an international field of study can trivialise cultural knowledge, and bridging cultural knowledge to other knowledge systems can decontextualise the cultural knowledge and/or the conventional mathematics. Lipka (2002a, p.2) acknowledges this by stating,

> Elders' knowledge is tied to a specific context and time, and removing this 'knowledge' from these places can transform it so completely that it is no longer recognised by the Elders' themselves.

The same transformation may happen when mathematicians' knowledge is applied in real life contexts. Therefore, the challenge is to place in parallel and 'bridge' the knowledge systems without trivialising, stereotyping, or decontextualising them.

The objective of developing an ethnomathematical curriculum model for Maldivian classrooms is to assist students to become aware of how people mathematise or think mathematically in their culture, to use this awareness to learn about formal mathematics, and to increase their ability to mathematise in any context in the future. The learners use the mathematical experiences from their culture to understand how mathematical ideas are formulated and applied. This general mathematical knowledge is then used to introduce conventional mathematics in such a way that it is better understood, its power, beauty and utility are better appreciated, and its relationship to familiar practices and concepts is explicit. Hence, the 'bridge' in this model is mathematising or thinking mathematically.

However, Borba (1997, p. 268) was concerned that

> ... [an] awakened interest in ethnomathematics does not automatically transfer to an interest in learning/developing any other ethnomathematics, such as academic mathematics. Students may not have much interest in investigating deeply the concepts which underlie their ethnomathematics.

This could be seen as a worry that the bridge is not a natural pathway for students. His suggestion is to develop problems in conjunction with students.

Figure 6a gives a framework for the ethnomathematical curriculum model used in this study. The model provides linkages between areas of mathematical activity. The connection indicated by the highlighted arrow that links mathematical activities in the students' culture to conventional or school mathematics, is privileged by an ethnomathematical curriculum. A detailed version of this connection is given in Figure 6b.

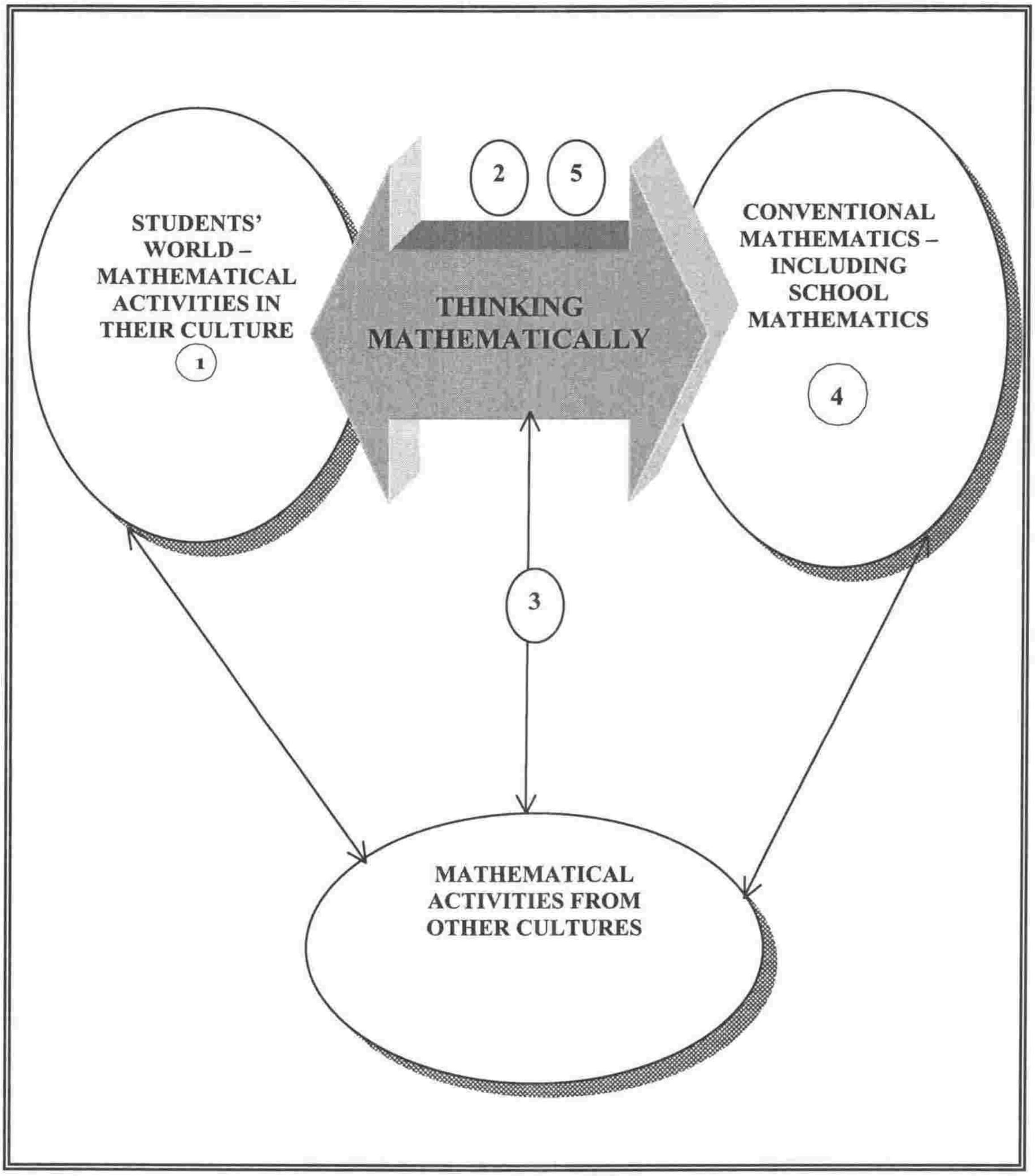


Figure 6a: Framework for an Ethnomathematical Curriculum Model

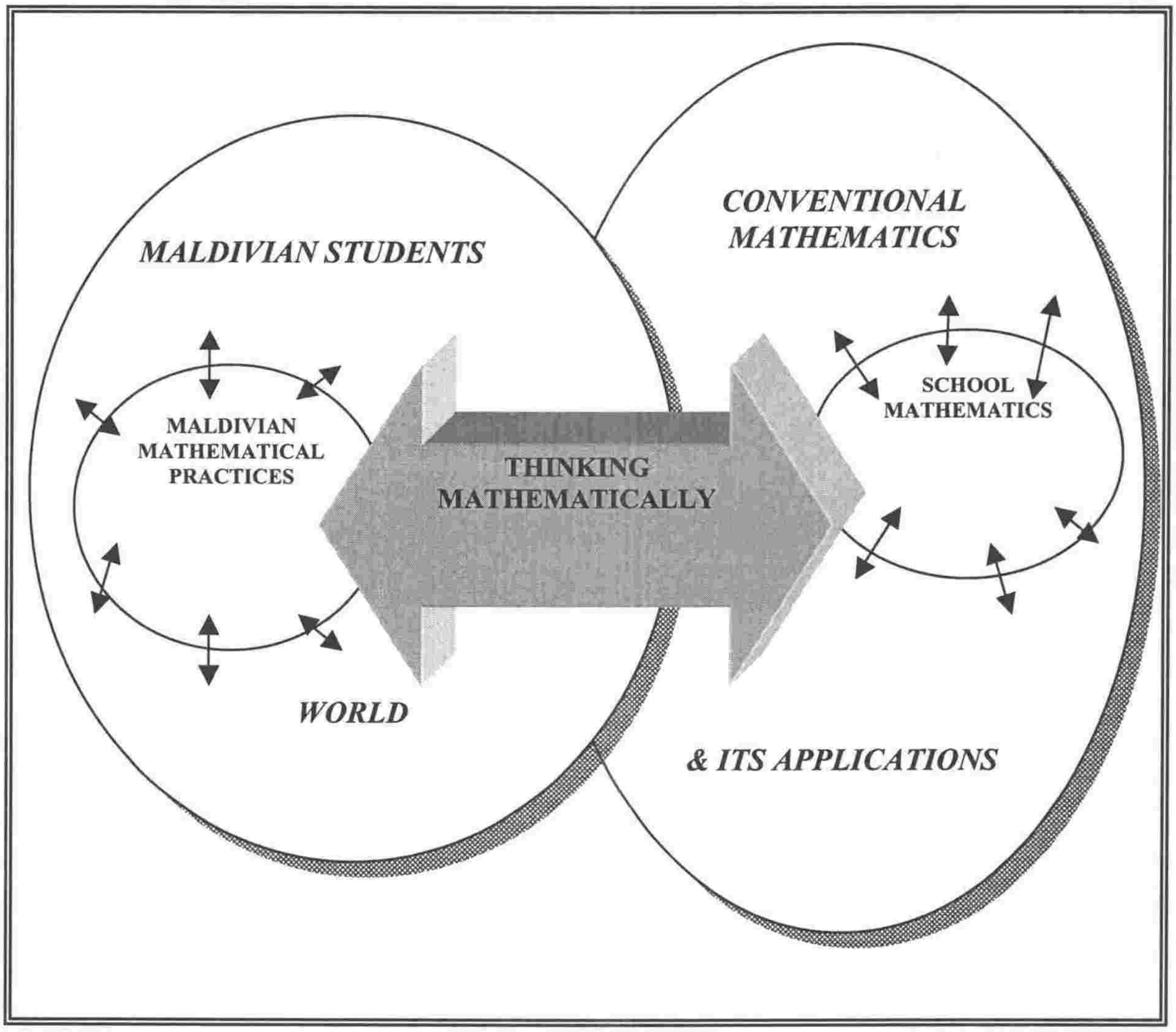


Figure 6b: The Connection Privileged by an Ethnomathematical Curriculum

In Figure 6b, the arrows between Maldivian students' world and Maldivian cultural practices characterise the relation between the practice and the context and vice versa. Similarly, the arrows between school mathematics and conventional mathematics and its applications characterise the relation between the practice (at school) and the context (conventional mathematics) and vice versa.

This ethnomathematical model leads to the development of a sequence of instructional activities that enable students:

1. To become aware of potentially mathematical practices in their culture so that they understand the nature and origins of mathematics better, and value and appreciate the existing knowledge.

2. To understand and experience these cultural activities from a mathematical point of view, thereby making it easier for them to make the link between school mathematics and the real world or life in the Maldivian society.

3. To connect knowledge of 'their mathematics' to parallel ones outside their experiences or culture using mathematical thinking, thereby making it easier for them to appreciate that each culture has its own way of mathematising and that different strategies can be and have been invented whenever the need arose.

4. To learn about and learn to use conventional mathematical systems, notations, and techniques by discussing the ways in which this mathematics was also developed – in response to human needs.

5. To understand conventional mathematics better so that it feeds back into and contributes to a broader understanding of the culturally-based mathematical principles.

The study proceeded using this model. However, there are certain questions arising from this way of thinking about an ethnomathematical curriculum and themselves raising further subsidiary questions. They are as follows.

1. How does understanding of the nature of mathematics happen when students become aware of the mathematics in their culture?

When students become aware of the mathematics in their culture they see mathematics as a human activity rather than just a set of symbols, numbers, and figures, which are presented, only at school. They see a human face to mathematics. As a result, do they start asking deeper questions about mathematics and do they see mathematics as something one does to solve problems, communicate ideas, and reason out situations as part of their everyday life? And what can teachers do to facilitate this?

2. What do we mean by 'thinking mathematically' if it is to be used as a bridge?

Cultural mathematical practices can be related to conventional mathematical systems, and vice versa, through mathematical thinking. Mathematical thinking involves symbolising, generalising, abstracting, and making logical connections. This could be facilitated by seeing mathematics in various cultural contexts and learning mathematics through practical examples and investigations. However, as a result of relating mathematics to real world activities, do students' understanding of mathematical concepts facilitates, and the quality of conventional mathematics learned improve? And what can teachers do to make this process easier?

3. What other bridges between cultural practices and mathematics are possible and appropriate?

One possible bridge could be how the connections between mathematics and the real world are realised by both the teachers and students. That is, the examples they use, and the aspects of each that they choose. Another possible bridge is that the real world is just an example of mathematics but not a generator of it, and as a result students' interest and motivation in learning mathematics may be enhanced. However, are we sure that mathematics teachers and learners make the link between ethnomathematics and mathematics? Even if they do, what is the extent to which this link has been made? How would we know?

These questions encourage reflection on and criticism, and analysis of the curriculum model throughout the implementation process. The appropriateness of the model in the Maldivian classrooms is part of the analysis.

Two intended implications of this ethnomathematical curriculum model are as follows.

1. It brings a broader understanding about mathematics into the classroom mathematics programme.

Most classroom mathematics curricula focus on mastery of skills, accumulation of facts, rules, and algorithms that are necessary for examinations. The curriculum is characterised as mathematical content. As a result most students leave school thinking that mathematics is something to be done only at school and that it has no relevance to their real life. An ethnomathematical curriculum introduces an understanding about mathematics as a part of mathematics education. When students understand the nature of mathematics, they will better comprehend the relevance of mathematics in the various aspects of their everyday life, and be better able to use mathematical thinking in a variety of contexts.

2. It focuses on mathematics as a process, rather than as a collection of facts.

The model is based on the idea that mathematics is a human creation that emerges as people attempt to understand their world. Therefore, mathematics is seen as a process, and as a human activity, rather than just as content. This implies that a mathematical curriculum is not just about application of relevant contexts in learning and teaching mathematics. It is also about generating formal mathematics from cultural ideas. Thus formal mathematics is better understood, appreciated and made more meaningful to its learners.

Furthermore, as discussed in Chapter Five, teachers play a key role in the development and implementation of a curriculum. Therefore, this ethnomathematical model has implications for Maldivian teachers such as: changing their professional development; changing their conceptions of mathematics; encouraging teachers in engaging in mathematical explorations. If done successfully, this may result in a sense of empowerment. Teachers who have had a conventional mathematics education may have particular difficulty understanding an ethnomathematical curriculum. This is because, in order to appreciate an ethnomathematical curriculum, they need to stand outside their mathematical point of view. However, experiencing ethnomathematics is a means by which they can step back from mathematics. This is a circular bind. Before an ethnomathematical curriculum can be successfully implemented in their classrooms, teachers need to re-evaluate or 're-know' their beliefs about mathematics and mathematics teaching and learning.

6.3 RESEARCH QUESTIONS

The purpose of this study is to evaluate the preliminary stages of implementation of an ethnomathematical curriculum in teaching and learning mathematics in a primary classroom in the Maldives. The study seeks to answer the following questions:

1. What are the issues and considerations in preparing an ethnomathematical curriculum unit?

There are several issues that need to be considered in preparing an ethnomathematical curriculum unit in the Maldives. For instance, in the Maldives where a Western education system is valued and British syllabuses are followed at secondary schools, community acceptance of a new perception of mathematics is necessary. In addition, since external syllabuses and assessment are followed, can ethnomathematical material be added to the existing curriculum without removing existing topics, and would there be sufficient time to complete the syllabus? Considering that public examinations are in English, and given that cultural practices are likely to be better described in the language of the culture, what language should the ethnomathematical curriculum unit be taught in?

Another consideration is that not all desired mathematical characteristics may be found in any specific cultural context, and there may be a lack of cultural resources that are aligned to a predetermined mathematics curriculum. The extent of these considerations is investigated.

2. What are the problems in preparing the teachers in the Maldives for a curriculum unit based on ethnomathematical principles?

The mode of pedagogy in Maldivian classrooms relies heavily on a 'transmission of knowledge' model, and it is not normal for Maldivian teachers to engage in mathematical explorations. Therefore, the implementation of an ethnomathematical curriculum unit requires a change in teaching style, assessment procedures, student learning modes, and classroom discourse. Would Maldivian teachers, who are trained formally, be able to adapt to these changes and be able to see and utilise the link between school mathematics and mathematical practices in their culture? How about non-Maldivian teachers who do not share the same social and cultural background?

Lack of adequate resources means that teachers need to create appropriate resources to teach the ethnomathematical curriculum unit. What sort of guidance and support are necessary for the teachers in this situation? What kind of professional development programme will enable the teachers to become effective users of an ethnomathematical unit of work?

3. What issues arise in the implementation of an ethnomathematical unit?
   What are the practical limitations?
   What are the issues that need to be resolved for future developments?

Would students, who are used to the traditional methods of learning mathematics, accept a new perception of mathematics? What are the possible difficulties of an ethnomathematical curriculum from the teachers and students view? Would students and teachers make the link between ethnomathematics and school mathematics? Would students and teachers understand more about the origins of mathematics, and recognise mathematics in the real world?

Other issues that could arise during the implementation include the lack of time to undertake ethnomathematical explorations, as the teachers are under pressure to finish the prescribed syllabus, and sequencing, as the syllabus outline does not give much flexibility for teachers to change the order of topics.

4. What are the indications during the intervention of the efficacy of using an ethnomathematical curriculum unit?

   What are the student reactions, learning outcomes and affective outcomes of using such a curriculum unit?

   What are the teacher reactions and affective outcomes of using such a curriculum unit?

What are teachers and students feelings about using cultural practices in mathematics? Did teachers' confidence in mathematics and mathematics teaching change as a result of the implementation? Did the ethnomathematical unit have any impact on their teaching practice?

Did students' interest and motivation in learning mathematics change as a result of the implementation? Do students indicate preferences in their learning of mathematics? Did students gain a better understanding of mathematical concepts?

The next chapter addresses the data collection methods that were adopted to answer these research questions, and then the research results are presented, analysed, and discussed in Chapters Eight, Nine, Ten, and Eleven.

7 RESEARCH METHODOLOGY AND DESIGN

7.1 INTRODUCTION

The research investigates the effects of implementing an ethnomathematical curriculum unit in primary classrooms in the Maldives, and therefore, all data collection was carried out in the Maldives.

An ethnographic approach was used. In this study, my role as the researcher was that of a participant-observer. As a Maldivian, I have the benefits that come from being an insider. Hence, my previous experiences and assumptions were expected to have an influence on this study. I was not a neutral observer. However, the research was designed to minimise these influences, and the data collected are from the participants' point of view.

This chapter begins with a discussion of the choice of research method followed by my assumptions, and the limitations of this study. Then research design is discussed in detail with reference to the data collection strategies used, followed by outlines of ethical considerations, and the difficulties of the study. The chapter concludes with a description of the data analysis.

7.2 RESEARCH METHOD

This study investigated a situation involving the "sociocultural patterns of human behaviour" rather than testing a hypothesis involving the "quantification of human events" (Zevenbergen, 1998, p.19). Hence, an ethnographic evaluation was an appropriate research methodology. Ethnographic methods such as participant observation, interviews, questionnaires, workshops, and informal discussions were used to collect data.

Ethnography is an approach used for examining aspects of human beings by finding out their point of view: their beliefs, behaviours, ideas, values, or assumptions (Bogdan & Biklen, 1982; Emerson, Fretz, & Shaw, 1995). Ethnographers study and investigate these aspects by actively participating in natural settings and making sense out of the data from the participants' perspective. Therefore, ethnography is a form of research that relies on observations, gathering data from interviews and questionnaires, constructing assumptions and hypotheses as they emerge from the data and acting upon these findings.

Ethnography is open ended and there is access to non-verbal cues. It also involves interaction with people for a long time and therefore, the researcher can see how people lead their lives and can come to understand people's experiences. The researcher needs an ability to comprehend the language of the participants, a capability to see relationships within the data that is observed, and an awareness of how that data can be applied or its relevance to the particular study (Bannister, Burman, Parker, Taylor & Tindall, 1994). Thus, ethnographic research is inherent in the socio-cultural world it is trying to study.

Some of the problems or disadvantages of ethnography include: that it is time consuming and subjective; that the point of view taken by the researcher may influence the analysis and interpretations (Bannister et al, 1994; Emmerson et al, 1995); that power relations may exist between the researcher and the researched, even when the research is collaborative (Zevenbergen, 1998); and that the results of the research cannot be widely generalised as the data are not structured, and the main themes become apparent progressively through the analysis of the data (Cohen & Manion, 1994; Guba & Lincoln, 1994; Okely, 1996).

Since this study is concerned with investigating the effects of including cultural aspects in the teaching and learning of mathematics, it was necessary that an ethnographic approach be used to take into account the culture of the participants and thus gain insights about their experiences. Being an insider researcher who speaks the language and who appreciates the traditions, beliefs, and values of the culture, enabled me to fully participate in the research, and better enabled me to understand the participants' point of view. In addition, I was a participant in the same way as the others in the study were. I did not stand in a formal or authoritative role, and the research was very much a collaborative process. However, some of the participants may have assumed some power differences given that I was a Maldivian doing a higher degree, a researcher, and someone with a position of authority in the Maldives. As Zevenbergen (1998, p. 30) notes:

> In spite of intentions being democratic and collaborative, the researcher enters the fieldwork in a position that is privileged and authoritative ... Ultimately, the researcher has the power over what will be observed; what will be asked in the interviews; how the observations, data, or both will be used; who will gain most from the research; and what discourses will be used to frame the research, observations, and data.

These and other limitations of this study are discussed in section 7.4.

7.3 MY ASSUMPTIONS

Being a Maldivian, I knew some of the participants involved in the study. Due to this, the research began with my assumption that my presence as a researcher might cause some participants to express and share their ideas more freely, but could also cause others to feel reluctant about sharing their ideas and experiences with me. Overall, however, I assumed that as an insider my data would be richer, and analysis more true to Maldivian reality.

In addition, as I have previously explored the nature of indigenous mathematical thinking in the Maldives, I assumed that I was likely to have insights that others might miss, while remaining aware that the participants might have insights and ideas that I would have not thought of before.

Based on my experiences as a mathematics teacher in the Maldives, I believe that mathematics is not very meaningful to Maldivian students partly because there is little connection between school mathematics and their life. Therefore, I assumed that an ethnomathematical curriculum would be more meaningful to Maldivian students, and that it could be an effective teaching strategy to achieve the conventional curriculum objectives.

The indigenous mathematics skills and the mathematical heritage of the Maldivians have fallen into disuse due to globalisation trends, and the reliance on Western mathematical traditions. However, Maldivians do value traditions, customs, and practices of the culture, and research has been done on these practices (e.g., Shafeeg, 1988). As such, it was assumed that any cultural revalidation emanating from an ethnomathematical curriculum was likely to be valued by the schools and community.

7.4 LIMITATIONS

Given the time frame, the study was limited to Grade 5 teachers and students from two schools. As the Maldives is a very homogenous society with one indigenous cultural environment, I felt that the effects of the research would have been more or less the same even if the sample size was large and more schools from different regions of the Maldives were involved.

Only one unit of work (on measurement) was used as schools and teachers were willing to experiment only in a small scale in case the study went wrong, and also there were restrictions on the time that can be spent on the research. This is a limitation of the study because any successes of this unit may not automatically be assumed to apply on a wider scale. The reasons are as follows.

- There may not be enough cultural material for all the units.

- Ethnomathematical units may not be able to fully cover the contents of the current syllabus.
- Any successes may be due to the unit being something different and therefore, exciting for the teachers and students. Maldivian students who are used to the traditional method of 'chalk-and-talk' teaching may feel relieved from the boredom of the usual class, as the unit involved field trips and exploration of some mathematical activities in the class.
- A different teaching style was used which may not be suitable long term or for all mathematical topics.

There was a limitation to the level of objectivity achieved in this study. As the participants were aware that I was a deputy head of a school in the Maldives, and knew the Ministry of Education officials and the Principals on a personal level, I was concerned that I might have an effect on the participants as an authority figure. Nevertheless, my position of authority as a researcher did not appear to hinder the collaborative research process. The participants appeared ready to open up and share their experiences, and there were no incidents where I was aware that anyone refused or was reluctant to take part in the research. However, whether this was genuine openness or from a sense of obligation is not known. On the one hand, change takes time and resistance could be expected, yet the responses of the participants were very positive. Therefore, there may have been instances where the participants responded according to what they thought were appropriate responses for the study, rather than how they really felt. On the other hand, some of my ideas were challenged as some of the teachers and students expressed what they thought were the difficulties of an ethnomathematical approach to mathematics. This is evidence of a free exchange of ideas of equals. Moreover, even after the completion of the research, teachers volunteered further information that backed up data gathered during the research.

7.5 RESEARCH DESIGN

The research was conducted and data were collected during the first four months of 2002, in two primary schools of the Maldives. One unit of work on measurement (perimeter, area, and volume) from the Grade 5 syllabus of the Maldivian National Primary Curriculum was used.

The two primary schools were selected from Male', the capital, where the medium of instruction is English, and from a rural island where the medium instruction is *Dhivehi*. There were seven grade 5 classes at the Male' school, seven teachers teaching at Grade 5, and about 210 students (10 year olds) studying in these classes. All seven teachers were female; four were Maldivians and the other three were expatriates from Sri Lanka and India. At the Island school there were two grade 5 classes, two teachers teaching these classes and about 60 students (10 year olds). Both these teachers were Maldivian. One was male and the other female. Teachers teaching at both schools were not only teaching mathematics, but also all the other subjects (excluding *Dhivehi* and Religious Studies). Table 7a gives an overview of the sample structure of participants.

Table 7a: Summary of the Participants Involved in the Study

SCHOOL	TEACHERS		STUDENTS		
	FEMALE	MALE	FEMALE	MALE	TOTAL
Male' School	7	0	102	108	**210**
Island School	1	1	28	32	**60**
TOTAL	**9**		**130**	**140**	**270**

The research was first conducted at the Male' school and then at the Island school. Summaries of the data collection events are given in Tables 7b and 7c.

Table 7b: Account of Events

MALE' SCHOOL		
SESSION	**SESSION TYPE**	**SUMMARY OF EVENTS**
1 07.01.2002 (MON)	Meeting	- Met the Ministry of Education officials - Information regarding the research was given and advice was sought about which schools the research is to be conducted in
2 09.01.2002 (WED)	Meeting	- Met the Principal of one of the Male' primary schools - Information regarding the research was given - The Principal assured that every assistance needed for the research would be given by the school
3 16.01.2002 (WED)	Meeting	- Met the Grade 5 mathematics teachers - Information regarding the purpose of the research, time, and the amount of work involved were discussed. - Teachers assured that they would support me in every way they can
4 24.01.2002 (THURS)	Meeting	- All Grade 5 mathematics teachers signed the consent form - Discussed keeping a journal and a guideline on how to write a journal was given - Teachers filled in a questionnaire (pre implementation) - Some material on ethnomathematics and ethnomathematical curriculum (Appendix A) was given to teachers and discussed - Discussed when to have workshop sessions
5 27.01.2002 (SUN)	Workshop 1	Time: approximately 3 hrs - Material on ethnomathematics was discussed - Brainstormed about teaching and learning mathematics - Brainstormed about mathematical activities in the Maldivian culture that could be used in the mathematics class - Brainstormed about mathematical activities in the Maldivian culture related to measurement - Selected four fieldwork sites. They were fish market, local market, construction site, and carpentry site - In groups of two, questions that could be asked when we visit these sites were written and discussed among the whole group
6 02.02.2002 (SAT)	Workshop 2	Time: from morning till evening - Teachers visited the fieldwork sites identified during the workshop session and gathered information
7 06.02.2002 (WED)	Workshop 3	Time: approximately 3 hrs - Reflected on the fieldwork experience - Made a plan of the measurement unit and how lessons will be conducted during first week of implementation - Decided to take students to local market, construction site, and carpentry site - Parents to be informed in writing - Students' worksheets for fieldwork (local market and

		construction site) were written based on teachers' experiences from their fieldwork trip - Evaluation
8 09.02.2002 (SAT)	Fieldwork	- All grade 5 students (about 210) visited the local market and construction site - Students gathered information in groups of four or five
9 10.02.2002 (SUN)	Classroom Observation	- Students discussed their experiences from the fieldwork trip - Students (in groups) presented the information the gathered - The students brainstormed about what mathematics is and where mathematics is found/used in real life
10 13.02.2002 (WED)	Workshop 4	Time: approximately 3 hrs - Reflection - Lesson plans for the second week of implementation were discussed and written in detail with alterations and additions based on teachers experiences during the first of implementation - Prepared resources – in groups - Evaluation
11 18.02.2002 (SUN)	Workshop 5	Time: approximately 2 hrs - Reflected on the first week of implementation - Lesson plans for the third week of implementation were discussed - Students' worksheet for fieldwork (carpentry site) was written. Teachers decided to give a concept map to students - Evaluation
12 19.02.2002 (MON)	Fieldwork	- All grade 5 students visited the carpentry site - Students gathered information with the help of the concept map given to them
13 21.02.2002 (WED)	Classroom Observation	- Students discussed their experiences from the field work trip to the carpentry site with reference to the mathematics involved in carpentry and how it is related to the work they do at school
14 26.02.2002 (TUES)	Classroom Observation	- Students measured using different objects from the culture and shared their ideas in groups. A worksheet was given - History of measurement was discussed in terms of how mathematical units and measurement strategies were invented, whenever the need arose, in different cultures
15 27.02.2002 (WED)	Classroom Observation	- Students measure different objects using their body parts and a measuring tape. A worksheet was given - The need for accuracy and hence the use of standard measures to communicate across cultures, were discussed
16 28.02.2002 (THURS)	Classroom Observation	- Continued the discussion on the need for accuracy and why formulae are needed - Introduced perimeter of different shapes, areas of squares and rectangles, and volume of a cuboid by relating to real world examples or examples from culture

17 28.02.2002 (THURS)	Workshop 6	Time: approximately 2 hrs - Reflected on the second week of implementation - Scheduled interview times - Discussed teachers experiences from the three weeks of implementation - Planned lesson plans for the rest of the implementation - An information sheet on Maldivian and other ethnomathematical examples (Appendix B) was given to teachers - Evaluation
18 03.03.2002 (SUN)	Classroom Observation	- Continued perimeter, volume of a cube, and area of squares and rectangles - A worksheet was given
19 04.03.2002 (MON)	Classroom Observation	- All grade 5 students and teachers watched a video on boat building; discussion linking boat building to mathematics - Introduced area of triangle by relating to the real world examples
20 05.03.2002 (TUES)	Classroom Observation	- Continued area of triangle - A worksheet was given
21 05.03.2002 (TUES)	Interview	- Interviewed ten students from 4 classes
22 06.03.2002 (WED)	Classroom Observation	- Introduced area of compound figures by relating to the real world examples - A worksheet was given
23 06.03.2002 (WED)	Interview	- Interviewed six students from 3 classes - Interviewed six teachers
24 07.03.2002 (THURS)	Classroom Observation	- Revised area, perimeter, and volume - A worksheet was given
25 07.03.2002 (THURS)	Interview	- Interviewed one teacher
26 10.03.2002 (SUN)	Classroom Observation	- Assessment on volume, area, and perimeter
27 11.03.2002 (MON)	Workshop 7	Time: approximately 2 hrs - Reflected on the third week of implementation. - Teachers filled in the same questionnaire (post implementation) again - Talked about what we all learned from the whole process. Shared ideas and evaluated the whole experience

Table 7c: Account of Events

ISLAND SCHOOL		
SESSION	**SESSION TYPE**	**SUMMARY OF EVENTS**
1 13.03.2002 (WED)	Meeting	- Met the Principal and other staff of the school administration - Information regarding the research was given - The Principal assured that every assistance needed for the research would be given by the school
2 14.03.3002 (THURS)	Meeting	- Met the Grade 5 mathematics teachers - Information regarding the purpose of the research, time, and the amount of work involved were discussed. - Teachers said that they would support me in every way they could - Teachers signed the consent form - Discussed about keeping a journal and a guideline on how to write a journal was given - Teachers filled in a questionnaire (pre implementation) - Some material on ethnomathematics and ethnomathematical curriculum was given to teachers and discussed - Since there were only two Grade 5 teachers, decided not to conduct workshop sessions but have informal discussions with them everyday
3 16.03.2002 (SAT)	Discussion	- Discussed the implementation process in detail - Made a plan of the measurement unit - Decided to take students to a boat building shed and to a construction site - Parents to be informed in writing - Students' worksheets for fieldwork were written based on teachers' experiences
4 17.03.2002 (SUN)	Fieldwork	- Students visited the construction site and the boat building shed - Students gathered information in groups of four or five
5 18.03.2002 (MON)	Classroom Observation	- Students shared their experiences from the field work - A worksheet was given for group discussion. After discussion each group presented their work - Brainstormed about what mathematics is, where mathematics is found/used and link between mathematics and boat building/construction
6 18.03.2002 (MON)	Discussion	- Discussed how the last lesson went. How the lesson can be improved, what we liked about the lesson, what needs to improved, or added, the strengths the weaknesses - Planned the next lesson - Feedback and evaluation
7 19.03.2002 (TUES)	Classroom Observation	- Students measured different objects using their body parts and a measuring tape. A worksheet was given and was discussed by relating to the real world - Talked about history of measurement and the need for accuracy and use of standard measures
8 19.03.2002	Discussion	- Discussed how the last lesson went. How the lesson can be improved, what we liked about the lesson, what needs to

(TUES)		improved, or added, the strengths the weaknesses - Planned the next lesson - Feedback and evaluation
9 20.03.2002 (WED)	Classroom Observation	- Students measured using different cultural objects and shared their ideas in groups. A worksheet was given. - Students measured the perimeter and area of different leaves using different types of shells, type of seed (*madhoshi*) and sand. Discussed differences between different groups' measurements - The need for a standard measure to communicate across cultures was discussed
10 20.03.2002 (WED)	Discussion	- Discussed how the last lesson went. How the lesson can be improved, what we liked about the lesson, what needs to improved, or added, the strengths the weaknesses - Planned the next lesson - Feedback and evaluation
11 21.03.2002 (THURS)	Classroom Observation	- The need for accuracy in real life and hence, the use of formulae were discussed - Introduced perimeter of different shapes, area of squares and rectangles, and volume of cuboid - Teacher demonstrated the concept of capacity using different sizes of bottles, a glass and using sand and water
12 21.03.2002 (THURS)	Discussion	- Discussed how the last lesson went. How the lesson can be improved, what we liked about the lesson, what needs to improved, or added, the strengths the weaknesses - Planned the next lesson - Feedback and evaluation
13 24.03.2002 (SUN)	Classroom Observation	- Continued area of squares and rectangles, volume and perimeter by relating to cultural examples. A worksheet was given
14 24.03.2002 (SUN)	Discussion	- Discussed how the last lesson went. How the lesson can be improved, what we liked about the lesson, what needs to improved, or added, the strengths the weaknesses - Planned the next lesson - Feedback and evaluation
15 25.03.2002 (MON)	Classroom Observation	- Introduced area and perimeter of compound figures
16 25.03.2002 (MON)	Discussion	- Discussed how the last lesson went. How the lesson can be improved, what we liked about the lesson, what needs to improved, or added, the strengths the weaknesses - Planned the next lesson - Feedback and evaluation
17 26.03.2002 (TUES)	Classroom Observation	- Area and perimeter of compound figures continued - Introduced area of triangle - A worksheet was given
18 26.03.2002 (TUES)	Discussion	- Discussed how the last lesson went. How the lesson can be improved, what we liked about the lesson, what needs to improved, or added, the strengths the weaknesses

		- Planned the next lesson - Feedback and evaluation
19 27.03.2002 (WED)	Classroom Observation	- Revision. Students did the exercises given in the textbook
20 27.03.2002 (WED)	Discussion	- Discussed how the last lesson went. How the lesson can be improved, what we liked about the lesson, what needs to improved, or added, the strengths the weaknesses - Planned the next lesson - Feedback and evaluation
21 28.03.2002 (THURS)	Classroom Observation	- Revision continued
22 28.03.2002 (THURS)	Discussion	- Decided to give an assessment on measurement even though it was not part of this research - Feedback and evaluation
23 31.03.2002 (SUN)	Classroom Observation	- Assessment on volume, area, and perimeter
24 31.03.2002 (SUN)	Interview	- Interviewed two teachers
25 01.04.2002 (MON)	Questionnaire	- Decided not to interview students but a questionnaire was given to all students
26 02.04.2002 (TUES)	Meeting	- Met all Grade 5 students' parents as per their request. They conveyed that they were very happy with the work done on measurement unit and that they felt that this resulted in their children being more motivated and enthusiastic to learn mathematics
27 04.04.2002 (THURS)	Discussion	- Teachers filled in the same questionnaire (post implementation) again - Teachers handed in the journals - Talked about what we all learned from the whole process. Shared ideas and evaluated the whole process

After one year, in February 2003, a further workshop was conducted outside this research project for teachers on another of the units of the grade 5 syllabus - geometry. The workshop was conducted both at the Male' school and the Island school, and mathematics teachers from all grades participated in these workshops. Each workshop session was approximately three hours. Summaries of workshop sessions are given in Tables 7d and 7e.

Table 7d: Workshop 1 – Male' School

FIRST HALF	- The idea behind an ethnomathematical approach to mathematics curriculum were discussed - Practised three steps necessary in developing a unit of work 1. Choose a small, well-defined topic from the syllabus. For example, properties of quadrilaterals 2. Write down the more general idea that this topic represents. For example, properties of regular shapes 3. Find the places in the Maldivian society where this idea is represented. For example, creating sewing patterns, and dividing out *halva*
SECOND HALF	- In groups, teachers worked on different topics related to geometry. The aim was to make an initial draft of a worksheet that could be used on a class trip, and to make a list of three classroom activities. - Feedback and evaluation of the workshop session

Table 7e: Workshop 2 – Island School

FIRST HALF	- The idea behind an ethnomathematical approach to mathematics curriculum were discussed - Practised three steps necessary in developing a unit of work 1. Choose a small, well-defined topic from the syllabus. For example, using a protractor to measure angles 2. Write down the more general idea that this topic represents. For example, measuring angles 3. Find the places in the Maldivian society where this idea is represented. For example, carpentry, and navigating between islands.
SECOND HALF	- In groups, teachers worked on different topics related to geometry. The aim was to make an initial draft of a worksheet that could be used on a class trip, and to make a list of three classroom activities. - Feedback and evaluation of the workshop session

As evident from the Tables 7b and 7c, information was sought from teacher workshops, interviews, questionnaires, classroom observations, informal discussions, teacher journals and a research journal, and other resources.

Workshops And Unit Development

At the Male' school, initial workshops were conducted to induct teachers in the research, to explain the purpose of doing this research, and to work with the teachers on the draft material. Most of the workshop sessions were held at the school in the evenings or during the weekends. The workshop sessions involved talking about mathematics, the teachers and myself visiting different sites to observe, ask questions and gather information, and then planning and writing an ethnomathematical unit of work. As can be seen in Table 7b, the workshop sessions 1-4 were held before the implementation and 5-7 during the implementation.

The unit planned (see framework for an ethnomathematical curriculum model – Chapter Six) and written at these workshops was taught by the teachers in their respective classes over three weeks, replacing the standard unit in the curriculum. The three-week unit included:

- Exploring, within the Maldivian culture, some activities that have mathematical aspects.
  This included students visiting different sites. These were a carpentry site, a construction site, a boat building shed, and the market to see, observe, gather information by asking questions, and experience these activities. The purpose was to understand the nature and origins of mathematics better, and to value and appreciate the existing knowledge.

- Participating in activities relating to perimeter, area and volume using objects familiar to students.
  This included doing activities in the classroom using cultural objects related to measurement. For example, using cultural artefacts such as vases, mats, seeds, coconut shells, and shells to do activities related to measurement. The purpose was for students to understand and experience the cultural activities from a mathematical point of view, thereby enabling them to make the connection between the real world and school mathematics.

- Participating in activities relating to perimeter, area and volume that are outside students' experiences or culture.
  This included doing activities in the classroom that were outside students' experiences or culture. For example: measuring different objects using body parts and standard units. The purpose was for students to connect their 'mathematics' to parallel ideas outside their culture. This is to enable them to appreciate that each

culture has its own way of mathematising, and that different strategies can be and have been invented whenever the need arose, and that standard measurements enable communication among cultures in a globalised world.

- Participating in activities to learn about and learn to use conventional mathematical systems, notations and techniques.
  This included doing activities in the classroom to learn about and learn to use conventional mathematical systems, notations, and techniques by discussing the need for accuracy and examining real world instances where mathematical accuracy and formulae are needed, for example, a doctor's prescription. The purpose was for students to understand the link between the real world and conventional school mathematics, and thereby facilitate the understanding of mathematical concepts.

The lesson plans and work sheets necessary for the implementation of the ethnomathematical unit were written collaboratively during the workshop sessions. All teachers followed the same pattern and sequence during the implementation.

Workshops were not conducted at the Island School. However, based on the unit of work written at Male' School, informal discussion sessions were held at the Island School, where lesson plans and work sheets necessary for the implementation were written. Thus, the teachers at this school followed the same pattern and sequence. Appendix C gives some examples of worksheets prepared during workshops and informal discussion sessions.

Interviews

Interviews were conducted with all teachers of both schools, and 16 students from the Male' School, after the implementation of the unit. Two students (a low ability and a high ability) of each of the seven classes from Male' School, were selected by the teachers from their respective classes, and two other students volunteered to be interviewed.

The confidentiality of all responses was stressed at the beginning of each interview session. All interviews were tape-recorded and permission was sought before using the tape recorder. All participants agreed. Participants were allowed to talk freely without constraint. Interview guides (see Appendix D and Appendix E) were used rather than a set of formalised questions. In teacher interviews questions were asked about the implementation process – advantages and disadvantages, what students got out of the process, and issues of ethnomathematics. In student interviews questions were asked about whether they noticed anything different in the way the measurement unit was taught, whether they recognised mathematics in the outside world, and whether they made links between school mathematics and real world.

All interviews were held at the school and all interviews were conducted in *Dhivehi* except the interviews with the three expatriate teachers at Male' School.

Questionnaires

Questionnaires were given to both the teachers and students, and open-ended questions were used in both questionnaires.

A questionnaire (Appendix F) examining teachers' perspectives on mathematics teaching and learning, issues of ethnomathematics, and the implementation of the ethnomathematical curriculum unit, was given to all teachers from both schools, before and after the implementation of the unit. The purpose of giving the same questionnaire pre- and post-implementation was for validity and reliability reasons, and to see whether teachers' thinking about learning and teaching of mathematics had changed as a result of the implementation. This questionnaire was written in English and some questions were translated to teachers when it was necessary.

A questionnaire, (Appendix G) based on the interview guidelines used with the student interviews at Male' School, was given to all students (total 60) of the Island School, after the implementation of the unit. This concerned the effects of ethnomathematical ideas on students' mathematical abilities and their dispositions towards mathematics. The questionnaire was written in *Dhivehi.*

Classroom Observation

One class from the Male' School and both the classes from the Island school were observed throughout the implementation. Some of the parameters used for observation were: the use of context during the lesson; the teacher helping and encouraging students to talk about mathematics in the classroom; the teacher and students' use of their own ethnomathematical experiences; and the teacher and students linking ethnomathematics to school mathematics. Notes were taken during classroom observation and my role in the classroom was as a colleague of the teacher involved. I did not stand in a formal role with the students except by association with the teacher.

Informal Discussions

Informal discussions were held with the teachers of the Island School every day during the data collection process, and the ethnomathematical unit was planned and written during the discussions held prior to the implementation. Informal discussions were also held with Male' School teachers most days and after each lesson with the teacher whose class I was observing. During these informal discussions, teachers discussed the strengths and weaknesses of the lesson, how to improve it, and shared their experiences and student feedback from the lesson. This process of collaboration was insightful for both myself, trained in the Western way as a secondary mathematics teacher doing research at primary level, and for the primary teachers trained in the Maldives as they came to understand the concept of an ethnomathematical curriculum.

Journals

All teachers from both the schools were invited to keep a journal and were given a guideline (Appendix H) for writing a journal. Keeping a journal was voluntary. Two teachers from the Island School kept journals and were happy to hand them in at the end of the data collection process.

I kept a personal research journal throughout the data collection process reflecting on the events, my experiences as a researcher, and feedback from parents and others. This process of reflection through a research journal was very useful during the data collection process and in data analysis to remind myself of how the events occurred, drawbacks, and what to resolve in future developments. Thus, I was learning from reflecting on the experiences.

Other Resources

Data from other resources included:

- Examples of student work selected by teachers and photocopied.
- Teacher resources produced in the workshops.
- Lesson plans of some teachers, chosen randomly.
- Feedback from parents, school administration and others, given informally during and after the implementation to both teachers and myself. The feedback was given during informal discussions and sometimes just voluntarily.
- Students' marks from the assessment of measurement, even though these assessments were not associated with the project. The teachers provided a record of the students' performance once they were assessed just after the implementation of the unit.

The findings, from the above-discussed ways information was sought during data collection, are reported in Chapters Eight, Nine, Ten and Eleven.

7.6 ETHICAL CONSIDERATIONS

The schools to be invited to take part in this project were decided in conjunction with the Ministry of Education, Maldives. The Principals of the primary schools were approached and the research was conducted with their consent. All Grade 5 teachers in the selected schools were invited to take part in this research. They were informed both orally (as it was more culturally acceptable) and in writing about the research process, the time, and amount of work involved. They were also informed that taking part in this research was voluntary and that they had the right to withdraw any time they wished. This issue of the right to withdraw from the project did not arise at all.

7.7 DIFFICULTIES

Even though being an insider researcher helped in obtaining the necessary consent from the Ministry of Education, schools, teachers, students, and parents, there were some minor difficulties that arose during the research, some of which were anticipated at the beginning of the research. These related to the timing, the sequence of the syllabus, the language, non-Maldivian teachers, traditionally trained teachers, access to external sites, student behaviour, and absenteeism.

Timing

In the Male' School, the Grade 5 classes were held both in the morning and afternoon sessions. Hence, workshops and discussion sessions had to be conducted in the evenings or during the weekends. However, the teachers were always willing to attend workshop sessions, even during the weekend, and were very supportive and enthusiastic. In addition, public holidays of more than a week coincided with the implementation process and therefore the process took longer than anticipated at the Male' School.

The problem of time did not arise at the Island School as both Grade 5 classes were held in the afternoon session and there were no public holidays or any other factors that prolonged the implementation process.

Sequence Of The Syllabus

In the Grade 5 syllabus, the measurement topic is the last topic to be taught for the year. However, since the research was conducted at the beginning of the academic year, the sequence was changed to teach the measurement topic early. This caused some minor problems as there were some prerequisites in the syllabus such as addition, subtraction, multiplication, and division that needed to be taught before the measurement topic. This did not cause too many problems as all students had been exposed to these arithmetic operations in the previous grades.

The Language

Even though the language of instruction is English at the Male' school, Maldivian teachers had to code switch frequently to describe the cultural practices, as these practices were best expressed in the language of the culture. This was not a problem at the Island school as the medium of instruction there is *Dhivehi*. However, the teachers were concerned that if they taught the whole unit in *Dhivehi*, students might not be able to do as well in the examinations, as all assessments are given in English. Hence, they preferred to code switch while teaching the ethnomathematical unit of work.

Additionally, because there were non-Maldivian teachers at the Male' school all the workshop sessions and group discussions had to be conducted in English. During implementation these teachers had some difficulty describing the cultural practices in English.

Non-Maldivian Teachers

Non-Maldivian teachers do not share the same cultural and social background as the Maldivians. Therefore, they needed to themselves see, experience, and understand the Maldivian mathematical practices before they could feel comfortable with an ethnomathematical curriculum. However, this did not seem to be much of a problem as these teachers have been living in the Maldives for some time and were very enthusiastic and willing to learn.

Traditionally Trained Teachers

Maldivian teachers who are trained formally are not used to being able to see and employ the links between school mathematics and mathematical practices in the culture, but this is necessary before they can accept an ethnomathematical approach to the curriculum. However, Maldivian teachers were also willing to try out new ideas and were very enthusiastic and motivated to try out a different approach.

Access To External Sites

There was no difficulty getting access to external sites. This is because teachers at both schools took the initiative to contact the people concerned, and to get the necessary permission. The people involved in doing the activities at the external sites were very welcoming and they were very willing to share their ideas and experiences.

Student Behaviour

Students responded very well to new teaching modes and this did not deteriorate into indiscipline. In fact, students who were not very enthusiastic previously in the mathematics class were very much motivated to try out new ways of doing mathematics.

Absenteeism

There were no problems in regard to absenteeism from either teachers or students. Both teachers and students were very cooperative with the new modes of teaching and learning mathematics.

7.8 DATA ANALYSIS

As mentioned before, the data for this study were obtained from workshops, interviews, questionnaires, informal discussions, journals, and participant observation.

The formal interviews were audio taped and all the data from questionnaires, interviews, journals and other resources were transcribed. Since the data were in both English and *Dhivehi*, the transcribing was done in English after translating the data from *Dhivehi*. Translations reflect my interpretations of what the participants had said.

After reading the transcribed data and with reference to the framework, research questions, and my assumptions, certain themes were identified from the data, and a tree diagram was drawn to categorise the information. Initially, the tree diagram had two main themes – evidence of successful implementation, and evidence of unsuccessful implementation. As the research is not only concerned about whether the implementation was successful or not, these themes did not prove useful to fully address the research questions. Hence, the tree diagram was changed so the main themes were the participants of the research – teachers, students, others, and myself. This again did not fulfil the aims and objectives of the research, nor enable the research questions to be answered appropriately. Finally, different themes and issues were identified from the data and a tree diagram was drawn (see Appendix I). The main themes included ethnomathematics issues, implementation issues, and students and teachers reactions to implementing an ethnomathematical curriculum unit. The qualitative data handling tool - NUD*IST (Quantitative Solutions and Research, 2002) was used to analyse all data. A statistical analysis was not done, as all data were qualitative. A summary of the coding system is given in Table 7f.

Table 7f: Participants Coding System

Type	Total Number	Code
Teacher Interviews - Male' School	7	MT1, MT2, ... MT7
Teacher Interviews - Island School	2	IT1, IT2
Pre-questionnaire – Male' School	7	PREMT1, PREMT2, ... PREMT7
Post-questionnaire – Male' School	7	POSTMT1, POSTMT2, ... POSTMT7
Pre-questionnaire – Island School	2	PREIT1, PREIT2
Post-questionnaire – Island School	2	POSTIT1, POSTIT2
Student Interviews - Male' school	16	MS1, MS2, MS3, ... MS16
Student Questionnaires - Island school	60	IS1, IS2, IS3, ... IS59, IS60
Teacher Journals	2	JIT1, JIT2
Personal Journal	1	PJ
Total	**106**	

The aim of this study is to investigate the implementation of an ethnomathematical unit of work in primary classrooms in the Maldives. In each of the following four chapters, the research results are presented, analysed, and discussed using relevant quotations and extracts from the data. More specifically: Chapter Eight considers the issues, considerations, and problems in preparing an ethnomathematical curriculum unit; the issues of implementing ethnomathematical curriculum unit are outlined in Chapter Nine; the outcomes of using an ethnomathematical curriculum unit in are described Chapter Ten; and the implications of introducing ethnomathematical ideas into the curriculum are discussed in Chapter Eleven.

8 ISSUES, CONSIDERATIONS, AND PROBLEMS IN PREPARING AN ETHNOMATHEMATICAL CURRICULUM UNIT

8.1 INTRODUCTION

This chapter begins the section in which the research results are presented, analysed and discussed. This chapter focuses on the issues, considerations, and problems in preparing an ethnomathematical curriculum unit for the Maldivian classrooms. The research questions addressed in this chapter are:

- *What are the issues and considerations in preparing an ethnomathematical curriculum unit?*
- *What are the problems in preparing the teachers in the Maldives for a curriculum unit based on ethnomathematical principles?*

The chapter is organised around the themes: beliefs about the nature of mathematics; style of teaching; valuing a 'Western' education system; language of instruction; resources; and professional development of teachers.

8.2 BELIEFS ABOUT THE NATURE OF MATHEMATICS

In the Maldives, teachers generally have an instrumentalist view of mathematics, that is, mathematics is perceived as a collection of facts, rules, algorithms, and skills to pursue some 'external end' (Ernest, 1991, 1994). They tend to believe in the strict following of a text and in the mastery of skills. Mathematics is seen as infallible and objective, and, as such, mathematical facts are taught in a context-free unchangeable manner, without any relevance to the real world students are experiencing. This was evident in teacher discussions about the teaching and learning of mathematics, during the initial workshop session.

> *We teach mathematics mostly using the textbook. We do bring objects into the classroom but practical lessons are very rare. We teach lots of mental arithmetic and give worksheets and assessment after each topic* [PJ].
>
> *In addition being attentive in class, memorising the formulae and lots of practice helps* [PJ].
>
> *Best way to learn mathematics is through lots of practice* [PJ].

Any link to real life appeared to be expressed as general statements or examples limited to superficial calculations. In the questionnaire when teachers were asked what would their response be if a student asked why they have to study mathematics at school, some of their comments were:

> *Life is full of calculations. Without mathematics we cannot calculate* [PREMT2].
>
> *As a subject they should learn mathematics as without mathematics we cannot do our daily routine* [PREMT3].
>
> *You need mathematics to do anything in real life. For example, if you want to buy something from the shop you need to know the amount the shopkeeper should charge you and whether or not he should give you change and the amount of change* [POSTIT2].

These comments confirm that teachers had an instrumentalist view of mathematics, and, as Boaler (1993) notes, this would have resulted in most students leaving school believing that mathematics has little relevance in the real world.

This is an important issue to be considered in preparing an ethnomathematical curriculum unit. From an ethnomathematical perspective, mathematics is a human construction (e.g., Barton, 1996a), and therefore, the sociocultural environment affects the way mathematics is taught and learned. In addition, the curriculum model adopted involves connecting school mathematics to the real world, for meaningful mathematics learning to take place (e.g., Zaslavsky, 1996). Therefore, the ethnomathematical unit had to be prepared in such a way that teachers and students saw and experienced mathematical ideas in community practices, and learnt about mathematics and its role in the society. The question, therefore, is whether teachers, who for many years have believed mathematics to be infallible and objective, would be able to successfully make the connection between school mathematics and life in the Maldivian society?

The data evidence showed some change, as there were indications that the teachers were able to see mathematics beyond something that is only done at school.

> *It was easier for them [students] to understand that mathematics is something, which is done everywhere, not only at school ... this was something I also haven't thought of before* [MT2].

> *This has made a lot of change in the children. Before I also used to believe that mathematics is what is given in the textbook, mastery of skills, and learning by formulae* [MT3].

> *Both students and us teachers learnt a lot about our culture ... also students were able to connect school mathematics to real world ... before it is thought that mathematics is something which is only done at school* [MT5].

On the one hand, this could have been just a temporary suspension of belief, as teachers knew it was a one-off intervention, and so they might have simply gone along with it. However, on the other hand, there was no evidence that any teacher was resistant to this different philosophy of mathematics. In fact, they seemed quite prepared to take on board a new perspective of mathematics.

> *All maths teachers should get together and discuss ideas. It'd be very good if we can induct other teachers to teach this way as well ... we could have some type of coordination or communication system where we can discuss and share ideas and include cultural aspects in our teaching. Otherwise our students will leave school without knowing how to apply what they learnt in school to the different aspects of their life* [IT1].

It is known that belief change takes time (e.g., Britt, Irwin, Ellis, & Ritchie, 1993). Nevertheless, it was interesting to talk to these teachers one year after the implementation of the ethnomathematical unit. In 2003, a further workshop was conducted outside this research project for teachers on another of the units of the grade 5 syllabus - geometry. During the workshop teachers were able to identify mathematical practices in the Maldivian culture related to a new topic, geometry, were very much involved in the study, and expressed a willingness to do more in the future.

It is concluded, therefore, that this intervention represented a first step for these Maldivian teachers to conceptualise a different belief or philosophy of mathematics. Furthermore there is sufficient evidence to suggest that, given similar conditions, continued development would occur.

8.3 STYLE OF TEACHING

In the Maldives, examinations shape what is taught. There is a tendency to focus on preparation for assessments and examinations, which usually leads to an emphasis on covering content material given in the syllabus irrespective of students' learning needs. Consequently, teachers opt for providing the students with the necessary skills they need by working out problems similar to those that are in the textbooks and that are likely to appear in the assessments. The mode of pedagogy in Maldivian classrooms relies heavily on the 'transmission of knowledge' model. The use of the 'chalk-and-talk' method is very common, and there is little inclination to experiment with either mathematical ideas or pedagogical techniques such as cooperative learning environments where students are encouraged to use problem solving, reasoning, and communicating. Apart from my own experience of Maldivian classrooms, the teacher interviews provided confirming evidence of these behaviours and evidence that teachers were aware of them.

> *I have always been taking classes inside the classroom and wherever I taught I had the classroom experience. Only for science subjects we usually go for field tips* [MT2].
>
> *Even though I did learn different methods of teaching when we did teacher training, once at school, it all changed back to the traditional ways* [MT7].
>
> *When I started my teaching career I tried to teach in such a way that students would be more involved in learning. For example, by doing group activities. But after a while due to time constraints and no one being there to guide and give ideas, my teaching also shifted to more blackboard-teaching* [IT1].

The ethnomathematical model required that the learning of mathematics should involve experiencing cultural practices as they occur, and exploring these practices in a controlled classroom environment (e.g., D'Ambrosio, 2001). Thus, the implementation of the unit required a change in teaching style, and classroom discourse. Furthermore, when cultural practices are used in the classroom, it is likely that some students (or their parents) will have more knowledge about the object of classroom study than the teacher, especially teachers who do not share the same social and cultural background as their students. This means a shift in some power relations is likely. As some of the non-Maldivian teachers acknowledged:

> *I have a student in my class who always get more information about the fieldwork sites we have been to and the work that people do there, from his parents, and share this information in class. It is a good learning experience for me also as I learnt things about the culture that I have not known before* [PJ].
>
> *The whole process is a new item for us. Especially because I am an expatriate teacher I am not used to these cultural practices even though I have heard about these things* [MT4].

The ethnomathematical model highlights the importance of mathematical explorations, group work, and communication in the mathematics classroom (e.g., Gerdes, 1994). This is because students need the opportunity to experiment and reason out mathematical problems, and need to be encouraged to talk about mathematics and share their ideas in a group. This is aimed at students having an understanding of mathematics, and a better grasp of the relevance of mathematics to different aspects of their life.

Teachers did show some conditional willingness for mathematical explorations and group work. This was apparent from the responses that they gave when asked what their response would be if students protest after a group project that they would work better individually.

> *I will encourage them to work in group explaining that more students together get more ideas* [PREMT6].

> *When you work in groups the weaker students can learn from the brighter ones. Also the brighter students can remember the concepts well when they explain it to someone* [PREIT1].

> *If the student cannot work in a group then I will give the student work to do individually and the rest of the students will work in groups* [PREIT2].

Further, during the implementation of the unit, teachers adopted exploratory and group work approaches. Teachers did not express problems with this approach, apart from one teacher when talking about one instance.

> *The class was quite noisy today. I think that was because all groups gathered around the same object, sometimes, and they were quite excited and some groups wanted to measure before the other group. If I conduct a lesson like this again, I will give different objects to different groups at different corners of the class. This way all students won't gather around the same object and the lesson would be more successful than today* [JIT2].

In fact, teachers observed that students responded well to new teaching modes, and that this did not deteriorate into indiscipline.

> *Students were very much involved in learning when taught this way ... I also found that students didn't have time to idle so we didn't have any discipline problems also ... they were so motivated and interested ... after we started doing the text book problems most of students completed the exercises in advance* [IT1].

> *Students were very much motivated during the lesson after the fieldwork and they all took part in the discussions and were very much involved. I feel that the reason for this is that this was something very different from*

> *what they have been doing, as they never had a chance to go out and visit sites and gather information during a mathematics lesson ... in addition, I felt that students were so motivated because they had a chance to express their views and ideas* [JIT2].

> *They [students] found the lessons very interesting as the lessons were very practical and they had a chance to do the investigations themselves. They really liked it* [MT6].

Moreover, after the implementation of the unit teachers expressed the view that they would try to teach other mathematics topics the way the ethnomathematical unit was taught, as they felt students seemed to enjoy learning mathematics more, when taught this way.

> *I will try and teach other mathematics topics this way, not only in the Grade 5 classes but in other grade classes as well ... students are very much involved in learning when taught this way ... they were so motivated and interested, they were just waiting for the mathematics lessons to do the investigations* [IT1].

> *I will try to teach other mathematics topics this way ... I feel that when mathematics is taught this way, it is very beneficial to students ... they were very much interested and involved in doing the activities* [MT1].

It is concluded that the style of teaching required by an ethnomathematical approach did not seem to be a problem. This could be because teachers did as they were told, or because teachers saw it as a one-off temporary thing they could handle, or because teachers never realised the extent of the change being suggested. Nevertheless, there is sufficient evidence to conclude that the teachers were both willing to contemplate the teaching styles necessary, were capable of implementing them, and remained favourably disposed to these styles.

8.4 VALUING A WESTERN EDUCATION SYSTEM

In the Maldives, British syllabuses and assessments are followed at secondary schools, and, as a result a Western education system is valued. This was evident from the teachers' responses, both before and after the implementation, when asked directly whether it is generally believed that the Western education system is better than the Maldivian education system.

> *I agree because Western people are more educated than the Maldivians so they know better than us* [PREMT1].

> *I agree because Western system is more advanced and believed to have a better standard* [PREMT2].

> *To do the Ordinary Level Examination, we have to follow Western System because our curriculum is based on it* [POSTMT5].

> *I agree. Because Maldivian education system is not developed or facilitated, equipped with teaching aids and other resources upto the Western education system level* [POSTMT6].

Teachers feared that parents wanted perceived Western-style educational outcomes and visible work.

> *...they [parents] will only be worried about whether or not the problems in the textbook are completed* [MT7].

Nevertheless, teachers acknowledged the importance of including cultural aspects in the current curriculum.

> *It would be easier to follow a Western curriculum using their methods and ways. But we need to teach our students our cultural values as well. So, it would be good if we can include cultural aspects in the curriculum* [IT1].

> *If we can change our curriculum in such a way that includes our cultural values and beliefs I think it will be very good* [MT6].

> *I think our students will benefit more if we teach them mathematics using real examples that are familiar to them. Then only they will be interested in choosing careers that are culture-oriented* [POSTIT2].

There was evidence that teachers did take up the opportunity provided by the ethnomathematical unit to carry through on these attitudes, and they brought up new cultural ideas during the workshops and classroom discussions. For instance, teachers discussed mathematical activities in the Maldivian culture such as lacquer work, handicraft, and fishing during the workshop sessions, and activities such as sewing and cooking were discussed in the classroom [PJ].

The strong valuing of Maldivian culture and national pride indicated a willingness to look beyond the Western examples, and teachers saw this method as a way of retaining the culture (see 11.2 for further discussion).

> *It is good for the students to know the traditional things about measurement. Then only they will remember. They will remember the culture throughout their lifetime ... Otherwise these cultural things may fade off. So when it is included in the syllabus students will be able to retain the cultural practices* [MT4].

> *It is good to include cultural aspects in mathematics. Students will be aware of their cultural practices ...otherwise it will fade away* [IT1].

> *Students will learn more about their culture. And because they have observed the cultural activities and investigated these activities for themselves, they were very much interested in learning mathematics and also facilitated their understanding of mathematical concepts* [MT6].

Thus, teachers seemed to be willing to move beyond Western paradigms, as they seem to view an ethnomathematical approach as something that enhances mathematics learning, and as a means to preserve the culture. However, it is possible that this motivation is due to the fact that teachers saw ethnomathematics as 'another' Western paradigm.

It is concluded from this evidence that, although there is strong and persistent valuing of Western educational paradigms, these will not necessarily present a barrier to an ethnomathematical curriculum implementation because a role for culture within education in general is recognised.

8.5 LANGUAGE OF INSTRUCTION

Considering that the medium of instruction at the Male' School is English, and the Island School is *Dhivehi*, and the public examinations are in English, the issue of what would be the most effective language to teach mathematics, was raised in the study.

> *I think it is easier for students to learn mathematics when taught in Dhivehi. From my experience students grasp the concepts better when taught in Dhivehi ... I found that in the exam, even though the questions are given in English, those who are used to learning mathematics in Dhivehi do much better* [IT1].

> *The purpose of teaching mathematics is to teach in such a way that the students understand the mathematical concepts. So even if we teach in English or Dhivehi it doesn't matter as long as the students understand ... it is a strict rule at school that we teach in English. So we don't have a choice. But I think as long as the students understand, the language doesn't matter* [MT5].

> *Since their mother tongue is Dhivehi, it would be easier for students to understand if taught in Dhivehi* [MT7].

> *I think teaching in Dhivehi would be more appropriate. For example if we are teaching how to compare fractions and if the students are unable to understand in English there is no use. For me personally, it is easier to teach in Dhivehi* [IT2].

Even though most comments were in favour of using the indigenous language in mathematics teaching, there were some who felt that English should be used as the medium of instruction since the students are being prepared to sit for examinations in English.

> *Because we are preparing students for exams in English, I think it is better to teach in English* [MT3].

> *As the medium of instruction is English and as we are preparing students to sit for examinations in English, it is better to teach in English as the students need to know the mathematical terms in English* [MT4].

> *Even though it is easier for students to grasp the mathematical concepts when taught in Dhivehi, they can do well in the Ordinary Level exam if they learn mathematics in English. For example, if we teach measurement*

totally in Dhivehi, then it would be very difficult for a student to answer a measurement question written in English [IT1].

Nonetheless teachers do code switch whenever necessary in normal mathematics classrooms. When asked in what circumstances they change the language of instruction, some of their responses were:

When teaching students of low ability and if the student finds it difficult to grasp the concept [PREMT1].

When it is difficult for the students to understand [PREMT7].

When introducing certain topics where we have to use lots of new mathematical terms [POSTMT6].

This raises the question of how the ethnomathematical unit should be taught, given that cultural practices are likely to be better described in the indigenous language?

It is easier to describe cultural practices in Dhivehi [POSTMT5].

When we teach the cultural and traditional mathematical practices we need Dhivehi words to explain [MT2].

When we relate culture and mathematics it is easier to teach in Dhivehi [POSTMT7].

These comments indicate that teachers were in favour of using the indigenous language to teach the cultural aspects at least of the ethnomathematical unit. In the event, there was more *Dhivehi* spoken during the implementation of the unit than is normal in the mathematics lessons [PJ]. This was especially so at the Island School as the ethnomathematical unit was mostly taught in *Dhivehi*, and all the work sheets were written in *Dhivehi* - even though the medium of instruction is *Dhivehi*, usually the worksheets are in English as the text books are written in English and students sit for examinations in English [PJ]. In addition, students from both schools communicated in *Dhivehi* with people on field trips, and even in the classroom student discussions were mostly in *Dhivehi* at Male' School and all in *Dhivehi* at the Island School.

However, even though teachers did not express any problems, the use of *Dhivehi* required by an ethnomathematical curriculum is likely to be problematic for non-Maldivian teachers in any long-term intervention.

> *As I am an expatriate I can only use English. Students will be able to understand more clearly in their mother tongue. It is quite natural for everyone. They mostly speak in Dhivehi, especially when the measurement topic was taught - when they were discussing among themselves* [MT4].

> *I can see that students find it easier to discuss in Dhivehi among them ... when measurement topic was taught, I was able to learn some of the Dhivehi terms used in cultural practices from the students* [MT3].

This would be an on-going problem in the Maldives, as most of our teachers, especially at the secondary school are non-Maldivians.

It is concluded that teachers recognise that *Dhivehi* instruction and discussion between students is likely to be best for mathematical understanding and for linking between cultural activities and mathematics. Despite a perceived need for English for assessment purpose, teachers were willing to use or allow *Dhivehi* where appropriate.

8.6 RESOURCES

As international syllabuses are followed in the Maldives, international resources are used in teaching and learning of mathematics. However, for an ethnomathematical curriculum, no international resources are possible since it is about Maldivian culture for Maldivians. Therefore, resources had to be produced collaboratively by the teachers during the workshops and discussion sessions. Producing resources for the measurement unit did not seem to be a problem, as there are several cultural practices and artefacts that can be used in teaching this topic, the people who are involved in cultural practices were very willing to share their ideas and experiences, and teachers were enthusiastic about creating these resources. However, as some teachers pointed out:

> *The problem is time constraints ... it is not easy to get cultural artefacts to do the investigations in class* [MT1]

> *The problem is time ... we have to make sure that all the contents in the syllabus are covered and that students do all the problems given in the textbook* [MT7].

The workshops provided the necessary opportunity and motivated teachers to spend some of their time to produce resources. It is concluded, therefore, that producing resources might not be viable long-term as teachers are pressed for time to cover the contents of the syllabus. For a larger implementation, time and money to produce resources would be necessary. The question remains as to whether there is enough variety of cultural material for all the units of the syllabus.

8.7 PROFESSIONAL DEVELOPMENT OF TEACHERS

Professional development is not a usual practice in the Maldives, and opportunities are limited for teachers. As a result, even though teachers were not generally critical of the existing curriculum, they were not used to having any flexibility to use their own creativity.

> *There are lots of disadvantages in the current curriculum we are following. We have to strictly follow the sequence and the textbook. We also have to make sure that all the problems in the textbook are done. We don't have any flexibility to change* [MT5].

Consequently, teachers were willing to look at something new and were excited about trying a new approach. They liked the opportunity to have professional development and the experience of working together on curriculum matters in general.

> *I am also very happy with the way we had discussion sessions everyday. Planning lessons for the next day, sharing ideas and planning the lessons in such a way that students will be motivated to learn mathematics. Before I enter the class I knew what I would be doing and all the worksheets and activities are planned in advance. So I was very satisfied* [IT1].

Though teachers did not have much warning about their participation in the research, there was no resistance, they participated fully and willingly, and subsequently appeared to appreciate the ethnomathematical approach.

> *I learnt something new, which I never had. You know like I didn't even know what ethnomathematics is. It was good* [MT2].

> *It was a very good experience that we have created and we have been given a good opportunity to learn. In my case I learnt the traditional things of the culture as well* [MT4].

> *This method of teaching is something very new. However, in light of what I have learnt and from the experiences and insights I've gained ... I will try and do my level best to teach mathematics by relating to real world and by stressing the importance of studying mathematics* [IT2].

Initially the teachers were concerned that they might not have the capability to work up to the expectations of the research, despite being assured that the curriculum innovation would be a collaborative effort where we would be learning from each other's experiences and insights. The teachers response was that they wanted to learn new things and try out different teaching strategies and that they would support me in any way that they can [PJ]. Teachers' willingness and enthusiasm was expected, as community spirit and participation are valued in the Maldivian culture. In addition, it is not common for teachers to show resistance as it is perceived as being disrespectful to authority. Moreover, it is also possible that teachers may have felt honoured to take part in the research, saw it as something that gave credit to their school, and felt a sense of ownership as they were involved in the preparation of the ethnomathematical unit.

Even though teachers were willing to try out new ideas, they needed the guidance in both designing an ethnomathematical unit of work and in putting it into practice.

> *... we will need guidance. If someone can give us some guidance then we can change our teaching methods this way and I think it will be very effective as well. I don't know whether I would be able to follow the method without any guidance* [MT6].

It is concluded from this evidence that teachers are willing to be involved in, but unpractised, at professional development that involves their participation in curriculum innovation. Thus, further implementation of an ethnomathematical curriculum would need to be initiated, guided, and supported on an on-going basis. Such professional development could be expected to be embraced by teachers.

8.8 DISCUSSION OF PREPARATION ISSUES

The willingness of teachers to include cultural material in a mathematics curriculum can be linked to the political aims of ethnomathematics as expressed by D'Ambrosio (1994a, 1994b) and Knijnik (1993). However, the Maldives, being a homogeneous society, is different from indigenous groups working under colonial oppression, and cultural pride is regarded as normal and of value throughout the society. Thus, it is not necessary to fight a cultural-political battle as part of a curriculum implementation.

From the teachers' comments it can be concluded that one reason for teachers' enthusiasm and willingness to consider the teaching styles required by an ethnomathematical approach was the students' being more motivated and more interested in learning mathematics. This can be linked to the importance of giving students opportunity for mathematical explorations and communication by relating to real-world for meaningful mathematics learning, as expressed by, for example, Gerdes (1994) and Zaslavsky (1991).

The inclination of teachers to accept a different belief about mathematics, and the willingness of teachers to embrace the professional development programme, was predicted to occur when professional development created an environment that encourages teachers to question their existing beliefs, self-reflect, and explore classroom activities (Begg, 1994; Britt et al., 1993). Even though Maldivian teachers are not used to self reflection and mathematical explorations, given the opportunity to take a significant part in curriculum change, they were enthusiastic about trying a different approach and were willing to do more. They also proved themselves capable of casting a critical eye on what was happening.

In preparing the ethnomathematical unit of work, teachers need to apply mathematical thinking to their cultural experiences. This is present in the theoretical model as an aspect of the left-hand arrow of 'Mathematical Thinking' (see Chapter Six). Although this was something new for the teachers, there is evidence that it occurred to a limited degree.

8.9 SUMMARY

Even though belief change takes time, there is sufficient evidence to suggest that the preparation and implementation of the ethnomathematical unit provided a first step for Maldivian teachers to conceptualise a different belief about mathematics. Given similar conditions, continued development would occur, as teachers were willing to contemplate the teaching styles necessary and remained favourably disposed to these styles. Further, despite the valuing of Western education in general, and the need for English for assessment purposes, teachers were willing to use or to let students use *Dhivehi* where appropriate, and they valued and recognised the role of culture within education. Teachers did observe the differences in the ethnomathematical approach and perceived them in terms of improved learning experiences.

However, producing resources necessary for an ethnomathematical curriculum might be costly long-term as time and money are necessary, and there might not be enough variety of cultural material for all the units in the syllabus. In addition, even though teachers are willing, they are unpractised at professional development that involves curriculum innovation. Therefore, they need to be initiated, guided, and supported on an on-going basis.

Nevertheless, the issues that were identified as likely to arise in preparing an ethnomathematical unit for the Maldivian classrooms did not seem to be much of a problem as teachers were very willing and enthusiastic. Therefore, it is concluded from the evidence of preparing for the implementation of the unit in this study that there would be no major problems preparing any further implementation. Indeed, such preparation would be likely to be welcomed by teachers provided that suitable leadership was provided.

9 ISSUES IN IMPLEMENTING AN ETHNOMATHEMATICAL CURRICULUM UNIT

9.1 INTRODUCTION

This chapter presents, analyses, and discusses the research results focussing on the issues of implementing an ethnomathematical curriculum unit in the primary classrooms of the Maldives. The research questions addressed in this chapter are:

- *What issues arise in the implementation of an ethnomathematical unit?*
  - *- What are the practical limitations?*
  - *- What are the issues that need to be resolved in future developments?*

This chapter is organised around the following themes arising from the analysis of the data: the idea of ethnomathematics; the advantages and difficulties of an ethnomathematical curriculum; and issues that need to be resolved in future developments.

9.2 THE IDEA OF ETHNOMATHEMATICS

One of the main issues in implementing an ethnomathematical curriculum is whether or not students and teachers 'get' the idea of ethnomathematics - as described in the five steps of the instructional sequence of the model (see Chapter Six, page 84), and the extent to which the ethnomathematical approach to mathematics has been fully internalised by teachers and students.

The data evidence showed that Steps 1 and 2 in the instructional sequence were achieved. Teachers and students became aware of mathematical practices in their culture and were able to make the link between school mathematics and cultural practices. Responses from the pre-questionnaire, for a question that asked whether or not it is appropriate to discuss weaving in a mathematics class, indicated that some teachers perceived that it was not very appropriate, or that it was immaterial, to include cultural aspects in mathematics, as they felt that there was no link between the two.

> *It is not appropriate to discuss weaving in the mathematics class, because I think there are no topics related to weaving* [PREIT2].

> *It is not appropriate to discuss weaving. I don't see any relation between weaving and mathematics* [PREIT1].

> *Since measurements are used in weaving, there is no harm in discussing weaving in the mathematics class* [PREMT4].

However, responses from the post-questionnaire, for the same question indicated that teachers had changed their opinion:

> *Mathematics is definitely needed in weaving. For example, in weaving a mat, the width and length of the strands, their proportion, the amount needed should be calculated* [POSTMT4].

> *I think it is appropriate to discuss weaving in a mathematics class. That is because mathematics is used / involved in weaving* [POSTIT1].

> *It is appropriate to discuss weaving in mathematics because it involves a lot of mathematics – area, perimeter, measurement* [POSTMT6].

> *Yes. Because when we discuss weaving, we will be talking about how to take measurements, how to find out the area or perimeter etc* [POSTMT7].

In addition, similar responses were received for a question that asked about the relevance of using real world examples in the mathematics class.

> *At the primary level mathematics can be taught by examples from real world but as you go higher it is difficult* [PREMT2].

> *Certain topics can be related to real world – for example, while teaching money, profit, loss etc* [PREMT4].
>
> *If we relate mathematics to the real world, students will be able to understand that we use mathematics in everyday life. I have experienced this after the workshop – students also accepted that mathematics is used in real life* [POSTMT5].
>
> *If we use examples from real world or culture, students can grasp mathematical concepts easier, and faster* [POSTMT6].
>
> *From my experiences I can say that students were more motivated and interested in learning mathematics when mathematics was taught by linking to real world examples. Previously I did not use this method. I can see the difference now* [POSTIT2].

These comments show that, when presented to them, teachers were able to make the link between school mathematics and ethnomathematics, and to appreciate the importance and relevance of connecting school mathematics to the real world at all levels.

These ideas were successfully communicated to many students. They made a connection between school mathematics and life in the Maldivian society.

> *At the school we learn about measurement and even outside people use measurement to do different things. For example, at the carpentry they find the area of a sheet of wood* [MS2].
>
> *In the real world area is used in many places. For example, in offices, even in houses and buildings. Constructors also find area and perimeter when they build houses* [MS5].
>
> *Perimeter and area are used by carpenters to make a table, or a bed. Mathematics is also used at home to measure rice and things, and at the shops* [IS19].
>
> *Mathematics is used in fishing, in building and construction, carpentries, and shops* [IS55].

This was confirmed by evidence of new ideas from students of examples that were not used in the class.

> *Mathematics is used to do electric wiring at houses. Even when buying the wire as it is bought after taking the necessary measurements* [IS53].

> *Mathematics is used outside school. For example, when putting sand (kashiveli) on the compound, the amount of sand bags needed has to be calculated* [MS6].

> *Tailors use measurement to make dresses* [IS36].

However, there were instances where some students seemed not to fully internalise the latter steps of the instructional sequence. They were not able to make the connection between what they learnt during the field trips and the conventional mathematical problems they did on measurement in class. This was apparent from their responses when they were asked whether they noticed anything different in the way measurement topic was taught.

> *This time it was taught very well. Even other times teachers do teach well but they don't explain well* [MS5].

> *We had to do multiplication and division, which we didn't do in other topics* [IS6].

> *The difference is we were taken out and the topic was explained in more detail* [IS56].

These comments could also be attributed to the possibility that the question was not comprehended properly by the students because of the way it was structured.

Nevertheless, there was evidence from some students that they had appreciated Steps 4 and 5 of the instructional sequence. Being aware of the link between school mathematics and real world did lead students to become aware of and recognise mathematics in the society, and to understand the nature of mathematics better. Some teachers (see 8.2) and most of the students volunteered the information that they had not previously been aware that mathematics exists outside school and in their culture.

> *Before the measurement topic was taught, I did not think of mathematics outside school. Now I see mathematics everywhere. On the street....Mum also use measurement in cooking – to measure the rice. At the fish market to sell the fish* [MS1].
>
> *I see mathematics at carpentries, workshops, offices, and schools. At home when dad makes chairs and when mum cleans the rice and measure the rice for cooking* [MS2].
>
> *Boat building, construction sites, and when mum measures rice she uses mathematics* [IS60].

The field trips and making connections between school mathematics and real world activities in the classroom during their investigations on perimeter, area, and volume was integrated into their view of mathematics.

> *People use area and perimeter when building houses and tiling the floor. Volume is used when dad build water tanks ... when we grow up we have to know how to measure, so it is important to learn these things ... without mathematics we cannot do anything in life* [MS4].

The students' realisation that they would be using mathematics outside school led to the unexpected finding that they as well as the teachers seemed to be viewing mathematics as a human activity.

> *I see mathematics outside school especially the mathematics in the activities that people do* [MS10].
>
> *Now I think about mathematics when I see people doing different activities* [MS11].
>
> *When students go out and experience different activities for themselves and ask questions ... they also learnt about how people use mathematics in doing different activities in the society* [MT2].
>
> *... before I never thought about other people using mathematics in their work* [MS12].

This final level of an 'active' view of mathematics is an important criterion for success for an ethnomathematical curriculum, in the model used in this study.

Furthermore, for the teachers, a metacognitive stage was achieved in which awareness of mathematics in outside school activities prompted the realisation for some teachers that their traditional method of teaching had led to students thinking that school mathematics was not useful in the outside world.

> *I will include activities related to culture when teaching mathematics. When taught the way we have been teaching, students don't know how to use mathematics they learn at school when doing real life activities. They can't make the connection* [IT1].

> *I will try to include activities related to culture when teaching mathematics, so that students would be able to see the link between mathematics and real life ... also they [students] will realise the importance of studying mathematics* [IT2].

> *When we relate mathematics to real life, now they [students] know maths is everywhere in their surrounding and that they need maths for their daily life. Now whatever they do they need maths and they use maths* [MT4].

> *I feel that if an ethnomathematical curriculum can be implemented it would be very beneficial for students. Now, what happens is students come to class write what's written on the board ... they think of what they learnt at school and what they do in their day to day life as two different things without any connection ... I feel that if we relate other subjects also to real life situations it would be easier for students to understand and relate to real life* [MT7].

Another way to interpret this data is to see it as evidence that professional development where teachers assume some control of curriculum issues leads to them developing critical thinking in respect of their practice. This is exactly what is suggested by the literature on professional development (see Chapter Five, pages 69-71).

The experience of one unit provided evidence from which it is concluded that not only the content of the unit, but also the wider aims of an ethnomathematical curriculum, can be approached by teachers and students. This evidence could have been obtained by 'obedient' teachers just repeating the things they heard in the preparatory workshops, or likewise students replicating what their teachers have said. There were no instances, from my observations, where teachers repeated anything that I said verbatim. They were genuinely using original ideas, and not just reproducing particular aspects of the curriculum unit. Additionally, as discussed before, students provided new ideas. Furthermore, teachers did discuss and question the ethnomathematical curriculum model during the initial workshop session. My own subjective feeling was that teachers did get the idea of ethnomathematics and what an ethnomathematical curriculum is about, even though I do not know whether I was able to convey fully to teachers the theory behind an ethnomathematical approach. It is not known whether teachers and students would further integrate the idea of ethnomathematics, or to make the link between school mathematics and cultural practices, for topics other than measurement.

9.3 ADVANTAGES

The main advantage of the successful implementation of an ethnomathematical approach is that students and teachers enhance their learning through the integration of a cultural perspective, as noted in the previous section. In addition, teachers themselves identified positive practical advantages. All teachers recorded some advantages for one or more of the following reasons: that mathematics was more enjoyable and interesting for students; that students were able to understand that mathematics is used in the real world and their everyday life; that mathematical concepts and formulae were understood more easily; and that cultural aspects are heightened and future generations will also know how their ancestors practices relate to mathematics. Evidence of this is present in the quotes cited in Section 9.2 and as follows:

> *It is more advantageous to teach this way than the way we have been teaching. It was easier for students to understand. They also learnt about the traditional ways of measurement and the way it is done. So this helped students thinking processes as well and it was easier for students to understand the mathematical applications* [MT1].

> *It would be very effective if we can teach all maths topics this way* [MT7].

> *[When] we took the children on the field trip ... they also enjoyed everything they saw even at building and construction. They won't get a chance to see all these things ... in the city they won't go to these places. So in the school when they get the chances it is good for them and the other thing is when they go and ask questions it is a thrill for them and they learn more rather than when we say. They may sometimes not get the drill in their memory. When they go, they ask the questions and they find the answers they remember those things* [MT4].

Another advantage noted by some of the teachers and some of the students were that the ethnomathematical unit made 'weaker' students more motivated and that it was a great encouragement for these students:

> *I would also like to note that it was a great encouragement for the weaker students. They were very much motivated and interested in learning when the measurement topic was taught. I think the reason for this was because the topic started with something students are familiar with and can connect to* [IT1].

> *It was very good for weaker students. They were able to learn a lot* [MS7].

> *Even students who were not interested in mathematics lessons previously were also very much involved and interested in doing the activities* [JIT2].

Thus, the ethnomathematical unit of work provided a good experience, enhanced existing classroom practices, and opened up possibilities for the teachers.

Although teachers need ongoing support and guidance, an advantage of this implementation is that teachers were awakened to new possibilities in their practice. This was evident from teachers' responses when asked what they would like to change if they had a chance to change the current curriculum.

> *Teaching with lots of field trips and aids. Do lot of project work* [POSTMT2].

> *More field trips and more projects* [POSTMT7].

> *I will include activities related to our culture and lots of fieldwork and practical activities. This is because the present curriculum doesn't allow*

> *students to link mathematics with the real world. Hence, students don't know how to use the mathematics they learn at school when doing real life activities* [POSTIT1].

As Begg (1994) observes, teacher motivation and willingness can help bring adaptive changes, and they need assistance to acquire methods and tactics to promote reflection on their classroom experimentation.

A further advantage of the ethnomathematical approach was that it provided opportunities for closer community and school relations, bringing community involvement into the curriculum as well as into the surface features of school life. This was evident from the willingness of the people involved in cultural practices to share their experiences and ideas. This might not be able to be sustained for all the units of the syllabus, as people might not be so willing if they have to do it continuously. A danger of community involvement may be that tensions could emerge due to uncertainty of their role as found by Meaney (2001) as she traced attempts to involve community members formally into the detail of curriculum policy and planning. Another danger could be the trivialising or decontextualising of cultural knowledge when it is brought into the classroom, as indicated in Lipka's (1994) study. However, the opportunity arises for bringing community experts into the school environment to ensure the significance of the cultural practices becomes evident.

9.4 DIFFICULTIES

Many teachers identified sequence of the syllabus and the time available as the two main difficulties of the implementation process.

> *It was good. We need more time only* [MT3].

> *The method was very good ... we have to follow a scheme strictly and there won't be time to try this method if we follow the scheme strictly* [MT5].

I am very happy with the way measurement unit was planned. But, I think it would have been better we can include learning multiplication tables as part of the unit. As we haven't taught multiplication and division this year yet, some students had difficulty doing these operations when they were finding the area of a triangle [IT1].

I feel if we had more time to do the exercises in the workbook, it would have been very helpful [MT1].

It was a bit hard to explain division, as they have not done addition, subtraction part this year yet. So, it was difficult for students to do the multiplication, division part of area and volume. If we had followed the sequence of the syllabus and taught the measurement topic this way it would have been much more effective [MT6].

The problem is time and we have to follow the curriculum make sure that students do all the problems given in the textbook ... the only disadvantage is time. It is very time consuming [MT7].

Other difficulties or limitations identified by individual teachers included: not being sure whether the implementation was conducted according to the research plan;

I'm not sure whether I conducted the lessons the way you actually wanted ... I think it would have been very helpful if you demonstrated a lesson in class. This is something very new to us and the teaching methods we used are also very new. So I feel may be if you demonstrated a lesson it would have been very helpful to us [MT1].

Not having enough facilities;

It was Ok. But I think it is not possible ... here we don't have many facilities to take the children out. So, more facilities are needed ... have a school van or something to take them out, then it will work out [MT2].

Not enough fieldwork;

We could have done some more fieldwork [MT3].

And practicality of taking students to some of the fieldwork sites.

I think taking 10 year olds to a construction site wasn't such a good idea. They found it hard to understand levelling the walls and stuff [MT6].

No students commented on any of these difficulties.

The main disadvantage or difficulty of the implementation is that teachers were not fully self-motivated and needed to be led:

> *... We will need guidance. If someone can give us some guidance we can change our teaching methods this way and I think it will be very effective as well. I don't know whether I would be able to follow the method without any guidance* [MT6].

This is evidence that teachers do not seem to have the confidence or self-motivation to continue using this type of an approach to curriculum. Nevertheless, any curriculum change requires an input of resources and support, and an ethnomathematical one is no exception.

Thus, it can be concluded that the advantages of this implementation were more deep-seated than the disadvantages. The latter are all practical matters that can be overcome provided sufficient planning and resources are committed to further ethnomathematical development. The former indicate that such development may have long-term conceptual implications for mathematics education in the Maldives.

9.5 ISSUES THAT NEED TO BE RESOLVED IN FUTURE DEVELOPMENTS

As evident from previous discussions, even though teachers are willing to try out new ideas, they need guidance in both designing an ethnomathematical unit of work and putting it into practice. As mentioned in Chapter Eight, as a step towards giving support and guidance to teachers, a further workshop on geometry was conducted for teachers. Here, we met teachers who were involved in the study and who were willing to do more, but did not exhibit the confidence to initiate further activity. It is concluded that researchers and curriculum developers need to be committed over a long time period for successful ethnomathematical change. This confirms previous work on professional development that discusses the long time period needed for effective change, for example Begg (1993).

Maldivian parents expect visible 'formal work' from their children. This needs to be recognised in future curriculum developments so that parents are comfortable with the new initiatives. On this occasion there were no negative reactions from parents. However, as one teacher pointed out:

> *It would be very effective if we can implement a national curriculum this way. But, I think we should have awareness programs for parents and the general public. Otherwise we might get negative reactions. This time we didn't get any negative reactions and the parents were quite happy. But if we change the whole curriculum before making them aware first, there might be some reactions* [MT7].

If a more comprehensive implementation was attempted, then there is recognition that it is important that parents and the community are more involved.

> *I think it will be very good both for the teachers and students. However, we need to make a lot of changes not only to the curriculum but the textbooks, and people's views. Before an implementation of a national curriculum we need to find out about the views of teachers, educators, parents and the general public* [MT1].

> *This is only one unit that we did ... in the other units also we can do practical work and experiment and after that only we can come to a final conclusion ... And after that it must be the idea of all the other mathematics teachers and those who write the curriculum. They also have to approve. Then only it can be successful* [MT4].

> *If we can implement the whole curriculum this way it will be very good. Students were very interested and motivated when this topic was taught. I think it would be very fruitful to implement a curriculum like this. If we are to implement a national curriculum this way, we need to find the views of lots of people including the parents* [MT6].

A further consideration indicated by this study is that, when as researchers, we try out new things we need to tell students what we are doing and why, and involve them in curricular change. The students responded well to being involved and offered their views freely and with some insight.

> *This time we went out on field trips, asked lots of questions and gathered information from people. Also, we did mathematics in class by using different artefacts and we talked about and looked at the differences between traditional and present ways of doing mathematics* [MS10].

> *It was taught differently. We did lots of activities ... we were taken out on field trips. We were never taken out on field trips in mathematics before ... I never thought about mathematics this way. Now I even look for mathematics even when I walk on the streets or at home* [MS3].

These comments indicate that students were aware of the research, and were conscious of the radical changes of approach. There is cause to believe that this unit will have a lasting effect on some students.

To achieve the wider aims of the curriculum, as Singh's (1992) study indicates, it is important that in future developments of the curriculum, the school administrators and the community to be educated about the change process, and their role in the change process.

Another issue is that of encouraging teachers to engage in mathematical explorations so that they can be comfortable using these strategies in their classrooms. As Maldivian teachers are not used to mathematical explorations they would need on-going guidance and necessary support. However, as resources and expertise are limited, it may not be viable to use this approach extensively in the syllabus.

This raises the question of how extensively can this approach be used through the syllabus, and how much is needed to achieve wider aims? A more comprehensive ethnomathematical curriculum model requires teachers to know more about mathematics and to have additional pedagogical skills in order to effectively help students. As evident in literature (e.g., Hannif, 1996), teachers can be reluctant to implement curricular innovations due to a limited background of subject matter and pedagogical skills. This study suggests that the Maldivian situation may be easier than many in this respect, but this remains a complex process, and it would take time

9.6 SUMMARY

The main issue in implementing an ethnomathematical curriculum is whether or not students and teachers were able to internalise the ethnomathematical approach and 'get' the idea of ethnomathematics. It is concluded that teachers and students were able to make the link between school mathematics and cultural practices, recognise and become aware of mathematics in the society, understand the nature of mathematics better, and seemed to view mathematics as a human activity. Thus, from one unit of an ethnomathematical approach significant advances were made with respect to the educational aims as outlined in the theoretical model.

On a practical implementation level, it is concluded (in agreement with the literature), that even though teachers are positive if an opportunity for development arises, they need further support to be fully self-motivated and to have the confidence to initiate further activity. Full implementation requires researchers and curriculum developers to be committed for a long time period with sufficient resources.

Further, it is important that students, parents, and the community are involved in future curriculum developments if these developments are to have a chance of having a lasting effect.

10 OUTCOMES OF USING AN ETHNOMATHEMATICAL CURRICULUM UNIT

10.1 INTRODUCTION

This chapter is to one side of the research, which is about the *effects of implementation* of an ethnomathematical curriculum. Nevertheless, certain outcomes of using an ethnomathematical curriculum unit emerged from the data. These research results are presented, analysed, and discussed in this chapter. The research questions addressed in this chapter are:

- *What are the indications of the efficacy of using an ethnomathematical curriculum unit?*
    - *What are the student reactions, learning outcomes and affective outcomes of using such a curriculum unit?*
    - *What are the teacher reactions and affective outcomes of using such a curriculum unit?*

Questions are discussed under the two themes: motivation and interest; and facilitation of understanding of mathematical concepts.

10.2 MOTIVATION AND INTEREST

All teachers appreciated the motivational effect of the ethnomathematical curriculum unit. They felt that once the measurement topic started, students were more involved, more motivated, and more interested in learning mathematics. They attributed this to the unit allowing students to go out on field trips, ask questions, and do the mathematical investigations.

> *Even students who were not very interested in mathematics lessons previously were also very much involved and interested in doing the activities* [JIT1].

> *Students were very much interested and involved in doing the activities. They enjoyed going out on field trips. They also mentioned that after going to local market and other places, and after seeing the way people measure etc it was easier for them to remember and keep it in their memory* [MT1].

> *I could see that students' interest in mathematics changed a lot during the time when the measurement topic was taught ... previously they would look so bored and sleepy in the class. But once the measurement topic started they seemed to have lot of energy and I found that even in other classes they were much motivated than before* [MT7].

Moreover, from the survey in which students were asked which method of mathematics learning they preferred, 91 percent of the students said that they preferred to learn mathematics the way they learnt the ethnomathematical unit on measurement. Typical of students' comments were:

> *I prefer this way of learning mathematics. Going out on field trips, observe what other people are doing and then come back to classroom and do the mathematics ... it is easier to learn mathematics when taught this way, and it is more interesting* [MS2].

> *I prefer to go to field trips and then learn mathematics. Because when we learn in class we might not know some of the things. But when we go on field trips we know the things we have to learn in class and more than those things. So field trips are much better* [MS4].

> *I prefer to learn mathematics this way by going out on field trips. When we learn mathematics just in the class, we don't learn as well as when we do mathematics practically. And it is more interesting. Now I know what measurement is. I have seen people at local markets and construction sites use different measurement strategies* [MS9].

> *This method. Because we can go out on field trips* [IS1].
>
> *When taught this way it is easier to learn. This is because we visited different sites and spoke to the people to get information* [IS33].
>
> *This method. Because it was taught in Dhivehi. It was difficult to understand when mathematics was taught in English. I understood this topic very well as it was taught in Dhivehi* [IS36].

Students' enjoyment as reported above may not only be due to the implementation of the ethnomathematical unit of work. It may well be that Maldivian students who are used to the traditional method of 'chalk-and-talk' teaching were relieved from the boredom of class, as they were able to go out on field trips, and experiment and explore some of the mathematical activities in the class. Alternatively, were the students feeling content and interested because they were not being challenged mathematically in the conventional sense? None of the students expressed or commented that they felt that they were not learning 'mathematics' when the measurement unit was taught, nor did they express boredom in the classroom. The nine percent of students who stated that they preferred to learn mathematics in the traditional way seemed to prefer the security of formulae and given techniques.

> *I am more interested to learn when the formulae are given straight away. I do enjoy going out on fieldwork trips and doing experiments in class. But still I am more interested when formulae are given* [MS1].
>
> *The other method. I don't like to go out on field trips* [MS14].
>
> *The other method. I like it when formulae are first given and explained on the board* [MS15].
>
> *Previous methods because I could understand better then* [IS40].

Evidence of the teachers' positive response to the unit was seen in their interest and willingness to come to workshops a year later when the opportunity arose. Even teachers who did not take part in the study also joined the workshop sessions as they had observed the enthusiasm of the teachers and students who were involved in the study, and therefore, they were interested and keen to try out the new approach.

The conclusion that the implementation had positive motivational outcomes cannot be necessarily extended to teachers' and students' interest and motivation if the same approach is followed in all or most curriculum units. Also, apart from the effect one year later, we do not know whether teachers' and students' positive feelings will be long lasting.

The motivational aspect was prominent in the data, and there is ample empirical evidence that good motivation is necessary for meaningful mathematics learning (e.g., Zaslavsky, 1991). However, this aspect of motivation is not included explicitly in the ethnomathematical curriculum model framework for this study. There is a need, therefore, to redraw the model to include this component.

10.3 FACILITATION OF UNDERSTANDING OF MATHEMATICAL CONCEPTS

Not only did this ethnomathematical approach allow students to make the connections between school mathematics and real world activities (see Chapter Nine), but it also seemed to assist their understanding of formal, conventional mathematics, as is evident from both the teachers' and students' comments.

> *Previously when taught using chalk and talk, students were not very involved in learning mathematics. But this time ... they had a better understanding and they were able to apply what they've learnt and it was easier for them to grasp the mathematical concepts. By the time we introduced the formulae, the students had an understanding of the concepts of area, volume and perimeter* [MT7].

> *This [approach] helped students' thinking processes and it was easier for them to understand the mathematical applications.* [MT2].

> *I can understand mathematics better now ... I know how to use formulae and things better after seeing how people do things in [for example] construction of houses* [MS12].

> *Now, I can see that students have a very thorough understanding of area, perimeter, and volume* [JIT1].

> *During this lesson the need for a standard measurement and how different measurement strategies were invented, were discussed ... I felt this was a very beneficial lesson as students had an understanding of how measurement strategies were invented* [JIT2].

> *Students learnt the topic very thoroughly. They also enjoyed all the activities that we did in the class. Even the weaker students understood the topic very well* [MT5].

> *Accuracy is needed when calculating area. If we want to calculate the area of playground accuracy is important. Also when levelling the walls in building a house* [MS1].

Even though assessment was not associated with the research project, at the end of the ethnomathematical unit of work, a test on measurement, similar to that given in previous years, was given both at the Male' School and the Island School. Male' teachers reported that the students performed well in the test and that they perceived that students had done much better than in comparison to other mathematics assessments that students had done. Similarly, the Island School teachers observed that student performance was good and that the weaker students performed exceptionally well in comparison to their previous results. They felt that the reasons for this were that the students were motivated and interested in learning, as they were able to see and learn about mathematics. This was also one of the implications of the ethnomathematical curriculum model used in this study (see Chapter Six). Further, this is in line with Lipka's (2002a) findings that students who have been taught using an ethnomathematical approach perform better on conventional mathematics tests.

There are indications that the ethnomathematical unit of work facilitated students' understanding of mathematical concepts. These indications of 'successes' may well be due to the Hawthorne effect, as they knew that this unit was the subject of a research study and was therefore new and special. Students might have been paying more attention than usual or worked harder due to these reasons rather than because of the nature of the unit. Such activity could result in better understanding. Or it may well be that teachers or students wanted it to work out well out of sense of loyalty to the researcher or the principal who had supported this initiative. They may have reported what they thought were appropriate responses to the study so that the experiment they were involved in was seen as a success. Nonetheless, teachers and students also commented on what they thought were difficulties of an ethnomathematical approach to mathematics, and were open about their concerns.

It is concluded that the balance of evidence on this implementation is that conventional mathematical learning objectives were achieved at least as well as using existing methods.

10.4 SUMMARY

Teachers' and students' enhanced awareness of mathematics as a social phenomenon, and other steps on the ethnomathematical sequence of instructional activities can be regarded as outcomes of implementation, but were considered earlier (see Chapter Nine) as part of the implementation. This chapter dealt briefly with the more conventional outcomes of motivation and interest in mathematics, and understanding and achievement of conventional mathematics.

It is concluded that the implementation of this unit was more successful overall in its motivation effects and at least as successful on conventional achievement. Whether these outcomes can be attributed solely to an ethnomathematical curriculum model is debatable. Also open is the question of whether they can be achieved across all teachers and all students. It may well be that Maldivian teachers and students, who are used to the traditional method of 'chalk-and-talk' teaching and learning mathematics, were relieved from boredom, as they were able to go out on field trips, and explore mathematical activities in class. Further research needs to be done to establish significant causes for changes in attitudes. Nevertheless, the results that are reported here do coincide with those predicted in ethnomathematical literature (e.g., D'Ambrosio, 2001; Gerdes, 1994) and reported elsewhere (e.g., Lipka, 2002a; Zaslavsky, 1991).

11 IMPLICATIONS OF INTRODUCING ETHNOMATHEMATICAL IDEAS INTO THE CURRICULUM

11.1 INTRODUCTION

After discussing and analysing the data with respect to the research questions in Chapters Eight, Nine, and Ten, this chapter presents and analyses the data focusing on the implications of introducing ethnomathematics into the normal curriculum of the primary schools in the Maldives. These implications are discussed under the themes arising from the analysis of the data: preservation of culture; assessment; professional development of teachers; and student learning.

11.2 PRESERVATION OF CULTURE

Since Maldivians value traditions, customs, and practices of the culture, one of the assumptions of this research was that any cultural revalidation provided by an ethnomathematical curriculum was likely to be appreciated and valued by the schools and community (see Chapter Seven).

As mentioned briefly in Section 8.4, the data confirmed that teachers in particular do value culture generally. This was apparent from teachers' comments when they were asked in the questionnaire what they thought the traditional schools of the Maldives offer which the formal schools did not.

> *Maldivian ways are used in traditional schools. They use cultural methods in teaching* [POSTMT1].

> *The value of the culture* [POSTMT4].

> *The teaching methods and materials of our own culture, which the students can get to know and are familiar with* [PREMT6].

> *Things that are more culture related* [PREMT7].

Valuing of culture appeared to lead to an appreciation of the cultural aspects of the curriculum. When asked whether there was anything that they would like to change or include in the ethnomathematical curriculum unit, cultural values were mentioned several times in teachers' responses.

> *No. It is better for them to know the traditional things about measurement. Only then they will remember. They will remember the culture throughout their lifetime. When each and every generation learn otherwise these cultural things may fade off. So when it is included in the syllabus it will remain in their memory* [MT4].

> *It is more advantageous to teach this way than the way we have been teaching. It was easier for students to understand. They also learnt about the traditional ways of measurement and the way it is done* [MT1].

> *The fieldwork was great. Students had the opportunity to ask questions and learn about their cultural activities* [IT1].

Teachers felt that it was a good opportunity for students to learn about the cultural activities, and as one teacher said, students would realise the importance of studying mathematics when they could see the connections between school mathematics and cultural practices, and therefore, would be interested in choosing culture-oriented careers.

> *I think our students will benefit more if we teach them mathematics using real examples that are familiar to them. Only then they will be interested in choosing careers that are culture oriented … I will try to include topics in the curriculum where the links between mathematics and culture will be seen. This is because then students will realise the importance of studying mathematics* [POSTIT2].

Further, during the interviews, when teachers were asked how they felt about using cultural practices in mathematics, more than 90 percent of the teachers said that it would be a good way of retaining and preserving the culture. Typical of teachers comments were:

> *It is very good. Students will be aware of their cultural practices. Otherwise it will fade away. I think it will be good to connect all subjects to cultural practices* [IT1].

> *... I feel it is good because our culture won't fade away and students will learn about the different strategies used in our culture* [MT1].

> *It is very good. Both students and we teachers learnt a lot about our culture. So it won't fade away* [MT5].

> *I think our cultural practices are fading away now. At schools students are not taught these things so students don't have much knowledge of their cultural practices. But, as we've found students are very much interested in learning about the cultural activities. So I think it is something that would be very fruitful* [MT7].

These comments also seem to indicate that teachers fear that cultural practices are not taught enough at schools, and therefore, when students leave school, they do not know much about the cultural practices or how they link to school learning. Does this mean that teachers' anxiety is due to Maldivian cultural practices slowly 'fading' away and being replaced by other beliefs, values, and practices? No teacher directly said this. However, it is quite surprising that most teachers used the word 'fading away'. This was not discussed in the workshop sessions or during informal discussions. The only possible explanation for this is that they might have literally translated the *Dhivehi* word for 'fading away'. Nevertheless, these comments highlight implications for mathematics educators, curriculum developers, and policy makers regarding curriculum implementation and innovation.

Additionally, as discussed in Chapter Nine, the community welcomed the ethnomathematical curriculum unit and were very much willing to share their ideas and experiences. Parents provided positive feedback during the research, and after the completion of the research. For instance, teachers volunteered the information that, even after the completion of the research, a number of parents asked them to continue teaching mathematics using cultural aspects as they felt their children were more motivated and interested in learning mathematics when taught this way, and no parent expressed any anxiety.

This community acceptance and willingness to preserve the mathematical culture also contradicts some of the arguments put forward by some of the critiques of ethnomathematics, such as by Dowling (1998), and by Rowlands and Carson (2002). An example is the criticism that ethnomathematics denies cultural values and prevents a certain culture having their own voice hence defeating one of the purposes of ethnomathematics – that of the preservation of culture. However, the findings of this study show that, in this society at least, the criticism is not valid. This could be because cultural practices are valued and respected in the Maldivian society even though cultural aspects are not emphasised in the school curriculum.

Teachers and parents clearly appreciated and welcomed someone encouraging the introduction of cultural practices into school curricula. It is concluded that a way forward towards implementing a wider ethnomathematical curriculum is to build on the idea that mathematics values and appreciates the customs, traditions, and practices of the culture. Even more involvement of the community in curriculum design is also recommended.

11.3 ASSESSMENT

Assessment was not part of this research project because it would be impossible to attribute test results solely to the intervention when it was so short and because the intervention was a trial and therefore not fully developed. Hence, it is an unresolved issue requiring further research. However, as discussed in Chapter Nine, assessments based on the conventional methods were given at the end of the ethnomathematical unit. Note that assessing in the conventional way means that the aims and objectives of an ethnomathematical curriculum are not fully addressed.

In future implementations, effort needs to be given to the type of assessment procedures that should be used in a curriculum based on ethnomathematical principles. Such an assessment would draw on experiences that are common in the students' socio-cultural environment, and use these experiences to provide contexts in which students' mathematical knowledge can be evaluated.

Development of appropriate assessment requires more professional development for teachers and curriculum developers. This will be a significant problem as there are limited professionals in the Maldives, and there is a reliance on external ideas and resources. In addition, as international validity is seen as necessary, and as Maldivian students seek to excel in international examinations after secondary schooling, it may not even be possible to change the assessment structure of Maldivian classrooms. A danger of including ethnomathematical principles in assessment is that learning of cultural values and practices might become the subject of assessment when they are a birthright. How can cultural elements be assessed appropriately if they are deeply integrated within the mathematics? Further research needs to be done in the Maldivian context, to establish the types of assessment procedures to be used in a curriculum based on ethnomathematical principles.

11.4 PROFESSIONAL DEVELOPMENT OF TEACHERS

As discussed earlier (Section 8.7), even though there is great potential for the development of an ethnomathematical curriculum in the Maldives, since ethnomathematical approaches are completely new, Maldivian teachers would need ongoing support and guidance. In addition, no international resources are possible for an ethnomathematical curriculum based primarily on a national culture, except ones that can be used as minor supports. Therefore teachers need to develop resources, or resources have to be provided for teachers as part of the implementation. This would also require a change in the format of textbooks, and carefully selected local materials need to be sensitively included in the textbooks and other teaching resources. This would require confidence, experience, and time to change. The implication of this for mathematics educators and curriculum developers is that they need to be committed over a long time period with substantial funding.

11.5 STUDENT LEARNING

It was an assumption of this research that an ethnomathematical curriculum is more mathematically meaningful to Maldivian students, and that it is an effective teaching strategy to achieve the conventional curriculum objectives (see Chapter Seven).

As discussed in Chapter Ten (see 10.2 and 10.3), it was apparent from the teachers' and students' responses that the students were more motivated and interested in learning mathematics as a result of the implementation of the ethnomathematical unit of work; and that the ethnomathematical approach seemed to have facilitated students' understanding of conventional mathematics. There was also a suggestion of success within conventional ways of assessing mathematics.

This again challenges some of the arguments proposed by some of the critiques of ethnomathematics such as those of Vithal and Skovmose (1997) and Greene (2000). For example, it addresses the criticism that it reinforces the relation between power and culture, and the criticism that learning mathematical methods of other cultures hinders development of mathematical thinking needed for more abstract mathematics. Such evidence as exists within this study indicates that these criticisms are not valid for the Maldivian society. This could be because Maldives is a homogeneous culture and there are no racial tensions, and so Maldivian students may have taken pride in learning about their culture. In fact it may reverse the power relationship because non-Maldivian teachers were aware of their lack of cultural expertise and were forced into using students' experiences and ideas (see Section 8.3).

It is possible the successes in student learning may have been due to the Hawthorne effect, as the unit was something new and interesting (see Section 10.3). Nevertheless, the responses of teachers and students seem to confirm the implications of ethnomathematics to student learning, such as making mathematics more meaningful to students, suggested by, for example, Barton (1993), Orey (1989), and Zaslavsky (1994).

11.6 SUMMARY

A prominent implication of extending the ethnomathematical curriculum for the Maldivian classrooms appeared to be that of preservation of culture. This validates one of the objectives of ethnomathematics – that of revalidating cultural skills and preserving the mathematical culture.

Other implications for further implementation include deeper understanding of mathematics in the society, and making mathematics more meaningful to students. The evidence of this study is that this can occur with no drop-off in traditional mathematical skills.

12 CONCLUSIONS

12.1 OVERVIEW

Every culture exhibits some forms of mathematical activity. This mathematical activity is directly related to formal, conventional school mathematics in its motivations and modes. The term ethnomathematics, as coined by D'Ambrosio (1985) to describe the mathematical practices of identifiable cultural groups, may also be regarded as the study of these mathematical ideas. More specifically, ethnomathematics can be described as the way people from a particular culture have common systems for dealing with quantitative, relational, and spatial aspects of their lives (Barton, 1996a).

Ethnomathematical initiatives have been the subject of several studies in mathematics education. However, few studies have been done on implementing ethnomathematical principles in mathematics curricula and pedagogy. The only evaluative study is that of Lipka (2002a) whose work connects Yupi'k Elders knowledge to school mathematics in Alaska. What is needed is a model or framework on which to build a coherent programme and to be able to identify problems and issues that need resolving. Using Lipka (1994) as a basis, the ethnomathematical curriculum model devised for Maldivian classrooms is a first step towards this. My intention was to consider what such an ethnomathematical curriculum model could be and whether it would be worthwhile. The use of this model in practice has thrown up certain issues and questions for other educators attempting comprehensive introduction of ethnomathematical ideas into school curriculum.

There are many different approaches to an ethnomathematical curriculum. Which approach to use depends upon what one is trying to achieve. Some of the ways an ethnomathematical approach has been used include: using examples of ethnomathematics to make mathematics more interesting; using ethnomathematics to teach about particular groups of people; showing how the same mathematical idea is present in many contexts; enhancing feeling of cultural worth and unity - often used to try to help students from minority groups in a society; and using ethnomathematics as an educational tool to help students to understand what mathematics is about and make it part of their own knowledge. It is this last use of ethnomathematics that was developed into a model for this study.

The study was designed to investigate the implementation of such an ethnomathematical curriculum in the primary classrooms of the Maldives. Hence, the research questions this study sought to address were:

- What are the issues and considerations in preparing an ethnomathematical curriculum unit?

- What are the problems in preparing the teachers in the Maldives for a curriculum unit based on ethnomathematical principles?

- What issues arise in the implementation of an ethnomathematical unit?
  - What are the practical limitations?
  - What are the issues that need to be resolved for future developments?

- What are the indications of the efficacy of using an ethnomathematical curriculum unit?
  - What are the student reactions, learning outcomes and affective outcomes of using such a curriculum unit?
  - What are the teacher reactions and affective outcomes of using such a curriculum unit?

This chapter reviews the research findings, and their practical implications, followed by a critical analysis of the ethnomathematical curriculum model used in this study. Then it considers some broad implications of the study for mathematics education. Suggestions for further research are given, and the chapter ends with concluding thoughts and remarks.

12.2 SUMMARY OF RESEARCH FINDINGS

This section summarises the main results of the study. Analysis of data is discussed under the headings: issues, considerations, and problems in preparing an ethnomathematical curriculum unit; issues of implementing an ethnomathematical curriculum unit; outcomes of using an ethnomathematical curriculum unit; and implications of the study for introducing ethnomathematical ideas into the curriculum.

Issues, Considerations, And Problems In Preparing An Ethnomathematical Curriculum Unit

The issues that were identified as arising in preparing an ethnomathematical unit for the Maldivian classrooms included: beliefs about the nature of mathematics; style of teaching; valuing a 'Western' education system; language of instruction; resources; and professional development of teachers. In this study, none of these issues presented much of a barrier to implementation as the teachers were very willing and enthusiastic, and the school administrators and the community were very supportive.

In the Maldives mathematics is generally seen as infallible and objective, and as such mathematics is taught in a context-free manner without relating to the real world students are experiencing. However, there were indications in the data that teachers were able to see mathematics beyond something that is only done at school. Therefore, this could have been a first step for Maldivian teachers to appreciate and conceptualise a different philosophy of mathematics.

The mode of pedagogy in Maldivian classrooms relies heavily on the 'transmission of knowledge' model. The use of the 'chalk-and-talk' method is very common, and there is little inclination to experiment with cooperative learning environments where students are encouraged to use problem solving, reasoning, and communicating. It is also not normal for Maldivian teachers to engage in mathematical explorations. Nevertheless, the more open teaching style implied by an ethnomathematical curriculum did not seem to be a problem as teachers were willing, enthusiastic, open to new ideas, and proved to be capable of implementing them.

In the Maldives, British syllabuses and assessments are followed at secondary schools, and therefore, the Western education system is valued. However, teachers acknowledged the importance of bringing cultural ideas into the classroom. There was evidence that teachers brought cultural ideas into the workshops and classroom discussions, and seemed to be motivated to move beyond Western paradigms. Thus, the strong valuing of Western educational paradigms did not necessarily present a barrier to implementing an ethnomathematical curriculum as a role for culture within education is appreciated and recognised.

Most teachers were in favour of using the indigenous language in teaching mathematics. However, there were some who felt that English should be used as the sole medium of instruction as the students were being prepared to sit for examinations given in English. Nevertheless, those teachers who were able did code switch whenever necessary. This was problematic for non-Maldivian teachers who do not share the same social and cultural background as their students. This would be an on-going problem in the Maldives as more than 70 percent of our teachers are non-Maldivians. So, despite a perceived need for English for assessment purposes, teachers were willing to use and to allow *Dhivehi* wherever appropriate.

Resources had to be produced collaboratively with the teachers for the ethnomathematical unit of work. This might be costly long-term as there might not be enough variety of cultural material for all units of the syllabus, and an investment of time and money to produce and design resources are necessary.

Professional development opportunities are limited for Maldivian teachers. As ethnomathematics is something completely new to Maldivian teachers, they needed the guidance in both designing an ethnomathematical unit of work and putting it into practice. Even though teachers were willing to try out new ideas, confidence to initiate further development seems to be a problem. They will need ongoing support and guidance.

The willingness and enthusiasm shown by teachers could be because it was just one unit of work that was being implemented. In a full implementation there needs to be on-going work and teachers need to be self-motivated – which they are not now. There was evidence that in preparing the ethnomathematical curriculum unit, teachers were able to apply mathematical thinking to their cultural experiences. This was part of the ethnomathematical curriculum model used in this study, and is a necessary pre-condition for further development.

Issues Of Implementing An Ethnomathematical Curriculum Unit

One of the main issues in implementing an ethnomathematical curriculum is whether or not students and teachers 'get' the idea of ethnomathematics, and the extent to which the ethnomathematical approach has been fully internalised by teachers and students. The data evidence showed that Steps 1 and 2 of the instructional sequence (see Chapter Six) – becoming aware of mathematical practices in their culture and making the link between school mathematics and cultural practices – were achieved. Similarly, there was evidence that Steps 4 and 5 of the instructional sequence – those of understanding conventional mathematics better and of viewing mathematics as a human activity – were appreciated. This implies that not only the content of the unit, but also the wider aims of an ethnomathematical curriculum can be approached by teachers and students.

In addition, the ethnomathematical approach provided opportunities for closer community and school relations, and the approach was accepted and welcomed by school and the community. This was evident from the willingness of the people involved in cultural practices to share their experiences and ideas and from the support provided by the school authorities.

There was little evidence of negative aspects in the implementation. Teachers themselves identified positive practical advantages, and difficulties that could be overcome by sufficient planning and resources. Therefore, this ethnomathematical approach provided a good opportunity and a positive experience for both the teachers and the students.

On one hand, it may be possible that the ethnomathematical unit was appreciated and welcomed because it was something different and therefore it was stimulating for both the teachers and students. On the other hand, this could also be interpreted as evidence that professional development in which teachers feel a sense of ownership in curriculum innovations leads to them developing critical thinking in respect of their practice (e.g., Begg, 1994). However, if a more comprehensive implementation was attempted, then there is recognition that it is important that parents and the community are more involved in order to have a chance of having a lasting effect.

Teachers' willingness to include cultural material in mathematics curriculum fulfils one of the political aims of ethnomathematics as expressed in the literature (e.g., D'Ambrosio, 1994a), although the political aims of ethnomathematics were not explicitly used in the ethnomathematical curriculum model used in this study.

Outcomes Of Using An Ethnomathematical Curriculum Unit

This was not the main focus of the research, which is about the *effects of implementation* of an ethnomathematical curriculum. However, some of the outcomes, such as motivation and interest, and an indication of the facilitation of understanding of mathematical concepts, were identifiable in the data.

The aspect of motivation was not included explicitly in the ethnomathematical curriculum model framework for this study. However, all teachers commented appreciatively on the motivational aspect of the implementation. They felt that once the measurement topic started, students were more involved, motivated, and interested in learning mathematics. Therefore, the implementation of the ethnomathematical unit was overall more successful in its motivational effects and at least as successful in conventional achievement. This aspect was prominent enough to justify adding it to the theoretical model – see Figure 12a.

Whether these indications of 'successes' can be attributed solely to an ethnomathematical curriculum model is debatable. Also open is the question of whether they can be achieved across all teachers and all students. It may well be due to the Hawthorne effect, as the unit was something new and therefore interesting and stimulating. Or else it could be that the teachers and students reported what they thought were appropriate responses to the study so that the experiment they were involved in was seen as a success. However, as teachers and students also reported what they thought were difficulties the latter explanation is unlikely. Further research needs to be done to fully understand the outcomes of extensive use of this approach. Nevertheless, the results do agree with those envisaged in the literature (e.g., D'Ambrosio, 2001; Zaslavsky, 1996).

Implications Of Introducing Ethnomathematical Ideas Into The Curriculum

The implications of the study for introducing ethnomathematical ideas into the normal curriculum of the primary schools in the Maldives relates to: preservation of culture; student learning; professional development of teachers; and assessment.

With respect to the preservation of culture, Maldivians generally value culture and those involved in the implementation saw the ethnomathematical curriculum as a means for retaining and preserving the culture. Hence, the community welcomed the ethnomathematical curriculum unit and were very much willing to share their ideas and experiences. The community acceptance and willingness may be due to the fact that the unit was something that they could identify with and provided a means for getting involved in school life.

Other implications include deeper understanding of mathematics in the society, and mathematics being more meaningful to students. The evidence of this study is that this occurred, and it indicated that there was no drop-off in traditional mathematical skills.

Professional development needs to be on-going and teachers need the support and guidance. The implication of this for curriculum developers and mathematics educators is that they need to be committed over a long time-period.

Assessment was an unresolved issue as it was not part of this research project. However, an implication of this study is the type of assessment procedures that should be used in a curriculum based on ethnomathematical principles for assessment.

Further implications for both mathematics educators and policy makers regarding the implementation of further ethnomathematical curriculum units are as follows.

- In the project students responded well to new teaching modes and in the Maldives this did not deteriorate into indiscipline. They understood and appreciated what was going on. As researchers, when we try out new things we need to tell students what we are doing and why, and involve them in curricular change.

- Students were very much interested and involved in the study. Student involvement in the activities enabled them to be more interested in studying mathematics and they were able to relate real-world activities to formal mathematics – something they did not seem to be aware of before. However, the important question to be considered seems to be how to move beyond motivation and application of mathematical ideas. It is an implication for us as researchers to put more effort into how to do this properly.

- Practical issues such as length of time needed to complete the unit did not seem to be an issue academically. However, Maldivian parents expect visible 'formal work' from their children. This needs to be recognised in future curriculum developments so parents are comfortable with the new initiatives.

For many years now, the Maldives has relied on external ideas and resources. The current mode of pedagogy in Maldivian classrooms relies heavily on the transmission of knowledge model. However, the study indicated that there is a great potential to develop an ethnomathematical curriculum model in Maldives so that mathematics will be more meaningful to the students. Moreover, for Maldives in particular, an ethnomathematical curriculum model will naturalise mathematics education. This potential was recognised and welcomed by teachers, school administrators, and the community.

Thus, it is concluded that, in a homogeneous context like the Maldives, and with the support demonstrated by the schools and the community, the development of the ethnomathematical curriculum can be continued extensively.

12.3 AN ANALYSIS OF THE ETHNOMATHEMATICAL CURRICULUM MODEL USED IN THIS STUDY

From the literature five possibilities for an ethnomathematical curriculum were conjectured (Adam, 2003). After analysing these possibilities, an ethnomathematical curriculum model was developed for Maldivian classrooms using Lipka (1994) as a basis (see Chapter Six). The objective of developing an ethnomathematical curriculum model for Maldivian classrooms is to assist the designers of the curriculum and organizers of professional development to make sure there is a coherent vision of what is being done and why (Adam, 2004).

The model both expresses a coherent vision of what an ethnomathematical curriculum is supposed to do, and also provides means to investigate what difference an ethnomathematical curriculum will make. Therefore, when analysing the model, we have to ask ourselves whether it performs these functions.

The model helps us understand the relationships between mathematics and culture and education, and express what an ethnomathematical curriculum is supposed to do. However, more detail is needed, in particular: What does the bridge or mathematical thinking represent? For example, in the study, after students went out on field trips to the construction site and seeing people measuring sand using sacks they were able to relate to how people put '*kashiveli*' or broken shells on the front yard of the house. Normally, people would estimate the number of sacks needed to put *kashiveli* in a certain area. This involves mathematical thinking about the need to formalise in order to communicate area. Formalising is part of the right-pointing arrow (see Figure 12a).

Another example is the use of units of measurement in the local market. In the local market half coconut shells are used for measuring. Students observed that people in the local market were using half coconut shells to measure liquids and that if the coconut shells are different in sizes then it would not be fair for the buyers or sellers. That is why the government had to set up a standard size coconut shell. The emergence of the concept of standard measurements and accuracy is part of generalisation – another feature of the right-pointing arrow.

What does the left-pointing arrow represent? It represents the ability to reflexively use formal mathematics to re-view aspects of cultural practice. In the study teachers demonstrated it as they developed the unit and needed to look mathematically at different activities. It was demonstrated by a student, for example, when he said that now he looks for mathematics in activities that people do which was something that he did not realise before.

A failing of this model is that the role of other ethnomathematics is not clear. This needs to be made more explicit in further developments. In this study, the role of other ethnomathematics was to draw parallels and make comparisons with students' ethnomathematics, thereby making it easier for them to appreciate that each culture has its own way of mathematising (see Chapter Six). However, such teaching was not a large part of the implementation.

The second function of the model is to provide a basis for investigation of an ethnomathematical curriculum. The model makes it clear that we need to see evidence of the bridge (mathematical thinking) – not just learning about cultural practices or heightened motivation. It focuses on the development of mathematical thinking for teachers and students.

Another question is how this model is different from other curriculum models? As an example, the approach taken by the New Zealand mathematics curriculum could be labelled as mathematics in a meaningful context. Mathematics in a meaningful context refers to just mathematics made familiar or realistic by using situations students know about or can imagine. This ethnomathematical curriculum model, on the other hand, looks for parallels in the types of thinking between school mathematics and cultural practices.

This ethnomathematical curriculum is not just about application of relevant contexts in learning and teaching mathematics. It is not just examining mathematics in practice. It is about looking at the characteristics of school mathematics and the students' real world to provide a connection between these two via mathematical thinking so that formal or conventional mathematics is better understood, appreciated and made more meaningful to its learners. Similarly, better understanding of conventional mathematics feeds back into and contributes to a broader understanding of the culturally-based mathematical principles.

The model now needs to be developed after the implementation of the ethnomathematical curriculum unit. The model has been redrawn to include the motivational aspect that emerged prominently in the data (see Chapter Ten), and is also strong in the literature (e.g., Zaslavsky, 1996). Good motivation is necessary for meaningful mathematics learning. There is evidence from the data (see Chapters Eight and Nine), that teachers and students were motivated to learn mathematics as a result of seeing and becoming aware of mathematics in the society.

A further development of the model is its provision of more detail of the nature of mathematical thinking and reasoning in this context. Formalising and generalisation are parts of the right-pointing arrow, re-viewing cultural practices are parts of the left-pointing arrow. The model is open to further additions to these components. Figure 12a gives an overview of the development of the new ethnomathematical curriculum model.

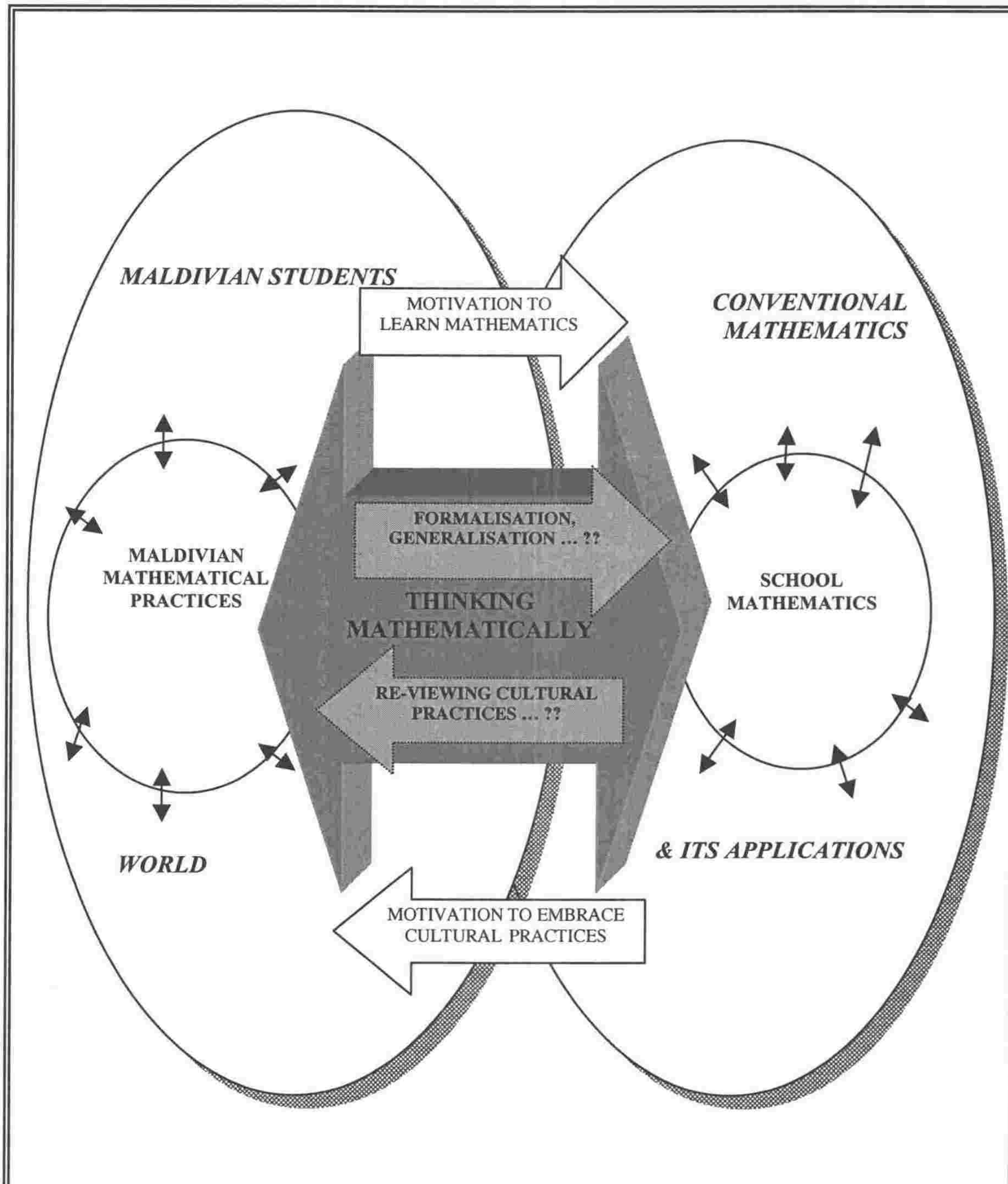


Figure 12a: An Overview of the Development of the Ethnomathematical Curriculum Model

There are five steps in the instructional sequence of the ethnomathematical curriculum model (see Chapter Six). They, and the extent to which they are being realised, are as follows.

- Recognising and becoming aware of mathematical practices in the culture and valuing and appreciating existing knowledge – this is happening.

- Establishing links between school mathematics and cultural practices – this has started.

- Establishing links between cultural practices and parallel practices from other cultures – this is not clear.

- Learning about and learning to use conventional mathematical systems, notations, and techniques – this is happening.

- Understanding of the culturally-based mathematical principles – this is happening.

The instructional sequence was used in the design of the teaching programme. There was nothing in the implementation that leads me to consider a major revision or addition to this sequence. There is, however, room to expand on the detail of how these steps can be achieved in any particular situation.

This ethnomathematical curriculum model is just a beginning. It is a first step. Further research will point out to what needs to be done next, and how to develop the model further.

12.4 SUGGESTIONS FOR FURTHER RESEARCH

This investigation of the implementation of an ethnomathematical curriculum unit in the Maldivian classrooms is just a beginning towards implementing ethnomathematical principles in mathematics curricula and pedagogy. There is scope for further research in this area. This study provides a justification for wider implementations from which research on long-term mathematical outcomes can be based.

Another very important area to be investigated is to understand how teacher development in ethnomathematical curricula can occur and be sustained. In order to do this, continuous research needs to be done in the Maldivian society and the culture of the school, to update curriculum policies, practices, and teacher professional development programmes.

The language of instruction also needs to be investigated further. The issue of the language of instruction did arise in this study. However, it was based on one unit of the syllabus, and therefore, there is a need to investigate further in which language an ethnomathematical curriculum can be best taught.

In addition, further research needs to be done on what type of assessment procedures are appropriate for a curriculum based on ethnomathematical principles.

There is also a need for more pure ethnomathematical investigations. The area of measurement that was the focus of this study could be investigated further. Other well-developed ethnomathematical areas such as navigation, astronomy, designing, and mat weaving, that are part of the Maldivian society, could be investigated in detail.

12.5 CONCLUDING THOUGHTS

My interest in cultural issues began from my Masters work where I looked at indigenous mathematics thinking in the Maldives. The intention was to consider the inclusion of this material in future curriculum developments, as I perceived in this work potential for significant improvement in mathematics attainment in the Maldives.

This research has been a first step towards investigating the implementation of cultural ideas in the mathematics curriculum. It was a good learning experience that allowed me to understand the issues and considerations that need to be taken into account. In addition, the positive response and feedback received from the schools and community have encouraged me to continue working in this field of research. What I would like to do now is explore the possibilities of developing a comprehensive curriculum using this approach.

APPENDICES

APPENDIX A: Material on Ethnomathematics and Ethnomathematical Curriculum

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APPENDIX E: Interview Guide Used for Students

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APPENDIX H: Guideline for Writing a Journal

APPENDIX I: Tree Diagram Used for Data Analysis

APPENDIX A

Material on Ethnomathematics and Ethnomathematical Curriculum

NOTES FOR TEACHERS

What is ethnomathematics?

Ethnomathematics is the study of mathematics in the context of the culture in which mathematics arises. Mathematics is regarded as a human invention that originates inside one's culture – where culture is understood as the customs, coders, myths, jargons, symbols, achievements and ways of reasoning and inferencing of a particular group of people that one shares with. Ethnomathematics explores culturally specific mathematical practices. Examples of ethnomathematical ideas in other cultures include:

- Maori weaving patterns that have been studied in New Zealand for their symmetry
- The traditional Angolan sand drawings
- The *quipu* used by Incas (the Incas inhabited what is today Peru and parts of other South American countries). A *quipu* was an assemblage of coloured cotton cords. The Incas used knots as numerals
- Geometric symmetries exhibited in *Tapa* cloth of Pacific Islanders

What is an ethnomathematics curriculum?

An ethnomathematical curriculum involves development from the mathematical concepts and practices originating in the learners' culture to those of conventional mathematics. An ethnomathematics curriculum starts from a learner's world. That is, the learners start with what they know, or the experiences they have, from their environment or culture. The mathematical experiences from the culture are then used to understand how mathematical ideas are formulated and applied. Then, this general mathematical knowledge is used to introduce conventional mathematics in such a way that it is understood, its power, beauty and utility are appreciated, and its relationship to familiar practices and concepts are conceived. A *conventional school mathematics curriculum* allows students to learn about mathematics and then apply it in the real world. An *ethnomathematics curriculum* allows students to become aware of how people mathematize and use this awareness to learn about mathematics.

How can we develop an ethnomathematical curriculum unit to teach concepts like perimeter, area and volume?

An important aim of teaching mathematical concepts like perimeter, area and volume is to develop an appreciation and understanding of these concepts beyond the rules for finding the perimeter, area and volume of regular shapes. It is important to grasp these concepts fully so that the rules can be understood and appropriately applied. Classroom discussions need to be developed with activities using objects familiar to students. The discussion should include reasoning, problem solving and communication. Thus, the students' understanding of the qualitative aspects of their world are made explicit.

An ethnomathematical curriculum unit (on perimeter, area and volume) could include:

1. Exploring some activities in the Maldivian culture, which have mathematical aspects. This will allow students to understand the origins and nature of mathematics. It will also value their existing knowledge.
2. Activities about perimeter, area and volume using objects familiar to students so that they experience and understand these activities from a mathematical point of view.
3. Activities about perimeter, area and volume that are outside students' experiences or culture. This will allow students to connect the knowledge of 'their mathematics" through comparisons and link these activities with parallel ones outside their experiences, using mathematical thinking.
4. Activities to learn about and learn to use other mathematical systems of conventional mathematical notations and techniques. This will allow to bridge students' knowledge to other mathematical systems, learn about and learn to use other mathematical systems including symbol systems of conventional abstract mathematical notations and techniques.

Refer Figure 1 for an overview for an ethnomathematical curriculum unit

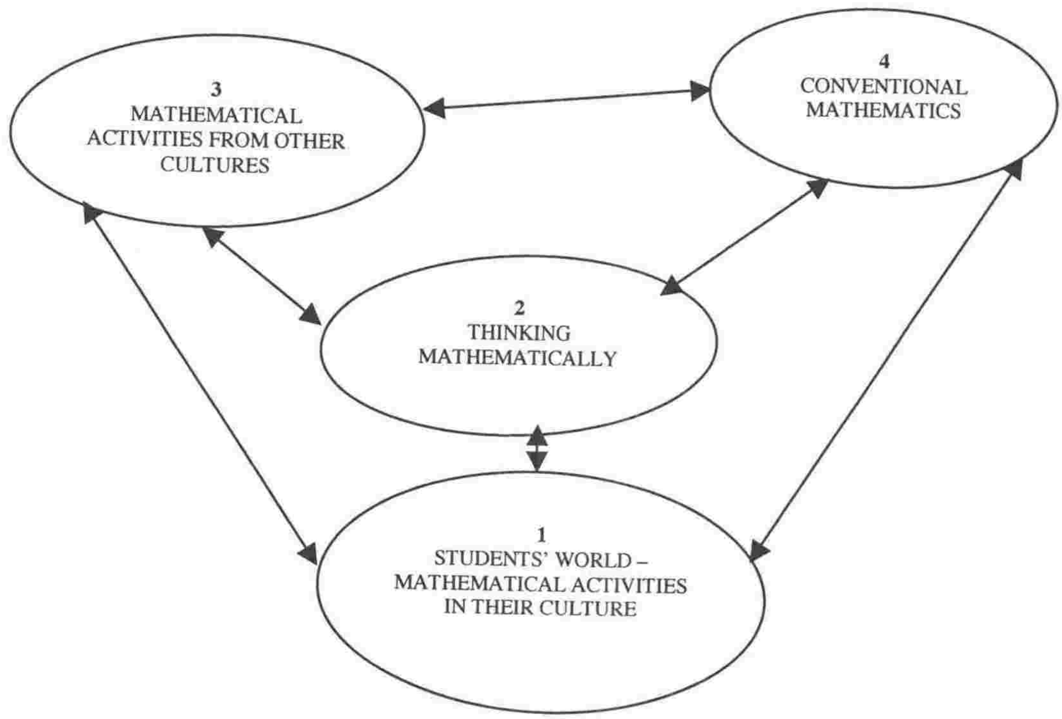


FIGURE 1: FRAMEWORK FOR AN ETHNOMATHEMATICAL CURRICULUM UNIT

It is hoped that an ethnomathematics curriculum unit will involve students in mathematical study by valuing and enhancing their existing knowledge. It is also hoped that a study of this nature will motivate students to recognise mathematics as part of their everyday life, enhance their ability to make meaningful mathematical connections, and deepen their understanding of mathematics.

APPENDIX B

Information Sheet on Maldivian and Other Ethnomathematical Examples

HISTORICAL DEVELOPMENT OF MATHEMATICS

A look at the historical development of mathematics reveals that there is hardly any culture that does not display some kind of mathematics. However, during the last 400 years or so, because of the dominant role played by Europe and her cultural dependencies in world affairs, histories of mathematics of indigenous cultures were rarely acknowledged.

The origins of Western mathematics can be traced to Egypt and Mesopotamia. It later spread to Greece and the Graeco-Roman world. After the fall of the Roman Empire, mathematical creativity almost ended in Europe, however it was believed to have been preserved in Persia. Following a period of inactivity for about two centuries, the enthusiasm for mathematics resurged in the Islamic world and from there mathematical knowledge spread to Sicily and Italy and throughout Europe

Prehistoric human beings probably learned to count at least up to 10 on their fingers. The Chinese, Hindus, Babylonians, and Egyptians all devised methods of counting and measuring which were of practical importance in their everyday lives. The first theoretical mathematician title is held to be by Thales of Melitus (580 B.C.), who is believed to have proposed the first theorems in plane geometry. His disciple Pythagoras established geometry as a recognised science among the Greeks. The later school of Alexandrian geometers included Euclid and Archimedes. Our present decimal numerals are based on Hindu-Arabic system which reached Europe about A.D. 100 from Arab mathematicians.

An Outline of the Period of Dynamic Mathematics Development

GROUP	PERIOD
Egyptian	3000 B.C. to 1600 B.C.
Babylonian	1700 B.C. to 300 B.C.
Greek	600 B.C. to 200 B.C.
Graeco-Roman	150 A.D. to 525 A.D.
Islamic	750 A.D. to 1450 A.D.
Western World	1100 A.D. to 1600 A.D.

SOME EXAMPLES OF MALDIVIAN ETHNOMATHEMATICS

Dhivehi Words Used for Place Values

DHIVEHI WORD	ENGLISH WORD	NUMERAL
Eykan	One	1
Dhiha	Ten	10
Satheyka	Hundred	100
Haas	Thousand	1 000
Dhiha Haas	Ten Thousand	10 000
Lakka	Hundred Thousand	100 000
Dhiha Lakka	Million	1 000 000
Kuroadu	Ten Million	10 000 000
Dhiha Kuroadu	Hundred Million	100 000 000
Arabu	Billion	1 000 000 000
Dhiha Arabu	Ten Billion	10 000 000 000
Karabu	Hundred Billion	100 000 000 000
Dhiha Karabu	Trillion	1 000 000 000 000
Neel	Ten Trillion	10 000 000 000 000
Dhiha Neel	Hundred Trillion	100 000 000 000 000
Padham	Quadrillion	1 000 000 000 000 000
Dhiha Padham	Ten Quadrillion	10 000 000 000 000 000
Sinku	Hundred Quadrillion	100 000 000 000 000 000
Dhiha Sinku	Quintillion	1 000 000 000 000 000 000

Money

Traditionally, small shells of certain molluscs were used as money in Maldives. The shells were counted as follows:

5 *boli* (shells) = 1 *agi*

25 *agi* (125 *boli*) = 1 *hiya*

8 *hiya* (1000 *boli*) = 1 *fau*

12 *fau* (12000 *boli*) = 1 *kottey*

Units Used for Linear Measure

Kaivaiy or handspan	Tip of thumb to tip of index finger on the same hand stretched out
Muh or half-arm span	Tip of the elbow to tip of middle finger on the same arm
Riyan or shoulder-length	Shoulder to tip of middle finger of same arm
Bama or two-arm span	Tip of middle finger of one arm to tip of middle finger of the other arm, both stretched out

Dry and Liquid Measures

4 *laahi* = 1 *naalhi*

16 *laahi* = 4 *naalhi* = 1 *kotte*

48 *laahi* = 12 *naalhi* = 3 *kotte* = 1 *faraa*

192 *laahi* = 48 *naalhi* = 12 *kotte* = 4 *faraa* = 1 *mulhi*

1200 *laahi* = 300 *naalhi* = 75 *kotte* = 25 *faraa* = 6 $^1/_4$ *mulhi* = 1 *kandi*

Maldivian Weighing System

1 kulhan'dhu = $^1/_2$ *thoalaa*

1 thoala = 2 kulhan'dhu

1 gau = 10 thoala

1 raatha = 4 gau

1 faula = 28 raathaa

1 handharu = 4 faula = 112 raathaa

1 tanu = 20 handharu

SOME EXAMPLES OF ETHNOMATHEMATICS IN OTHER CULTURES

Fiji

Fijian counting is based upon a system that counts only those items normally used in traditional festive presentations, and includes foodstuffs and traditional prized goods. These items are normally counted in units of tens. More abundant goods such as coconut and taro are counted in units of hundreds or thousands.

Papua New Guinea

Papua New Guinea has four main types of number systems. Type one is a 'body part' tally system where the parts of the body above the waist are enumerated. Type two is also a tally system where sticks are grouped into named sets. This type of counting has a base of 2, 3, 4, or 5. Type three has a mixed base of 5 and 20 while Type 4 counting system is based upon 'base 10'. Body parts are not used in this type.

Mende - West Africa

Counting is done at two number base levels, a sub-base 10 and a main base 20. There is a well-defined counting system among the Mende where the addition is built in the counting method. This method of counting leads to addition by expanding the numbers in 20s, 10s and units. Mende do not come across many instances where they have to count above 1000. However, the idea of infinity also exists which means too many to count. Few instances when Mende count up to 1000 are when the store bundles of rice count the number of 'kola' nuts in a bag. Multiplication and division are carried out as repeated addition and subtraction respectively.

Tonga

Tongans developed a number system as far as 100 000, before they came into contact with Europeans. Counting was mostly done in Tongan society for presentations at specific ceremonies. For example, the *inasi* ceremony - an annual ceremony where people presented the products of their labour. Counting is done mostly in twos or in pairs.

Popular Counting Methods in Mozambique

METHOD	DESCRIPTION
Knots	Used for recording age, months of the year, duration of long trips or hunts, and the months of pregnancy
Stones	A counting device applied to record the number of animals in a *kraal* (an enclosure for cattle)
Folds	Used mainly for counting the number of goals scored at a football match
Figures or traces	A way of counting that basket makers use. Traces on the ground to record the number of strips needed for a basket

Mende

When measuring clean rice they use both palms of their hand to take the rice from one container to transfer into another.

Liberia

Kpelle tradition of Liberia use a unit called *Kopi* – a cup, for measuring rice.

Brazil

In the southern Brazilian countryside, two methods are used for land area measurement, they are the Jorge's and Adao's methods. In the Jorge's method, the four walls of the land area are added, then the sum is divided by four and the number obtained is then multiplied by itself. In the Adao's method, two of the opposite walls are added then divided by two, then the other two opposite walls are added and divide by two and the two quotients are multiplied.

Tonga

In Tonga, for measurements of lengths, arm span or fathom, hand span (about 20 cm) and augmented hand span, (about 30 cm) were used. Nowadays, to measure the distance between rows of yams and between consecutive crops, one spade length is used.

SOURCE: (Adam, 1999).

APPENDIX C

Some Examples of Worksheets

A VISIT TO THE BUILDING SITE

Group Members ....

....

....

....

....

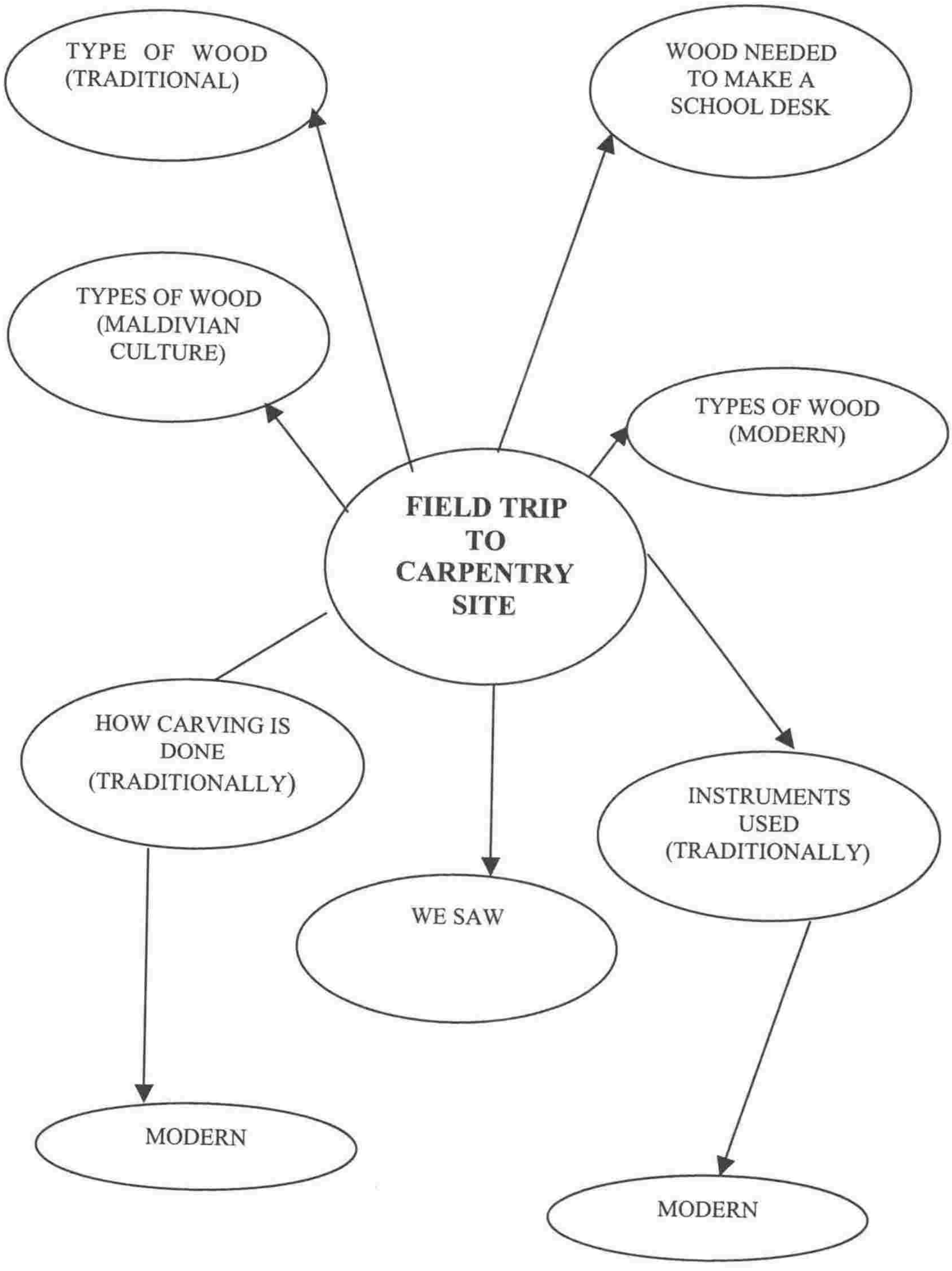
....

....

Date ....

1. What is the maximum height of a building in the Maldives?
2. How much of an open-space have to be left inside the boundary?
3. How many bricks can be made using one bag of cement?
4. What is the ratio of sand and cement to make a brick?
5. Using this (3) number of bricks, what is the length of a wall that you could build?
6. What is the equipment used for levelling the walls?
7. By looking at the plan how do you measure the actual length and breadth?
8. For a two-storey building how deep should the foundation be?
9. How many pipes are needed for plumbing?
10. How many tiles are needed to tile a floor 8' x 10' of a room?
11. How much space does a door need?
12. What is the normal height of a one-storey building?
13. Can we expand the balcony onto the road? How much can we expand?
14. How many wells cay put in the plot?
15. Normally, what is the thickness of a wall?

FIELDTRIP TO CARPENTRY SITE



WORKSHEET FOR MEASURING

26^{TH} FEBRUARY 2002

	BAIYPOLHI	MUSALLA	VASE	RAABADHI
COCONUT SHELL				
CONDENSED MILK TIN				
CANNED FISH TIN				
HANDFUL				
SHELL				
FUNA				
HANDSPAN				
MADHOSHI				

VISIT TO CONSTRUCTION SITE

- އާދައިގެ ގެއެއް ރާނަން ކިހާ ދުވަހެއް ނަގާތޯ؟
- ގެއެއް ރާނަން ކިހާވަރެއްހާ ބޭނުންވޭ؟
- ފަސްޓަރި އެޅުމަށް ނޫރާ ތެލިގަތޯ؟
- ގެއެއް ރާނަން ކިތައް ކޮޅު ސިމެންތި ބޭނުންވޭ؟
- ދޮވޮކޮޅު ކިހާ ސަރަހައްދެއް ފުޅާކުރޭ؟
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- އަޅުކަށިއެއްގެ ކޮންކަމަކަށް ބަލާއިރުތޯ؟
- ބައިގަނޑު ގެއްލޭ އިސްތިމާލުކުރާތޯ؟
- އެންމެ ބޮޑުކަން ބަރުދަނީ ގެގެ ކޮންތަކެއް؟
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- ރަނގަޅު ދަރުގަ ކުރާތޯ؟
- އުވިސްބަކުރު ދަރުގަ ކުރާތޯ؟
- ގޮވެލު ދަރުގަ ކުރާތޯ؟
- އުވިސްބަގެ ބޭނުމަ ކުރާތޯ؟
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- ފެންދަށިބޮޑުގެ ބޮޑު ވިސްނާތޯ؟
- ކަޖީރާ ޖަރަބައިގެ ވެސް ވިއްޔާ ބަރަބަރު ބޮޑުކުރާތޯ؟

- ފުރޮޅުގެ ބޮޑުވާތޯ؟
- ހިރަސްބޭނުމާ ޖިންގާ ބަރަބަރު ބޮޑުކުރާ ކިހިނެއް؟
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- ގެއަކަށް ކިތައް ތަނބު ޖެހޭތޯ؟
- ތަނބުގެ ބަރަބަރު އުސްމިން އެއްވަރަކީ ހިލާއި ސިމެންތި ފާރުގެ ބަރަބަރު އުސްމިނަކީ؟
- ތަނބު ޖަހައި ސިމެންތި މިލާ ކާގޮތަކަށް؟
- ހިރަސް ކަހައި ފައިދާ ބޮޑު ކާރު ދަމާ ނުވާތޯ؟
- ފަޅިއެއް ކާރު ދަމާ ނުވާތޯ؟
- ފުރޮޅު ހަރުކުރާ ކާ އިސްތިމާލު ނުވާތޯ؟
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VISIT TO BOAT BUILDING SITE

- ދޯންޏެއް ބަނދުވެނީ ކިހާ ދުވަހަކުން؟
- ގޯތިގަނޑަކަށް ކިހާ ލަކުޑިއެއް ފަހަރެއް ބޭނުންވޭ؟
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- ކަނޑައަޅަނީ ކިހިނެއްބަރުވަރު އަދި؟
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- ގުޅުކަށި ދޯއް ދިގުމިނަކީ ކޮބާ؟
- ކަށިގެ ދިގުމިނަކީ ކޮބާ؟
- އިސްކަލިތެޔޮ ކިހާ ދުރުގައި ދިނާ؟
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- ދޯންޏެއް އުސްމިނަކީ ކޮބާ؟

INFORMATION GATHERED FROM FIELDTRIPS

ހިސާބު ގްރޫޕު: 5

ރަށުގާއި ހިނގާ ރުކުރުގެ މަސައްކަތުގެ ކުރާއިރުން ބޭނުން ކަންތައްތައް

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APPENDIX D

Interview Guide Used for Teachers

CHECKLIST FOR TEACHER INTERVIEWS:

- The implementation process
  - how teachers feel about the whole process
  - things they would like to include or change in the curriculum unit
  - things they feel uncomfortable about in the curriculum unit
  - the impact of ethnomathematics curriculum unit on their teaching practice
  - has the teachers confidence in mathematics and mathematics teaching changed as a result of the implementation

- What students got out of the whole process
  - Do the teachers feel whether the ethnomathematical curriculum unit had any effect on student learning? Reasons

- Issues of ethnomathematics
  - Teachers feelings about using cultural practices in mathematics, issues of equity, issues of the introduction of western culture and issues of language in mathematics education
  - Teachers views on implementing a national ethnomathematical curriculum in the Maldives

APPENDIX E

Interview Guide Used for Students

CHECKLIST FOR STUDENT INTERVIEWS:

- Did the students notice anything different in the way the unit was taught?
- Have students recognised mathematics in the outside world?
- Have they made a link between mathematics in the real world and school mathematics?
- Any spontaneous reactions to ethnomathematical principles
- Change in interests in mathematics and the reasons for it.

APPENDIX F

Questionnaire Given to Teachers

Ethnomathematics in the Maldivian Curriculum: An Inquiry

Aishath Shehenaz Adam

Name:... Date:...................

I am interested in finding out teachers' attitudes to mathematics. The questions or statements in this questionnaire do not have right or wrong answers, but it is important that your answers are sincere and reflects your personal opinion on what is being asked. And please do not leave any question unanswered.

The confidentiality of your answers is guaranteed and no names or identifiable information will be used in any of the writings.

THANK YOU FOR YOUR COOPERATION!!

TEACHER ATTITUDES TO MATHEMATICS

1. Weaving is practiced in almost all the cultures including the Maldivian culture.

a. Do you think it is appropriate to discuss weaving in a mathematics class? Why?

b. What questions would you ask your class about weaving?

c. In which topic(s) would you discuss weaving?

2. Aminath believes that examples from real world should be used in the mathematics classroom so that students will be able to relate mathematics to the real world. However, Ali believes that since mathematics is an abstract subject using real examples to teach mathematics would confuse students more and the students will not be able to see the relevance of it.

Whom do you agree with and why?

3. The London GCE Ordinary Level Examination statistics show that the educational achievement of islands schools are low compared to that of Male' schools.

a. Who do you feel is responsible for this?

b. What do you think you can personally do to resolve this issue?

4. The London GCE Ordinary Level Examination statistics show that the boys perform better in mathematics than girls.

Give three factors associated with this.

5. Maldivian society values a Western education system more than the Maldivian education system. And it is generally believed that the Western education system is better than the Maldivian education system.

Do you agree or disagree with this statement? Why?

6. Mathematics curriculum of Maldives is dependent on the British education system and hence Western values and culture influence it. Research shows that it is easier for students to understand mathematics if familiar values and contexts are used in the mathematics curriculum.

Do you agree or disagree with this statement? Why?

7. What do you think that the traditional schools of the Maldives can offer which the formal schools don't?

8. In what language do you teach mathematics?

9. In what circumstances would you like to change the language of instruction?

10. Are there times when a child is learning mathematics or when you are teaching a certain topic that you feel that one language would be more appropriate than the other? Give some examples

11. In the first lesson with your class in the new school year, one pupil raises his/her hand and asks you why they have to study mathematics at school.

What would be your response?

12. You have just finished a lesson in which students had to work on a group project. After the lesson three students come up to you and protest that they would work better individually.

What would be your response?

13. If you had a chance to change:

a. the current curriculum
b. your teaching style

Give two things you would like to change with respect to each of the above aspects and why?

THANK YOU AGAIN FOR YOUR COOPERATION

APPENDIX G

Questionnaire Given to Students

بسم الله الرحمن الرحيم

ހިސާބު ގްރޭޑް 5

(ޢަރަބި، އިނގިރޭސި، ދިވެހި)

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TRANSLATION:

1. Did you notice anything different in the way the unit (perimeter/area/volume) was taught? What are the differences?

2. How do you prefer to learn mathematics? The method you have been following always or the way that you learnt the measurement topic? Why?

3. Is mathematics used anywhere except at the school? Give some examples!

4. Give examples of how the following are used in the real world (daily life). Area, Perimeter, and Volume.

APPENDIX H

A Guideline for Writing a Journal

You are invited to keep a journal* throughout the research. You might write your ideas and personal feelings in the journal after each workshop session and after each lesson during the implementation. You may write the journal in any language you prefer, English, Dhivehi or both. You may or may not let me have the journal.

Here are some questions that might assist you in writing a journal.

After a workshop session

- Describe something in today's workshop that you enjoyed. Why?
- What did you find relevant and useful?
- Write down something puzzling or difficult
- Examples of ethnomathematics in Maldivian culture that we haven't discussed in the workshop that could be used in mathematics teaching
- What ideas do you think will be useful for students?
- If you have done a similar activity in a class, what questions would you ask your students for them to share their ideas and feelings?
- Are there any questions that you would like to ask me?

After each lesson

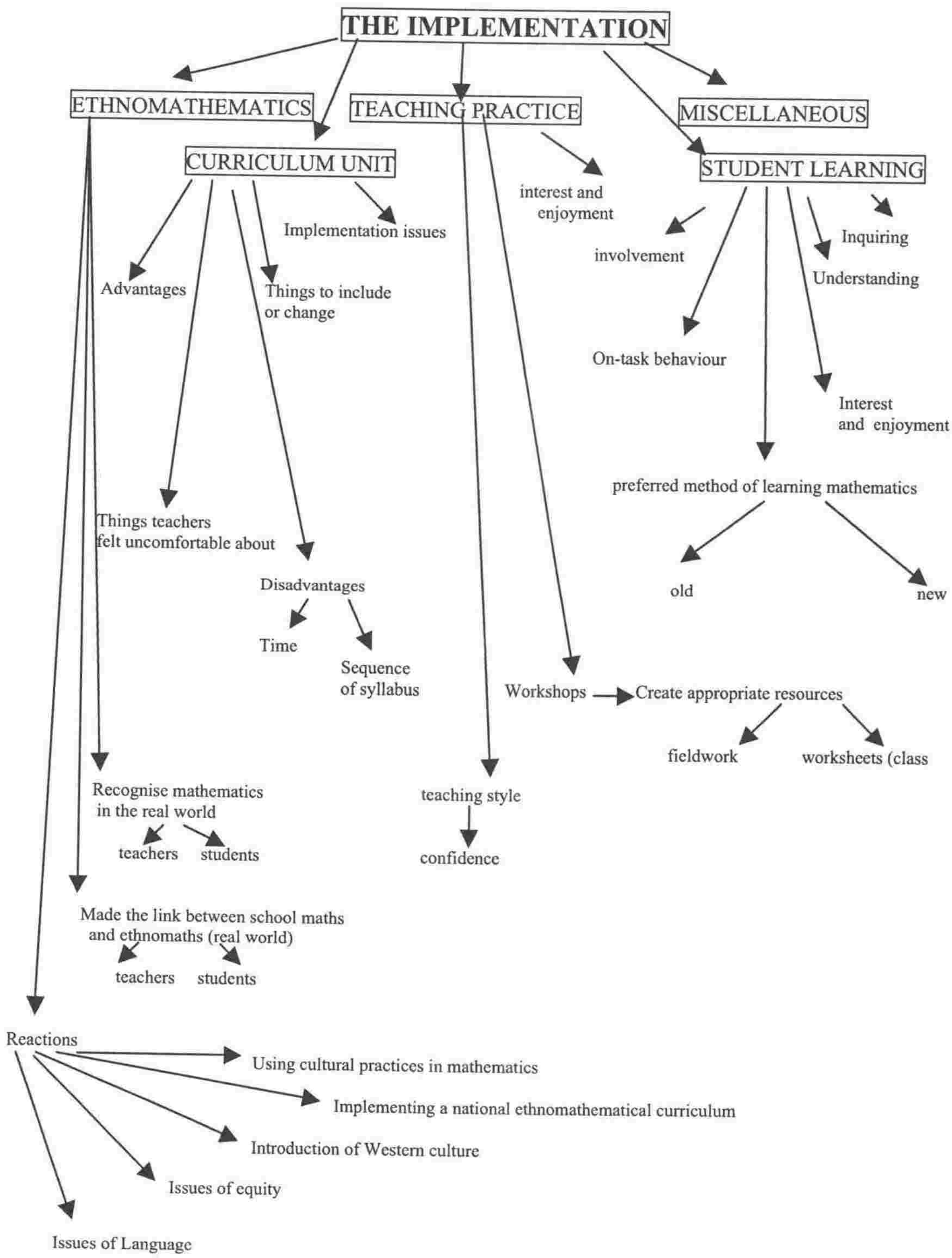
- Did the lesson work well today? Why or why not?
- Describe something in today's lesson that you enjoyed. Why?
- What did you find relevant and useful?
- What would you like to do more of next time? Or how do you think you could make the lesson more interesting next time?

- Write down something puzzling or difficult.
- What ideas did you think were useful to students?
- Did you encourage students to share their ideas? Instances
- Did you use your own ethnomathematical experiences in class? Examples
- Did you link ethnomathematics to school mathematics? Examples
- Did students use their own ethnomathematical experiences? Examples
- Did any student link ethnomathematics to school mathematics? Examples
- Describe an interesting learning incident (episode) that occurred in today's lesson
- Are there any questions that you would like to ask me?

* *A journal is a diary-like series of writing where ideas and feelings are expressed in own words.*

APPENDIX I

Tree Diagram Used for Data Analysis



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